CROP PRODUCTION AND MANAGEMENT

USE OF POLYMER HYDROGEL IN SOIL MOISTURE CONSERVATION FOR SUNFLOWER CULTIVATION IN RAINFED SITUATIONS OF NORTHERN KARNATAKA, INDIA: A CASE STUDY

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ABSTRACT

Impacts of climate change on food security are global and local. The agriculture production is being affected by change in mean rainfall and temperature. The inter-annual and inter-seasonal variation in rainfall pattern interms of distribution and quantum are projected change drastically in larger part of drylands in India. Sunflower being a drought tolerant crop, its productivity greatly affected by rainfall. With this background an experiment was mounted in deep black soils at University of Agricultural Sciences, Raichur for two consecutive seasons of kharif 2012 and 2013 in order to identify the appropriate moisture conservation techniques that would help to cope both under high and low rainfall situations. In comparison to first year of experimentation (2012), head diameter (cm), 100 seed weight (g) and seed yield (Kg/ha) recorded incremental change during second year due to more number of rainy days coupled with high rainfall. However, there was no drastic reduction in seed yield of sunflower due to use of agronomically sound moisture conservation techniques. Oil content (%) of sunflower seed was more under stress conditions (2012) than under non-stress conditions (2013) as crop received 469 mm in 2012, to 730 mm rainfall in 2013 between July to October which was most effective period for sunflower. Despite this large variation between rainfall, pooled data indicates that application of hydrogel @ 2.5 kg/ha along with Vermicompost @1 t/ha gave significantly highest sunflower seed yield (1815 kg/ha) as compared to sole application of hydrogel (@ 2.5 kg/ha (1642 kg/ha) or Vermicompost (@1 t/ha (1532 kg/ha) and this is on par with the application of hydrogel @ 2.5 kg/ha along with Gypsum @100 kg/ha (1740 kg/ha) and this was highly correlated with the soil moisture availability at different growth stages. However, the economics shows highest BC ratio was recorded with 2% $CaCl_2$ along with Gouch treatment (4.12) as compared to other treatments. There was strong correlation between head diameter against seed yield (r=0.9), gross returns (r=0.9), net return (r=0.85) and 100 seed weight (0.85). The 100 seed weight had significant correlation with gross and net return. Whereas, seed yield significantly correlated against net return which signifies increase in seed yield of sunflower increases the net profit margin for sunflower farmer.

Key Words: Hydrogel, Moisture Conservation, Sunflower, Yield, Oil percent

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed that originally belonged to subtropical and temperate zones (Demir et. al., 2010) crop and it is widely adaptable and more drought tolerant than most other grain crops (Usman et.al., 1994). It is well adjusted to soil that has high water-holding capacity but is easily adapted to a range of soil conditions (Ahmad et. al., 1992). Water and nutrients play an important role in sunflower growth and development. It was introduced to India as an oil seed crop during seventies. It gained importance and popularity as a commercial oilseed crop of India under rainfed conditions. This is due to its suitability to many agro ecological regions, short duration, good quality oil and market price. This crop is mainly cultivated in rainy season and post rainy seasons of vertisols but can be grown in any season of the year since this crop is considered as day neutral plant because of its low photoperiod sensitivity. The rainfed sunflower crop witnesses wide fluctuation in productivity due to erratic rainfall distribution and less availability of nutrients. Karnataka is the leading sunflower producing state in the country and contributes nearly 52 per cent of the total area and 40 per cent of the total production in the country.

In India during 1993-94 sunflower occupied an area of 26.7 lakh ha. 13.5 lakh tons production and drastically decreased to 5.5 lakh ha with a production of 4.15 lakh tons during 2014-15 (Anonymous, 2015). Though the crop has gained important place among farmers, the productivity of sunflower is very low. The low productivity is mainly due to the crop growing under rainfed conditions on poor fertility soils with non-availability of cultivars under moisture and nutrient stress situations. To increase production, it is important for decreasing of effects of factors reduced seed yield utilizing from higher production techniques in addition to develop higher yielding cultivars (Kaya et al., 2012 and Skoric, 2012). This crop is often considered as a soil nutrient depleting crop, which puts heavy demands on soil and applied nutrients (Thavaprakash et.al., 2002). Due to its high uptake of nutrients sunflower responds very well to applied nutrients. Application of nutrients increased the seed yield of sunflower by 50 per cent (Chorey and Thosar, 1997). The rainfed sunflower experiences erratic and undependable rainfall, excess and deficient of moisture within the same season. The critical analysis of production factors to increase the productivity of sunflower under different agro ecological situations of India revealed that moisture and nutrient are the key inputs to realize higher and sustainable production of sunflower cultivars under rainfed conditions. The farmers of this region are resource poor and use very little fertilizer. Identification of best agronomic practices suited to moisture and nutrient stress conditions are vital to the farmers of this region. Hence, the hydrogel along with FYM, vermicompost and gypsum were evaluated under the influence of moisture and nutrient management practices in sunflower.

MATERIAL AND METHOD

Water is the most important factor limiting crop productivity at different growth stages of crop growth and development. Water stress is likely the most important factor that adversely affects plant growth and development. In this direction, a field experiment was conducted during the kharif seasons of 2012 and 2013 at Main Agriculture Research Station (MARS), University of Agricultural Sciences, Raichur, Karnataka, India. Geographically the experiment place is located in North Eastern Dry Zone (Zone-2) of Karnataka State, which falls between 16^{o} 15' N latitude and 77^{o} 20' E longitude with an altitude of 389 meters above mean sea level. The soil of the experimental site belongs to medium black with clay loam texture. The soil of the experimental field in both years was sandy clay to clay with pH ranging from 8.0 to 8.7, organic carbon from 0.37 to 0.61%, available phosphorus 3 to 21 kg/ha and available potassium 293-588 kg/ha. The soil has field capacity of 16.6% to 28.2% and permanent wilting point of 7.47% to 13.1% with available water holding capacity of 10.24 to 16.96 cms at 75cm depth. The potential sunflower hybrid, RSFH-130 was used with eight treatments viz., 2% $CaCl_2$ + Gouch treatment, Vermicompost seed line application (1 t/ha), FYM seed line application (2.5 t/ha), Gypsum (100 kg/ha), Hydrogel (2.5 kg/ha) seed line application, Vermicompost (1 t/ha) + Hydrogel (2.5 kg/ha), Gypsum + Hydrogel (2.5 kg/ha) and control was 100 % NPK. The experiment was laid out in completely randomized block design with three replications. The observations were recorded on growth, yield attributes and yield. Economics were computed based on the prevailing market price. The oil content of sunflower seed was estimated by using Nuclear Magnetic Resonance (NMR) method (Model: Oxford MQA 6005). Finally the results were analyzed with suitable statistical analysis.

RESULTS AND DISCUSSION

Rainfall and Number of Rainy Days during Growth Period

Rainfall between July and October, the most effective rainfall period for sunflower growth varied from 361 mm in 2012, to 565.5 mm in 2013 against the past 30 years average of 730 mm, which were received in 25 and 34 days, respectively. However, entire year recorded hardly 468.9 mm in 31 days during 2012 and 729.9 mm in 48 days during 2013 (Table 1).

Table 1: Rainfall (Mm) And No. Of Rainy Days Observed During Sunflower Growth Period

Sl. No.	Month	2012		2013	
		Rainfall (mm)	No. of Rainy Days	Rainfall (mm)	No. of Rainy Days
1	July	103.6	06	116.4	10
2	August	50.0	03	102.2	06
3	September	126.0	09	250.0	13
4	October	81.4	07	96.9	05
Total		361.0	25	565.5	34
Total (Entire Year)		468.9	31	729.9	48

The data revealed that during rainy seasons of 2012 and 2013, application of hydrogel @ 2.5 kg/ha along with Vermicompost @1 t/ha gave significantly highest head diameter (18.3 cm and 19.9 cm, respectively) as compared to control i.e. 100% RDF (15.6 cm and 17.5 cm, respectively), sole application of hydrogel (@ 2.5 kg/ha (17.8 cm and 19.3 cm, respectively) or Vermicompost (@1 t/ha (16.9 cm and 19.3 cm, respectively) and this is on par with the application of hydrogel @ 2.5 kg/ha along with Gypsum @100 kg/ha (17.7 cm and 19.4 cm, respectively). Similar trend was also observed with 100 seed weight and oil content (Table 2). The results emphasizes that the combined effect of both hydrogel for moisture conservation and vermicompost or gypsum for nutrient supply have gave significantly higher values of, head diameter, oil content and 100 seed weight than the individual effect and as compared to 100% RDF. The moisture conservation effect and rainfall observed during the crop growth indicates that due to hydrogel use, the effect of deficit in rainfall during 2012 is reduced on the growth performance of the crop. The benefits of soil moisture conservation and nutrient supply in sunflower during post rainy season is also reported by Reddy et.al., 2003, Bakery et.al., 2009 and Aravinda Kumar et.al., 2010.

Seed and Oil Content

The two years rainy season pooled data (Table 2) revealed that the seed yield and oil content of sunflower was influenced significantly by integrated moisture conservation and nutrient source. Application of hydrogel @ 2.5 kg/ha along with Vermicompost @1 t/ha resulted in higher seed yield (1815 kg/ha) which was increased to the extent of 29% (1281 kg/ha) and 20% (1452 kg/ha) than 100% RDF (control) and FYM seed line application (2.5 t/ha), respectively. The various moisture conservation (2% $CaCl_2$ and hydrogel) and nutrient sources (RDF, FYM, vermicompost and gypsum) did not vary much in oil content. However, hydrogel @ 2.5 kg/ha along with Vermicompost @1 t/ha recorded higher oil content (36.8%) than 2% $CaCl_2$ + gouch treatment (36.1%). The oil content values during 2012 are higher than the 2013, this is because of rainfall occurred during flowering in 2013 causes pollen wash thereby reduction in oil content was noticed. Irrespective of the treatments, the seed yields recorded during 2012 are lower as compared to 2013. This is due to the variation in both rainfall amount (361mm and 565mm, respectively) and rainy days (25 and 34 days, respectively). However, between the years the quantity of sunflower yield reduction in 100% RDF (control plot) was higher (15%) than the 3% recorded with 2% $CaCl_2$ + gouch treatment, 5.5% with sole application of hydrogel (2.5 kg/ha) and 8% with hydrogel @ 2.5 kg/ha along with Vermicompost @1 t/ha. This is mainly due to the moisture conservation by both $CaCl_2$ and hydrogel and its utilization by the crop during requirement. Similar results have been observed by Megur et.al., 1993, Devidayal and Agarwal 1998.

The rainfed sunflower is sometimes more hungry than the thirsty which adds to its low productivity. There is strong interaction between nutrient source and moisture availability for crop yield. Application of nutrients facilitates root growth, which can extract soil moisture from deeper layers and moisture conservation practices ensured the better availability of moisture to the plants. Furthermore, supply of nutrients facilitates early development of canopy that covers the soil and intercepts more solar radiation and thereby reduces the evaporation component of the evapotranspiration. The moisture conservation effect and nutrient source for sunflower were found not significant for oil content.

Economics

The individual years and mean of two years data pertaining to the gross returns, cost of cultivation, net returns and B C ratio are given in Table 3. Pooled data reveals that the maximum gross returns of Rs.62586/ha was recorded under hydrogel @ 2.5 kg/ha along with Vermicompost @1 t/ha where as lowest gross returns (Rs.44147/ha) was recorded under control (100% RDF). Among moisture conservation options, maximum gross returns (Rs.56631/ha) was recorded under hydrogel (2.5 kg/ha) as compared to 2% $CaCl_2$ + gouch treatment (Rs.52624/ha). The moisture conservation with nutrient sources significantly recorded higher net returns (Rs.42354/ha) than rest of the treatments, while 100% RDF (control) recorded lowest net returns (Rs.31657/ha). The highest BC ratio was recorded with 2% $CaCl_2$ along with Gouch treatment (4.12) as compared to other treatments. Similar results were observed by Kazen et.al, 2013 and Singh et.al, 2005. The higher gross returns, net returns and B C ratio of moisture conservation and nutrient sources might be due to higher seed yield coupled with higher market price during both the years.

CONCLUSION

The results of two years experiment clearly indicated that adoption of moisture conservation techniques like use of polymer hydrogel and treating seeds with 2% $CaCl_2$ along with Gouch and supply of nutrients through organics like FYM, vermicompost, gypsum to nutrient exhaustive crops like sunflower are proved to be best one in Vertisols of Semi Arid Tropics of Karnataka for obtaining higher yield and monetary returns besides having higher production sustainability of sunflower.

Table 2: Effect af Moisture Conservatıon and Nutrient Source on the Performance of Sunflower Yield and Yield Parameters

Treatment Details	2012				2013				Pooled data			
	Head Diameter (cm)	100 Seed Wt (g)	Oil Content (%)	Seed Yield (kg / ha)	Head Diameter (cm)	100 Seed Wt (g)	Oil Content (%)	Seed Yield (kg / ha)	Head Diameter (cm)	100 Seed Wt (g)	Oil Content (%)	Seed Yield (kg / ha)
Control (100 % NPK)	15.6	2.63	41.1	1175	17.5	3.37	31.7	1387	16.5	3.00	36.4	1281
2% $CaCl_2$ + Gouch treatment	17.4	3.13	39.9	1502	18.2	3.53	32.2	1550	17.8	3.33	36.1	1526
Vermicompost seed line application (1 t/ha)	16.9	3.09	41.1	1389	19.3	3.50	31.5	1674	18.1	3.30	36.3	1532
FYM seed line application (2.5 t/ha)	16.7	3.04	40.9	1315	19.1	3.47	32.6	1589	17.9	3.26	36.7	1452
Gypsum (100 kg/ha)	17.5	3.00	40.4	1366	19.1	3.43	32.8	1555	18.3	3.22	36.6	1461
Hydrogel (2.5 kg/ha) seed line application	17.8	3.03	40.6	1595	19.3	3.53	32.2	1689	18.6	3.28	36.4	1642
Vermicompost (1 t/ha) + Hydrogel (2.5 kg/ha)	18.3	3.14	40.3	1740	19.9	3.57	33.0	1890	19.1	3.36	36.8	1815
Gypsum + Hydrogel (2.5 kg/ha)	17.7	3.05	39.6	1646	19.4	3.57	32.9	1835	18.6	3.31	36.2	1740
SEm $\pm$	0.71	0.21	0.76	99.28	0.65	0.12	0.81	113.31	0.38	0.07	0.61	72.34
CD at 5%	2.16	0.62	2.33	301.12	1.97	0.38	2.44	343.69	1.14	0.23	1.86	219.43
CV %	7.17	11.08	3.28	11.73	5.92	6.17	4.31	11.92	3.60	3.96	2.92	8.05

Table 3: Effect of Moisture Conservation and Nutrient Source on the Performance of Sunflower Economics

Treatment Details	2012				2013				Pooled data			
	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)	B C Ratio	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)	B C Ratio	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)	B C Ratio
Control (100 % NPK)	41137	12265	28872	3.35	47158	12715	34443	3.71	44147	12490	31657	3.53
2% $CaCl_2$ + Gouch treatment	52570	12565	40005	4.18	52683	13015	39668	4.05	52624	12790	39834	4.12
Vermicompost seed line application (1 t/ha)	48603	16265	32338	2.99	56924	16715	40209	3.41	52765	16490	36275	3.20
FYM seed line application (2.5 t/ha)	46037	14765	31272	3.12	54032	15215	38817	3.55	50037	14990	35047	3.33
Gypsum (100 kg/ha)	47810	12915	34895	3.70	52876	13365	39511	3.96	50340	13140	37200	3.83
Hydrogel (2.5 kg/ha) seed line application	55825	16765	39060	3.33	57438	17215	40223	3.34	56631	16990	39641	3.33
Vermicompost (1 t/ha) + Hydrogel (2.5 kg/ha)	60923	20765	40158	2.93	64248	21215	43033	3.03	62586	20990	41596	2.98
Gypsum + Hydrogel (2.5 kg/ha)	57610	17415	40195	3.31	62385	17865	44520	3.49	59994	17640	42354	3.40
SEm $\pm$	3473	--	3473	0.24	3852	--	3852	0.26	2491	--	2491	0.18
CD at 5%	10535	--	10534	0.73	11685	--	11685	0.79	7555	--	7555	0.55
CV %	11.72	--	16.78	12.32	11.92	--	16.66	12.71	8.04	--	11.37	9.13

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EFFECTS OF MICRONUTRIENTS ON OIL QUALITY OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Abstract

Oils, proteins and carbohydrates are essential nutrients for human consumption. Oils have an important role as energy source. A large amount of edible oils is obtained from plants. Sunflower oil, which has high nutritional value with higher unsaturated oil (69%) and lower saturated oil (11%) ratio, is considered an important oil among the plant based oils. It is, therefore, accepted as a good and healthy edible oil source. Storage conditions of the oil and also applied cultural techniques highly influence the quality properties of the oil. Especially, micronutrient applications may alter oil quality. This study aims to investigate the effect of micronutrients use on oil quality in sunflower.

Introduction

Sunflower (*Helianthus annuus* L.) is considered as one of the four important annual crops in the World for edible oil. Sunflower, with 41.3 million tones production in 2013/14, is the forth wildly produced oil crop in the World, right after soybean, rapeseed, and cotton seed (FAO, 2015). The seed yield and oil concentration are very exclusive characteristics for sunflower breeders due to being a vegetable oil source. Oil content of sunflower, which might range from 260 to 720 g/kg among the genotypes, is the most important property for marketing. (Hu et. al., 2010). The 24-49% of sunflower seeds contain oil, when the cake contains 25-35% of protein, which is used for livestock feed (Farokhi et. al., 2014). Sunflower oil is characterized by its high content of unsaturated fatty acids such as oleic and lenoleic which represent 90 % of total fatty acids (Al-Qubaie, 2011, Arshad et al., 2013). Also, sunflower oil is quite palatable and contains soluble vitamins A, D, E and K. It is used in manufacturing of margarine (Iqbal et al., 2009). The oil content of sunflower is shown in Figure 1.

Oilseed crops are very sensitive to Fe, B, Mn ve Zn micro elements loss (Rahimi et al., 2012). The most consumed micronutrients during sunflower development are iron, manganese, boron and copper (Kaya, 2008). The absence of these elements will cause some deficiencies on sunflower plants and oil quality. Using sufficient amount of micronutrient will increase the quality and quantity of the products, at the same time will decrease the amount of contaminants elements (Rahimi, 2014). Sunflower oil consist of different types of saturated and unsaturated fatty acids (palmitic, stearic, oleic and linoleic acids etc.). Palmitic and stearic acids are the major saturated fatty acids, whereas oleic and linoleic acids are unsaturated. Fatty acid composition of sunflower in particular and that of other oil seed crops in general are influenced by fertilizing managements.

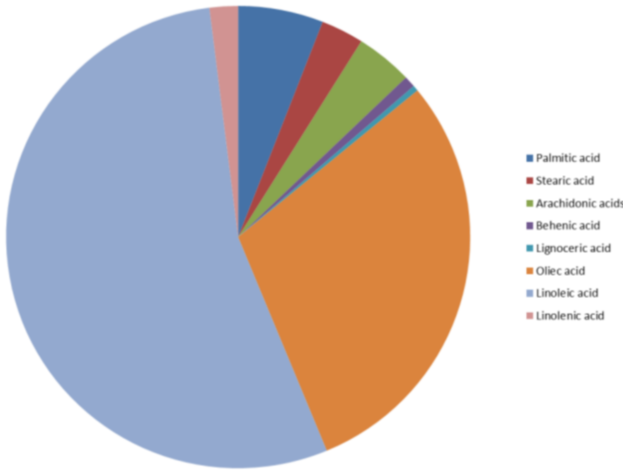

Figure 18: Oil content of sunflower (Nas, 2010).

Micronutrients in sunflower

Micronutrients, also called as trace elements, are nutrients, needed by organisms in small quantities. Micronutrients, used by sunflower, can be listed as; boron, iron, zinc, and manganese.

Boron (B): Sunflower is one of the most sensitive field crops to low B supply, and B deficiency in this crop has been reported from around the World (Blamey et al., 1997). Boron is absorbed by the roots of sunflower and accumulates the other organs and tissues of the plant. Most of B is accumulated in the larger leaves (Husa,1965). Boron has role on plant reproduction and pollen spikelet formation (Bolanos et. al., 2004). Besides, B is important for water relations, sugar translocations, cation and anion absorption and metabolism of N, P, carbohydrates and fat (Stiles, 1961; Shkolnik et. al., 1970). Boron deficiency occurs firstly in young leaves with bronze color and hardiness (Oyinlola, 2007). During fertilization of the sunflower field, the B concentration should be optimizated. In the study conducted by Oyinlola (2007), the optimized B concentration is 5.60-8.40 kg.ha^{-1}; on the other hand, there is a sharp decrese in oil content when the concentration up to 12 kg.ha^{-1}. Brighenti and Castro (2008) demonstrated that oil yield were increased by B consumption, and stated that B consumption increased the pollen fertility. Thus, with increase of the number of filled grain, yield is increased. Bahaa El-Din (2008) reported that application of 300 ppm B resulted in an increase of palmitic, stearic and oleic acids as compared to the treatment with 600 ppm B and control plants but the linoleic acid increased gradually with increasing B up to 600 ppm and cleared that B plays a vital role for increasing the productivity and quality of sunflower plants, especially when grown under B deficient soil. Significant decline in stearic acid and oleic acid contents while considerable increase in palmitic acid and linoleic acid contents was recorded by individual use of nitrogen and boron supplements. Farokhi et al. (2014) who found that oil yield and oil percantage were increased with B applicatian in sunflower. Tahir and his collauges (2014) conducted a study to show effect of B on sunflower yield (Table 1). They (2014) reported that the maximum oil contents were observed when B was applied at a rate of 8 kg ha-1 at the time of bud initiation.

Table 5: Effect of different boron concentrations on sunflower oil yield

Boron content	0 kg/ha	2 kg/ha	4 kg/ha	6 kg/ha	8 kg/ha	10 kg/ha	12 kg/ha
Oil yield (%)	40.82	41.53	42.46	42.77	42.85	41.92	41.36

Iron (Fe): Iron is critical for chlorophyll formation and photosynthesis and is important in the enzyme systems and respiration of plants (Havlin et all., 1999). Iron is cofactor of many antioxidant enzymes. Fe^{+3} reduced to Fe^{+2} by O^{-2} reacting with H_2O_2 to form OH^- through Fenton Reaction. Besides, iron involves in different metabolic reactions like; catalase, phenolic depend peroxidases, ascorbate peroxidase and Fe superoxide dismutase (Raniery et. al., 2001). Iron fertilizer is considered as an important element in plant nutrition. According to Farokhi (2014), iron sulfate fertilization decreases oil percentage and increase oil yield of sunflowers (Table 2).

Table 6: Effect of iron sulfate on oil concentration of sunflower

$FeSO_4$ (kg/h)	**Stem diameter (mm)**	**Oil percentage (%)**	**Oil yield (kg/ha^{-1})**
0	9.56	55.07	1406.76
4	10.79	50.35	1607.20
6	11.50	50.89	3703.98

Ebrahimian et all. (2010) said that oil content increases by use of Fe microelement and Fe foliar application significantly increased total unsaturated fatty acids in sunflower. Besides, they concluded that Fe application significantly decreased POD (peroxidase) and CAD (catalase) but increased significantly SOD (superoxide dismutase) activity in sunflower. Ghavami et al. (2015) also reported that Fe application significantly increased protein and oil content compared to the control treatment

Zinc (Zn): Zinc nutrient is very important to plants due to the role on membrane integrity of root cells. Besides, zinc is assigned on protein synthesis such as auxins, which is a very important growth regulator. On the other hand zinc could decrease the toxic effect of boron, sodium and chloride (Mirzapour and Khoshgoftar, 2006). Zinc sulfate ($ZnSO_4$) is commonly used for Zn fertilization due to high solubility in water (Mordvedt and Gilkes, 1993). 4.5-34 kg.ha^{-1} zinc, which depends on the soil need, is enough for inhibiting zinc deficiency in the field (Martens and Westermann, 1991). Zn fertilization with 10 to 20 kg per hectare increases oil content of the sunflower seed. In contrast, increasing in Zn concentration reduced oil content of the sunflower seeds (Mirzapour and Khoshgoftar, 2006). According to Khurana and Chatterjee (2001), more than 0.65 mg.L^{-1} zinc supply inhibits oil content of sunflower seeds (Table 3).

Table 7: Oil content of sunflower according to Zinc supply

Zinc supply (mg.L^{-1})	0.00065	0.0065	0.065	0.65	6.5	65
Oil content (%)	18.0	19.2	22.9	23.4	18.5	16.8

Ebrahimian et al. (2010) reported that oil content increases by use of Zn microelement and soil application of Zn micronutrients is more beneficial to oil biosynthesis. In addition, they concluded that foliar application of Zn microelement significantly increased POD (peroxidase) and SOD (superoxide dismutase) but decreased significantly CAT (catalase) activity and Zn foliar application significantly increased palmitoleic, linolenic, oleic and myristic acid content in sunflower. In another study, conducted by Eslami and colleagues (2015), spraying zinc sulfate to sunflowers effected oil content of the plants. The variations of oil content are showed in Table 4.

Table 8: Sunflower oil contents under different zinc sulphate concentration

	Oil percent (%)	Oil yield (%)	Linoleic acid (%)	Oleic acid (%)	Stearic acid (%)	Palmitic acid (%)
Z1*	34/55	1512/84	62/81	16/49	6/99	5/60
Z2*	35/20	1437/00	64/41	16/80	7/62	6/18
Z3*	34/9	1406/34	66/05	16/97	7/73	6/41

***Z1**: 0 kg/ha, **Z2**: 30 kg/ha, **Z3**: 60 kg/ha.

Copper. Copper is assigned with carbohydrate and protein metabolism, chlorophyll synthesis and activation of some enzymes. Cu deficiency could be listed as; reducing in growth, distortion of younger leaves and necrosis of the apical meristem (Gibson et. al., 2013). Solubility of Cu^{+2} in the soil depends on pH of the soil. Unfortunately, when the soil pH reaches 5, the Cu^{+2} toxicity occurs by binding of copper elements to cation exchange sites of the root (Lin et. al., 2003). Besides, using micronutrients individually, they can also be used as combination. Thus, the effects of micronutrient on oil content of sunflower can be increased. According to Rahimi (2014), combination of micronutrients increases oil content of sunflower (Table 5).

Table 5: The effects of fertilization treatment on oil content of sunfllower.

Fertilizertreatment	Linoleic fatty acid (%)	Oleic fatty acid (%)	Stearic fatty acid (%)	Oil yield (ha/kg)
T_1	54.70	33.61	4.95	854.81
T_2	45.35	34.29	5.24	969.37
T_3	51.76	38.22	4.62	114.79
T_4	59.13	30.18	5.37	123.48
T_5	60.04	31.47	3.29	125.6

T_1: N, P, K, Mg; **T_2**: N, P, K, Mg, Fe; **T_3**: N, P, K, Mg, Fe, B; **T_4:** N, P, K, Mg, Fe, B, Mn; **T_5**: N, P, K, Mg, Fe, B, Mn, Z

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PERFORMANCE OF SUNFLOWER HYBRIDS IN BLACK COTTON SOILS OF NORTHERN KARNATAKA, INDIA

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ABSTRACT

Sunflower (*Helianthus annuus* L.), was introduced during seventies as an oil seed crop to India, It gained importance and popularity as a commercial oilseed crop of India under rainfed conditions. This is due to its suitability to many agro ecological regions, short duration, good quality oil and market price. The productivity of Sunflower in India at present is far lower (500 to 800 kg/ha) than the world average (1380 kg/ha). This is to a large extent due to several biotic and abiotic factors that the crop is invariably subjected in different regions. The availability of heterotic hybrids for cultivations has phenomenally increased during the last decade (2000-2010), which is expected to improve yield and disease control of the crop significantly. Drought and incidences of diseases and insect pests are the major constraints in sustaining the higher productivity of sunflower, in India. In this direction, a study was conducted during the *Kharif* season of 2014 to evaluate different sunflower hybrids (both public and private) on rainfed Vertisols of Raichur district in peninsular India. The study results revealed that significantly highest plant height was recorded by DRSH-1 (177.5 cm) over other hybrids and shortest hybrid was KSFH-11-384 (134.25 cm). Head diameter was significantly high for NSFH-1009 and RSFH-130 (9.1 cm) over KSFH-011-384 and KBSH-72. Significantly highest test weight was recorded by KBSH-44 (5.25 g) over remaining hybrids. Significant variation was observed with volume weight and the highest value was recorded by KSFH-11-384 (45.8 g/100 ml) followed by NSSH-1201 (42.55 g/100 ml). The performance of hybrids such as KBSH-44 and RSFH-130 was superior and significant for seed yield (2509 and 2485 Kg/ha, respectively). Correlation between plant height and days to 50% flowering and maturity was significant. High significant correlation was recorded between days to 50% flowering and days to maturity and former had significant correlation with head diameter. The hybrid RSFH -130 has surpassed the test of trial over other hybrids in terms of seed yield and oil content, which may be promoted for cultivation under black cotton soils of northern Karnataka.

Key words: Sunflower, Hybrids, Yield, Oil content

INTRODUCTION

Among the oilseed crops, sunflower (*Helianthus annuus L.*) occupies fourth position in area and production in the world after soybean, rape-seed-mustard and groundnut. World harvest of sunflower was 31.72 mt from 22.92 mha (FAO statistical Year book, 2013). World sunflower production has remained almost stable over the last decade. Russian Federation, Ukraine, Argentina, India and the China are the top five countries in the world with respect to production. Europe alone accounts for about 16 per cent of world area and 21 percent of total production. India is among the top four countries in area after Russian Federation, Ukraine and Argentina. Notwithstanding spectacular spurt in area, the productivity is only 42 per cent of world average (1380 kg/ha). In India during 1993-94 sunflower occupied an area of 26.7 lakh ha. 13.5 lakh tons production and drastically decreased to 5.5 lakh ha with a production of 4.15 lakh tons during 2014-15 (Anonymous, 2015). Despite phenomenal growth rate in area expansion, the productivity of sunflower crop in India has remained low. Karnataka, in South India, is called the "Sunflower State" as it alone accounts for more than 45 per cent of the total sunflower area in the country. However, the productivity is only 5 q/ha. In general productivity is low as sunflower moves from North India to South India. Rainfed cultivation, biotic and abiotic stresses and poor quality seed are some of the important factors responsible for low productivity (Ghani *et. al.,* 2000). The decline in acreage and production during 1996-98, has been also due to the incidence of a new viral disease (necrosis) in Southern and Central peninsula comprising Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu. Of late, soybean has emerged as a remunerative crop because of higher productivity and as a consequence, a part of sunflower area was diverted to soybean planting in rainy season.

Wide variation exists in flowering and maturity periods of sunflower across environments. On an average, crop matures in about 95 days in the south to about 120 days in the north. High productivity in north can be attributed to longer duration of the crop and high-applied inputs. Sunflower cultivation and hybrid seed production has gained new dimension after the launch of New Seed Policy in 1988. It resulted in the import of exotic hybrids and germplasm lines, which subsequently helped to diversify genetic base of sunflower cultivars grown in India (Devidayal and Agarwal, 1998). In coming years, major emphasis is to be placed on increasing productivity and yield stability across environments (Kaya et.al., 2012). This necessitates to study the performance evaluation of high seed yield cultivars with inbuilt resistance to biotic and abiotic stresses.

METHODOLOGY AND DATA

The field experiment was conducted during the *kharif* season of 2014 at Main Agriculture Research Station (MARS), University of Agricultural Sciences, Raichur, Karnataka, India. Geographically the experiment place is located in North Eastern Dry Zone (Zone-2) of Karnataka State, which falls between 16^{o} 15' N latitude and 77^{o} 20' E longitude with an altitude of 389 meters above mean sea level. The soil of the experimental site belongs to medium black with clay loam texture. The soil analysis results reveals that available nitrogen was low, therefore addition of 12.5 kg ha^{-1} to the recommended level of nitrogen (90 kg ha^{-1}) was done (103 kg ha^{-1}) and medium in available phosphorous (90 kg ha^{-1}) and potassium (60 kg ha^{-1}). The experiment has nine different sunflower hybrid treatments, The trial was laid out in a

Randomized Complete Block Design (RCBD) with four replications. The fertilizers were applied as per the recommended package (90:90:60 kg NPK/ha). Analysis of the results was done using SAS program, orthogonal contrasts studies for treatments and interactions (Robert and James, 1980 and Peterson, 1985) were also done.

RESULTS AND DISCUSSION

Weather during crop growth period

Rainfall between July and October, the most effective rainfall period for sunflower growth was 634.70 mm, which was received in 26 days (Table 1). No single irrigation was given, the trial was toatally rainfed. The average maximum temperature recorded during the cropping season wadsNo single irrigation was given, the trial was toatally rainfed. The average maximum temperature recorded during the cropping season was 32.54 C^o and minimum was 22.64 C^o, which is very conjenial for sunflower growth (Kazemini *et.al*., 2009; Reddy *et. al*., 2003 and Singh *et. al.*, 2005). The maximum relative humidity recorded during the crop season was 82.88 per cent and minimum was 58.25 per cent, which favours the build-up of pests and diseases like necrosis and leaf eating caterpillars for their control sparyaing of Chloropyriphos & Imidacholprid @2 ml and 0.3 ml/ltr of water, Trisophos @ 1.5 ml/ltr and Emamectin & Imidacholprid @ 1 ml and 0.3 ml/ltr of water was done as per the recommendation (Thavaprakash et. al., 2002; Tolga and Lokman, 2003).

Growth and Yield Attributes

The analyis of variance for growth parameters viz., plant height, days to 50 % flowering, days to maturity, head diameter, 100 seed weight, volume weight, plot yield, seed yield and oil content indicated significant difference among hybrids (p=0.05). The coefficient of variation (CV %) was high (11.30 %) for plot yield (Kg/Net Plot) and low (2.30 %) for Volume weight (g/100 ml). High CV indicates hybrids are highly variable for plot yield and least variation was observed for Volume weight. Different sunflower hybrids have a significant effect on growth attributes, *viz*. Plant height (cm), days to 50 per cent flowering and days to maturity. Among the sunflower hybrids, significantly highest plant height was recorded by DRSH-1 (177.5 cm) over other hybrids and shortest hybrid was KSFH-11-384 (134.25 cm) similar results were reported by Megur *et al*. (1993). KBSH-71 and KSFH-011-384 (54 days) and KBSH-72 and NSSH-1201 (55 days) were earliest to complete days to 50% flowering and early maturing hyrids. The results also revealed taht different sunflower hybrids have a significant effect on yield attributes, *viz*. head diameter (cm), 100-seed weight (g) and volume weight (g/100 ml). Among sunflower hybrids, head diameter was significantly high for NSFH-1009 (19.15 cm) followed by RSFH-130 (19.1 cm) and KBSH-44 (19 cm) over KSFH-011-384 (17.65 cm) and KBSH-72 (16.85 cm). Among hyrids, highest volume weight (g/100 ml) was recorded by KSFH-011-384 (45.80 g) and NSSH-1201 (42.55 g), both differed significantly from regional check and lowest volume weight (g/100 ml) was recorded by Laxmi-225 (39.05 g). Highest 100 seed weight was recorded by KBSH-44 (5.25 g) and lowest by Laxmi-225 (4.10 g). Hyrids viz., KBSH-71, DRSH-1,KBSH-72,NSFH-1009, and KBSH-44 differed significantly from regional check (RSFH-130) for 100 seed weight (Aravinda Kumar. *et al*., 2010; Teama and Mahmood, 1994). Similar results were observed by Barmaki *et al*. 2009, revealed that the yield and yield components of sunflower were differed due to performance of different sunflower hybrids to weather and management practices. Similar type of synergetic effect was also reported by Patil *et al*. (2006).

Seed Yield and Oil Content

The hyrids have not differed for plot yield in comparison to regional check. However, KBSH-44 recorded highest plot yield (2.94 Kg/net plot) and lowest by Laxmi-225 (2.10 Kg/net plot).Most of the hyrids have differed among themselves for seed yield but in comparison to regional check, none of the hybrids have differed. The highest seed yield (2509 Kg/ha) was recorded by KBSH-44 and lowest by KSFH-011-384 (1923 Kg/ha). Hybrids have differed among themselves for oil content but in comparison to regional check none of them exhibited significant difference. However, highest oil content was recorded by KFSH-011-384 (41.76 %) and lowest by NSFH – 1009 (32.37 %). Similar results were observed by Kazem *et. al.,* 2013 and Mihaelaand Valeriu, 2010 in sunflower crop.

Correlation study results

The correlation among different agro-morphological and oil content has revealed highly significant positive correlation was recorded between days to maturity and days to 50 % flowering (r=0.98) indicating selection of hyrids of early maturity types may lead to correlated selection for early flowering types (Ahmad *et. al.*, 1992; Singh *et. al.*, 2005). Days to maturity also significantly correlated with plant height and head diameter (r=0.86; 0.67, respectively). Days to 50 % flowering was significantly correlated with plant height (r=0.85).

CONCLUSION

The new self fertile hybrids in sunflower both from public and private institutes in india, creates problem for the farmers in selection of perticular hybrid for their own land. Hence, the present study results gives some guidelines for the farmers based on their objective in selection of a perticular hybrid. Based on the study it is suggested that if farmer is interested for higher yield, then he should goi for long dration hybrids, as the long duration hybrids are highely correlated with higher yield and oil content. And if farmer is facing acute shortage of water and due to shift in rainfall pattern in this case farmer has to go for early maturing hybrids. Sunflower being a nutrient exhaustive crop, the new hybrids respond to both nutrients and water. Hence, the farming community has to be careful in selection of hybrids for their cultivation.

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Table 1. Weather parametrs recorded during the sunflower crop season at MARS, Raichur (July to October 2014)

Sl. No	Meteorlogical week	Weeks	Max. T (°c)	Min. T (°c)	RF (mm)	# Day	RH I (%)	RH II (%)	Evaporation	S. S Hrs	Win Speed
1	July 2-8	27	37.1	23.9	73	3	73	42	11.2	3.5	14.2
2	July l9-15	28	32.8	22.4	31.7	2	86	70	3.9	0.5	14.7
3	July 16-22	29	32.1	23.2	3.8	0	85	48	5.2	1.4	19.5
4	July 23-29	30	33.3	22.6	10.6	2	84	59	4.6	1.6	17.4
5	July 30-5	31	32.0	22.6	8.8	2	83	55	5.4	2.8	16.6
6	August 6-12	32	34.2	23.6	0	0	79	47	6.7	7.1	14.9
7	August 13-19	33	34.1	23.0	7.9	1	78	50	6.4	5.5	10.0
8	August 20-26	34	33.7	22.3	187	3	89	62	3.5	3.2	6.0
9	August 27-2	35	28.0	21.6	189.9	6	93	83	2.6	1.4	10.1
10	September 3-9	36	30.0	21.7	19.8	2	87	68	4.0	3.7	12.1
11	September 10-16	37	32.2	22.5	20.4	2	83	57	4.9	6.1	9.6
12	September 17-23	38	29.8	22.3	45.8	2	90	79	3.6	0.7	7.2
13	September 24-30	39	32.4	23.7	0	0	83	55	4.9	0.0	5.5
14	October 1-7	40	34.2	22.4	35.4	1	75	46	5.0	7.0	4.1
15	October 8-14	41	31.8	21.8	0.6	0	83	60	3.2	4.5	4.1
16	October 15-21	42	32.9	22.7	0	0	75	51	5.1	7.4	6.7
Avg/ Total			32.54	22.64	634.7	26	82.88	58.25	5.01	3.53	10.79

Date of Sowing: 08.07.2016 Date of Harvest: 18.10.2016

Table 2. AHT ANOVA Table

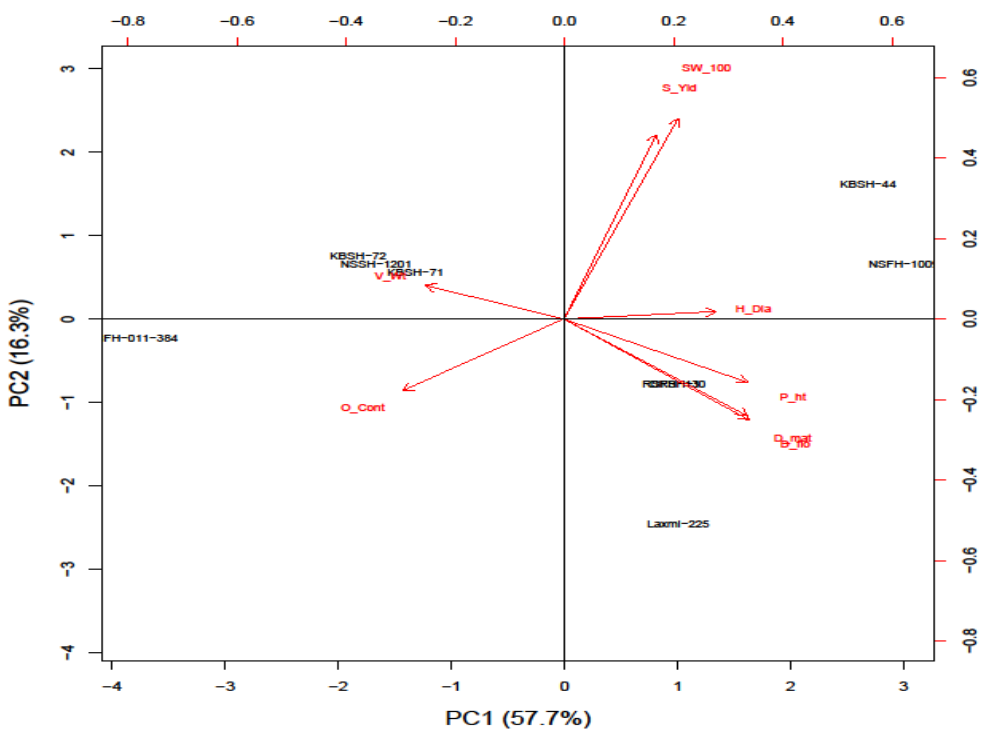
#	Treatment	Plant Height (cm)	Days to 50% flowering	Days to Maturity	Head diameter (cm)	100 Seed Weight(g)	Volume weight (g/100ml)	Plot Yield (Kg/net plot)	Seed Yield (Kg/ha)	Oil content (%)
1	KBSH-71	158.75	54	94	18.30	4.45	41.18	2.60	2225	40.49
2	DRSH-1	177.50	59	97	18.15	4.58	41.38	2.56	2184	39.87
3	KSFH-011-384	134.25	54	94	17.65	4.13	45.80	2.25	1923	41.74
4	KBSH-72	145.75	55	94	16.85	4.65	39.70	2.55	2180	39.66
5	NSFH-1009	173.50	60	97	19.15	5.00	40.40	2.70	2306	32.37
6	KBSH-44	167.00	59	97	19.00	5.25	40.15	2.94	2509	34.59
7	Laxmi-225	168.50	60	97	18.35	4.10	39.05	2.10	1797	37.13
8	NSSH-1201	146.75	55	94	18.40	4.30	42.55	2.68	2293	39.96
9	RSFH-130	163.25	59	97	19.10	4.03	40.30	2.91	2485	41.01
SEm$\pm$		3.98	--	--	0.40	0.12	0.49	0.15	122.05	1.14
C.D. at 5 %		11.60	--	--	1.18	0.35	1.43	0.59	356.25	2.35
C.V. %		4.96	--	--	4.40	5.34	2.38	11.30	11.04	4.16

Table 3. Decoded of sunflower hybrids with the respective institutes

Entry No.	Institutions
KBSH-71	UAS, Bangalore
DRSH-1	IIOR, Hyderabad
KSFH-011-384	Kaveri Seeds, Hyderabad
KBSH-72	UAS, Bangalore
NSFH-1009	Nuziveedu Seeds, Hyderabad
KBSH-44	UAS, Bangalore
Laxmi-225	Yaganti Seeds, Hyderabad
NSSH-1201	Nuziveedu Seeds, Hyderabad
RSFH-130 (Regional Check)	UAS, Raichur (Regional Check)

Table 4. Sunlfower correlation study

	S_Yld	*O_Cont*	*P_ht*	*D_flo*	*D_mat*	*H_Dia*	*SW_100*	*V_Wt*
S_Yld	1.00							
O_Cont	-0.23	1.00						
P_ht	0.27	-0.58	1.00					
D_flo	0.18	-0.65	0.85	1.00				
D_mat	0.23	-0.58	0.86	0.98	1.00			
H_Dia	0.53	-0.52	0.62	0.64	0.67	1.00		
SW_100	0.50	-0.75	0.38	0.27	0.26	0.22	1.00	
V_Wt	-0.24	0.49	-0.65	-0.61	-0.54	-0.25	-0.31	1.00



Graph 1. Principal component analysis of Sunflower hybrids performance

DEVELOPMENT OF SUNFLOWER PRODUCTION IN TURKEY

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ABSTRACT

The sunflower is the most important raw material of the oil sector among oilseeds produced in Turkey. Although adaptation areas of the sunflower that can be cultivated in dry or irrigated conditions almost in every region of Turkey are very large, cultivation areas have remained at the level of 500 000-600 000 hectars for many years. For this reason, it is necessary that support and incentives carried out should be increased in order to spread production in the potential areas after these areas are determined, yield should be increased, new species whose oil content is high should be developed, produced and spread. As a result, in order to enlarge cultivation areas of the sunflower, more areas, both dry and irrigated, should be opened to the sunflower agriculture through especially technical support and incentive of the government or the private sector.

Key words: Oilseeds, sunflower, cultivation

INTRODUCTION

The oilseeds which are among agricultural products can be counted as sunflower, cotton seed, soybean, rapeseed, safflower, groundnut, sesame and poppy (seed). However, the sunflower whose seed nearly %38-50 oil is obtained from among oil plants has considerable significance in the production and consumption of vegetable oil in Turkey.

The sunflower that is our traditional plant is the first thing that comes to mind in terms of oilseeds in Turkey. The sunflower which can be cultivated nearly in every region of Turkey and whose seeds include high rates of qualified oil is placed on the top in terms of cultivation areas of oil plants and amount of production. The sunflower meets the need of %68 of the production of oil plant in our country and %32 of the total use of oil (BYSD 2016).

In parallel to the rapidly increasing population in the world, the consumption of food stuffs and thus the consumption of vegetable oil is increasing day by day. In 2015, 527 million tonnes of oilseeds were produced in the world, and %7,6 of this consisted of the sunflower (USDA 2016). In Turkey, however, 3,2 million tonnes of oilseeds were produced in 2015, and %46 of this consisted of the sunflower. Our production of sunflower (for oil) which was 1 million tonnes in 2006 reached 1,5 million tones in 2015 with an increase by %50 in ten years (TUIK 2016). It can be said that this increase resulted from the increase in yield rather than cultivation areas. %50 of the production under discussion is made in Thrace-Marmara Region.

THE PRODUCTION OF SUNFLOWER IN TURKEY

Although adaptation areas of the sunflower that can be cultivated in dry or irrigated conditions almost in every region of our country are very large, cultivation areas have remained at the level of 500 000-600 000 hectars for many years.

There has not been much change in cultivation areas of sunflower (for oil) in Turkey for the last ten years. On the other hand, the amount of its production has increased from 1 million to 1,5 million owing to the increase in yield. 1,5 million tones of oil sunflower seeds were produced in the area of 569 000 ha in the season of 2015. The seed yield of the sunflower increased from 198 kg/da to 264 kg/da between 206 and 2015 (Table 1).

Table 1. Area, Production and Yield of Sunflower for Oil in Turkey

Years	**Area (ha)**	**Production (tons)**	**Yield (kg/da)**
2006	510.000	1.010.000	198
2007	485.700	770.000	159
2008	510.000	900.387	177
2009	515.000	960.300	186
2010	551.400	1.170.000	212
2011	556.000	1.170.000	210
2012	504.616	1.200.000	238
2013	520.260	1.380.000	265
2014	552.465	1.480.000	268
2015	568.995	1.500.000	264

TUIK 2016

Nearly %50 of the production of sunflower for oil (754 000 tonnes) in Turkey is made in Thrace-Marmara Region. Tekirdag, Edirne, Konya, Kirklareli ve Adana cities are respectively those in which the production of sunflower is mostly made (TUIK 2016). Thrace Region is followed by Central Anatolia Region. In terms of not yield per unit area but the length of cultivation aras, Tekirdag is on the first rank in Turkey (Table 2). In this region, the sunflower is cultivated in dry conditions. On the other hand, the city that has the highest yield is Konya (457 kg/da). This difference of yield per decares results from irrigated farming in Konya region.

Table 2. Area, Production and Yield of Sunflower in Turkey Cities in 2015

Cities	Area (da)	Production (tons)	Yield (kg/da)	Percentage (%)
Tekirdag	1.284.677	267.012	208	17,8
Edirne	984.061	226.573	230	15,1
Konya	460.376	210.307	457	14,0
Kirklareli	733.520	188.998	258	12,6
Adana	440.400	134.361	305	8,9
Corum	198.952	51.984	261	3,5
Aksaray	106.351	43.985	414	2,9
Tokat	134.962	41.593	308	2,8
Other Cities	1.346.651	335.187	-	22,4
Turkey	**5.689.950**	**1.500.000**	**264**	**100**

TUIK 2016

IMPROVEMENT OF PRODUCTION OF SUNFLOWER IN TURKEY

There are two basic ways that need to be followed in order to increase the production of sunflower. The first one is to increase its cultivation areas, and the second one is to increase yield. Certainly, carrying out both of these at the same time will be a more effective and quick way of increasing the production. Yet in real terms, the biggest potential in increasing the production of sunflower can be achieved first of all with the increase of cultivation areas and extending of sunflower agriculture in irrigable areas. Thus, increasing cultivation areas and other matters should be handled separately.

Adding New Areas to Sunflower Agriculture

The sunflower agriculture is carried out commonly in Thracian Region in Turkey. But the sunflower yield of the region is under the general average in Turkey. Significant attempts must be made in order to increase yield in this region. On the other side, it is observed that cultivation areas of the sunflower have remained constant for long years and that the production has increased due to high yield. The reason that the production costs of the sunflower are kept lower than those in the world in order to increase its cultivation areas and that it can compete with the products in areas where it is cultivated is very important and effective. Thus, projects that aim to expand its cultivation areas need to be put into effect. After the sunflower finds new cultivation areas for irrigation in the areas in the regions of especially GAP (Southeastern Anatolia Project) and KOP (Konya Plain Project), the total cultivation areas will increase, and its yield will also increase. Moreover, the cultivation of the sunflower has been common in Mediterranean Region in recent years. In this region, the sunflower is cultivated in February-March, and it is harvested in July. The fact that it is harvested early is very important for oil factories that are inactive especially in that period in terms of meeting their needs. Also, since it is the first sunflower of the production season (early grown), its prices are usually high (Kolsarici et al. 2015).

Irrigation Opportunities in Dry Cultivated Area

Considerable decreases in the proportion of yield and oil of the production of sunflower could be seen in dry years in Turkey. For instance, drought in 2014 in Thracian Region caused yield and oil content of sunflower to decrease, and thus it decreased the total production of vegetable oil in Turkey. For this reason, investments in irrigation should be increased, the sunflower agriculture should be encouraged in irrigable areas, and areas (arid and semi-arid areas) where annual rainfall is under 500-600 mm should be irrigated et least once or twice flowering priod (Baydar 2011). Especially in Thracian Region where the sunflower agriculture is carried out, irrigation should be made with appropriate methods, and drip irrigation should be focused on. If the aim in our country where an irrigation area of 5,9 million ha is elevated to that of 8,5 million ha and if the sunflower agriculture is carried out in new areas being opened to irrigation, increases in yield will be observed to climb to %100 and this increase will contribute considerably to our production of vegetable oil.

Use of Species Resistant to Diseases and Pests

Orobanche (*Orobanche cumana* Wallr.) is a parasitic plant which leads to a decrease of %100 proportion in yield of the sunflower in our, European and Balkan countries (Kaya 2013). On the other hand, another problem is concerned with broad leaves weeds that can not be controlled with herbicides before sowing. After sunflower hybrids that are resistant to IMI (Imidazolinone) due to CLEARFIELD applications have emerged, it is now quite easy to control, through herbicides for weeds, both orobanş and weeds that pose serious problems in the production of sunflower (Anonim 2013). Therefore, the use of species that are developed for that purpose should be extended in all of the areas where sunflower agriculture is carried out.

Encouraging Oleic Type Species of Sunflower

Breeding of the native seed and its production should be accelerated and supported by the government. Also, new species of sunflower (High oleic) which includes high proportions of oleic acids (omega-3) should be developed. This is because prospering the level of welfare and self-awareness of nutrition canalize the society into preferring healthy oils that are of good quality. Research has shown that oleic acid as unsaturated fatty acid diminishes the risk of hypertension and provides protection against heart and coronary diseases by balancing cholesterol (Karacor and Cam 2015). Also, oils being obtained from oleic type sunflower can be used more than once (twice-eight times) in hotels, restaurants and catering firms, and this can lead a great deal of saving (Kolsarici et al. 2015). Only through such a measure, a notable stability or decrease in our need of vegetable oil that is met with importing could be supplied.

Improving Support

Support of sunflower for oil per kilogram increased from 0,20 to 0,30 liras in the last ten years of 2006-2015. For this reason, producers in Thracian- Marmara Region cultivate wheat for two years and sunflower for one year in crop rotation instead of wheat for one year and sunflower for one year as they are not satisfied with the support for sunflower, and this causes significant deviations in values of sowing and production. In order to prevent this, price parity of sunflower/wheat should be kept in 2.5-3.0 in favour of sunflower so that sunflower can compete with wheat (Kolsarici et al. 2015). In addition, input costs of producers should be decreased by increasing amounst of support for fuel and fertilizers.

CONCLUSION

It is observed that cultivation areas of sunflower have remained constant for years in Turkey and that production has increased with yield. Thus, projects that try to enlarge cultivation areas should be put into action. The potential cultivation area of sunflower in Turkey is 1 450 000 ha. However, nearly 600 000 ha out of this potential is made use of. If sunflower is cultivated in the area of 850 000 ha that is not used and its yield reaches average 170 kg/da, the annual production of sunflower will reach the value of 1 450 000 tones, and thus the gap of vegetable oil that is supplied with importing will be closed in Turkey (Anonim 2015). Investments in sunflower agriculture should be risen, agriculture of this plant should be focused on, and areas (arid and semi-arid areas) where annual rainfall is under 500-600 mm should be irrigated at least once or twice in flowering period, Moreover, species which are resistant to diseases and pests, whose seed yield and oil content are high, and which have oil content of good quality should be devloped, produced, and their consumption should be made more widespread.

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CONFECTIONARY SUNFLOWER IN IRAN

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ABSTRACT

Cultivation area of confectionary sunflower has been increased to about 50,000 ha in Iran recently. The main production area is located in Khoy, West Azerbaijan with more than 20,000 ha average yielding 1500 Kg/ha. Kermanshah, Qazvin, Zanjan and Hamadan providences are followed by Khoy as the other main areas for cultivation of this crop. Regardless of having more than a century of cultivation history, there is no report for improvement of this crop and, farmers use only self provided seed annually. This condition has resulted in lower seed yield and also increase of the crop main destructive diseases such as Sclerotinia, Rust and Downey mildew. Moreover, due to open pollination nature of the plant, undesirable characteristics including heterogeneity, late maturity, higher plant height and lower seed set are still observed in the local land races. Despite these deficiencies, there is a wide genetic diversity which could be used as main sources for improvement of confectionary sunflowers. There are four main types of land races with different characteristics and different economic demand in local market. Development of genetic materials is a necessity for improvement of confectionary sunflower in Iran and international collaboration with reciprocal profit could accelerate this procedure.

Key Words : Confectionary sunflower, Disease, Land races, protein content

RELATIONSHIPS BETWEEN GERMINATION AND VIGOR TESTS WITH FIELD EMERGENCE OF SUNFLOWER IN IRAN

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ABSTRACT

In order to estimate the seedling emergence of sunflower cultivars, this research was conducted in both laboratory and field. The treatments were four sunflower cultivars (Record, Euroflor, Hysun and Azarghol) and three levels of seed germination(below standard or 80%, standard or 80% and above standard or 90%).The results indicated that increase of seeds germination in standard germination test caused the increase of normal seedlings percent and also the seedling weight and length vigor indices. Record cultivar and With high germination percent had a significant difference with other cultivars in most measured traits in laboratory and the reason is probably their genetic structure and less seed deterioration of these cultivars. The final seedling emergence at field was correlated with seedling weight and length vigor indices at laboratory. The normal seedlings number (germination percent) in standard germination test was correlated with final field emergence of seedlings. Therefore, by calculation the normal seedlings percent, we can predict the seed's potential for seedling production and establishment at field.

Key words: Germination, seed vigor, sunflower.

INTRODUCTION

The planting of high quality seed is an important factor of successful agriculture due to rapid and uniform seedling emergence and also higher establishment and achieving proper plant density which results in higher yield (TeKrony and Egli, 1993). The influence of seed vigor on seedling field emergence and establishment was assessed and specified that seed vigor affects the seedling field establishment, seedling emergence rate and it's uniformity which all of these factors, potentially can influence the accumulation of dry matter in plant population and therefore the yield (Heydecker, 1977).

The germination test determines the germination ability of seeds in a seed lot which it's results can be used for comparison of different seed lots quality and also estimation of required seed rate for planting (Anonymus, 2011). The study of germination test of 94 soybean's seed lots in laboratory and the results of seedling field emergence of same seed lots indicated that low germination caused the low seedling emergence and percent at a field (Delouche and Baskin, 1973). This research was conducted in order to estimate the seedling emergence of sunflowers cultivars with germination test.

MATERIALS AND METHODS:

In order to evaluation the correlation of seed germination with seed seedling field emergence of sunflower cultivars, a research was conducted in both laboratory and field in 2012. The treatments were four sunflower cultivars including Record, Euroflore, Hysun and Azarghol with three levels of seed germination as standard seed germination (85%) , above standard (the highest germination percent of each cultivar) and below standard level (80%) which were produced in 2011. The study was conducted as a factorial experiment based on completely randomized design for laboratory tests and as a factorial experiment with 2 factors based on randomized complete block design with 3 replications for field tests. The standard germination test was conducted according to rules of the international seed testing association (ISTA) (Delouche and Baskin, 1973). Two indices including seedling length vigor index and seedling weight vigor index were also were determined by Abdol-baki and Anderson approach (Abdul-Baki and Anderson, 1973). In order to estimate seedling field emergence percent and related traits; the seeds were sown and evaluated in experimental field of seed and plant certification and registration institute. The seedling field mergence index was determined by approach of Ram *et al*., 1998. The resulted data were analyzed by MSTAT-C software and the mean comparison was done by Duncan multiple range test. The correlation of measured traits was calculated by SPSS software and the charts were drawn by Excel software.

RESULTS:

The analysis of variance results of the standard germination test (table 1) indicated that the interaction of cultivar× germination ability was highly significant in all the traits. The normal seedlings from seeds of Record cultivar with 90 percent had the highest normal seedlings of 79%. However the lowest normal seedlings of 31 percent obtained from seeds of Record and Uroflor with 80 percent germination ability.

Table 1- The analysis of variance (mean squares) of studied traits at standard germination test.

S.O.V	df	Normal seedlings percent	Abnormal seedlings percent	Final germination percent	Seedling length vigor index	Seedling weight vigor index
Cultivar	3	1102.69**	835.657**	84.889**	634535.16**	100.416**
Germination	2	2692**	708.861**	10.33ns	361738.17**	761.967**
Cultivar × Germination	6	346.66**	158.713**	57.889**	81488.10*	56.54**
Error	24	9.361	10861	12.222	11526.19	9.124
Coefficient of variation) %(		5.49	13.62	3.76	12.6	12.96

ns,* and ** , respectively are non significant and significant at 1% and 5% level of probability

The maximum number of normal seedlings was obtained from seeds with 90 percent germination and the lowest was recorded in seeds with 80 percent germination (table 3). The highest abnormal seedlings of 49 percent observed from seeds of Hysun with 80 percent germination. The seeds of Record with 90 percent germination ability had the lowest abnormal seedlings percent of 8% (table 3). The maximum final germination percent (98%) belonged to seeds of Hysun with 80 percent germination ability. the lowest percent of final germination of 83 percent was recorded for Urofor with 90 percent of germination (table 3). The highest seedling length vigor index of 1220.200 was obtained from Azargol with 85 germination percent and the lowest was 374.800 from seeds of Hysun with 80 percent germination (table 3). The seeds of Record cultivar with 90 percent germination indicated the highest seedling weight vigor index of

34.6 and the lowest amount of 10.9 was observed in seeds of Uroflor with 80 percent of germination (table 3).

Table 2- The analysis of variance (mean squares) of studied traits at field.

S.O.V	df	seedling vigor index	Seedling emergence index	Final seedling emergence
Block	2	360.821 ns	22.886 ns	181.963ns
Cultivar	3	623.215 **	2.861 ns	16.671ns
Germination	2	968.160 **	26.258 ns	41.790 ns
Cultivar × germination	6	246.281**	7.265 ns	64.744 ns
Error	22	2436.838	9.278	74.162
Coefficient of variation(%)		15.37	11.59	11.40

ns,* and ** , respectively are non significant and significant at 1% and 5% level of probability

Table 3- The mean comparison of studied traits at standard germination test.

Cultivar	Germination (%)	Seedling weight vigor index	Seedling length vigor index	Final germination percent	Abnormal seedlings number	Normal seedlings number
Azargol	80	21.4de	1172.53ab	90cd	14d	63de
	85	26.7cd	1220.20a	94abc	22c	67cd
	90	28.8bc	1150.53ab	98ab	16d	70bc
Record	80	13.5fg	558ef	93abc	35b	31h
	85	30.9abc	1000.73bc	87de	18cd	72b
	90	34.6a	865.06cd	95abc	8e	79a
Hysun	80	14.0fg	374.80f	98a	49a	31h
	85	16.7ef	499.14f	95abc	36b	39g
	90	26.6cd	726.53de	97a	30b	51f
Euroflor	80	10.9g	531.86f	94abc	33b	31h
	85	22.5d	886.66cd	91bcd	15d	61e
	90	33.2ab	1211.20a	83e	15d	73b

The results of field's variance analysis (table 2) specified that the interaction of cultivar×germination ability was highly significant for all of the measured traits except of final seedling emergence and seedling emergence index. The highest seedling vigor index at field was 501.4 that observed at seeds of Record with germination ability of 80 percent and the lowest seedling vigor index at field recorded 163.6 at seeds of Azarghol with 80 percent germination (Table 4).

Table 4- The mean comparison of interaction of measured traits at standard germination test

cultivar	germination	Azargol	Record	Hysun	Euroflro
Vigor index	80	163.6e	501.4a	434.8a	343.9cd
	85	279.5d	293.2d	401.3bc	282.3d
	90	332.6cd	264.8d	262.6d	295d

The final field seedling emergence had high positive correlation with seedling weight vigor and seedling length vigor indices. The seedling vigor index at field showed positive and high significant correlation with seedling length vigor index and normal seedlings percent (table 5).

Table 5-The correlation of seedling emergence and seed vigor assessment at standard germination test.

	1	2	3	4	5	6	7	8
1.final seedling emergence	1							
2.seedling emergence index	0.82**	1						
3 .seedling field vigor index	0.126	0.136	1					
4.normal seedling	0.105	0.253	0.64**	1				
5.abnormal seedling	-0.005	-0.116	0.64**	-0.88**	1			
6.final germination	0.229	-0.208	0.232	-0.370*	0.416*	1		
7.seedling length vigor index	0.387*	0.382*	0.95**	-0.55**	0.610**	0.299	1	
8..seedling weight vigor index	0.52**	0.62**	0.178	0.032	0.194	0.21	0.382*	1

* and ** , respectively are significant at 1% and 5% level of probability

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GREEN AND BROWN BRIDGES AID SURVIVAL OF MULTIPLE DIAPORTHE/PHOMOPSIS SPECIES WITH A RANGE OF VIRULENCES ON SUNFLOWER, SOYBEANS, MUNGBEANS AND OTHER CROPS IN AUSTRALIA

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ABSTRACT

Multiple species of *Diaporthe/Phomopsis*, some well recognised, others new and undescribed have been identified from live sunflower, sunflower residues, other live crops plus crop and weed residues in the eastern Australian summer cropping regions. Pathogenicity tests have revealed that many of these species are virulent on other crops such as soybean, chickpeas and mungbeans. Some crops are susceptible to multiple species and other species are pathogenic on a range of hosts. In Australia, after thirty years of zero and minimum tillage practices where crop and weed residues are left on the surface in an effort to retain moisture, a significant inoculum reservior of many *Diaporthe/Phomopsis* species is present in the cropping system regardless of the presence of a favoured crop host. Although green bridges are well recognised in aiding surivival of many pathogens, the role of dead weeds left standing after herbicide applications, then acting along with crop stubble as a brown bridge, has largely gone unstudied. It is considered likely that other cropping systems worldwide would also be harbouring reservoirs of diverse pathogenic *Diaporthe/Phomopsis* species in the green and brown 'non-hosts' bridges associated with their individual cropping systems. Additionally, there is evidence that reservoirs of other pathogens and opportunitistic colonisers such as *Fusarium* and *Colletotricum* species are also surviving in the 'non-host' residues.

Key Words : Sunflower, Diaporthe, Phomopsis, pathogenicity, soybeans, mungbeans, green bridge, brown bridge, survival, weeds

PULSAR® PLUS AND EUROLIGHTNING® PLUS - HERBICIDES FOR ENHANCED WEED CONTROL IN CLEARFIELD® PLUS SUNFLOWER

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ABSTRACT

The Clearfield Sunflower Production System was introduced first in 2003 in Turkey and in the following years in the other key sunflower countries in Europe. The system combines high yielding sunflower hybrids with effective post-emergence herbicides such as Pulsar 40 or Eurolightning. Since the introduction, growers benefit from the possibility to control main broadleaf and grass weeds relying on the respective herbicide solutions. Starting from 2015 onwards, BASF and several seed partners started to introduce the so-called Clearfield Plus Sunflower Production System. Within that system, a new class of hybrids carrying the CLHA-Plus gene are combined with highly effective and reliable herbicide solutions such as Pulsar Plus and Eurolightning Plus. These herbicides, which have been developed especially for the use within the Clearfield Plus Production System, have been tested in field and laboratory trials starting from 2009 onwards showing robust performance. Laboratory tests proved, that the retention as well as the plant uptake of theses herbicides is enhanced compared to current market standards. In field trials, the herbicides provided a higher level of efficacy and reliability, an improved application timing flexibility and in combination with Clearfield Plus hybrids, an improved selectivity pattern compared to the available market solutions. With that, the growers can further improve the weed control in the crop, being the basis to use the full yield potentials of the modern sunflower hybrids.

Key Words : herbicide tolerance, sunflower, efficacy, formulations, weed control

CHEMICAL BROOMRAPE (*OROBANCHE CUMANA*) CONTROL IN CLEARFIELD® SUNFLOWER WITH DIFFERENT IMAZAMOX CONTAINING HERBICIDE FORMULATIONS

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Broomrape (*Orobanche cumana* Wallr.) in sunflower is one of the most important constraints in sunflower production in Europe. In the last twelve years, the chemical control option with the Clearfield Sunflower Production System in sunflower and the relevant Clearfield herbicides has been an important control strategy and complemented the genetic resistance against *broomrape.* The commercial formulation Pulsar® (Imazamox 40 g/l) exhibits besides broad-spectrum weed and grass control a unique efficacy on broomrape in sunflower. Season long broomrape control is, not at least, depending on a lethal concentration of Imazamox in the host plant over the time broomrape is attacking sunflower. The uptake of Imazamox and therewith the herbicidal concentration in sunflower is strongly influenced by the herbicide formulation. Between 2012 and 2015, field trials were conducted at locations in Bulgaria, Hungary, Romania and Spain to evaluate and compare the broomrape efficacy of Pulsar Plus, a new improved formulation, for the recently introduced Clearfield Plus tolerance. The Pulsar Plus formulation was evaluated at 30, 40 and 50 g ai/ha and compared to Pulsar, at the same rates. Pulsar Plus outperformed Pulsar in *O. cumana* control and sunflower yield.

Key Words : Broomrape, Clearfield, Clearfield Plus, Dose-response, Helianthus annus, Imazamox, Orobanche cumana

THE EFFECT OF CLIMATE FACTORS ON THE YIELD OF SUNFLOWER AND SUNFLOWER YIELD PREDICTIONS BASED ON CLIMATE CHANGE PROJECTIONS: EXAMPLE OF MARMARA REGION

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ABSTRACT

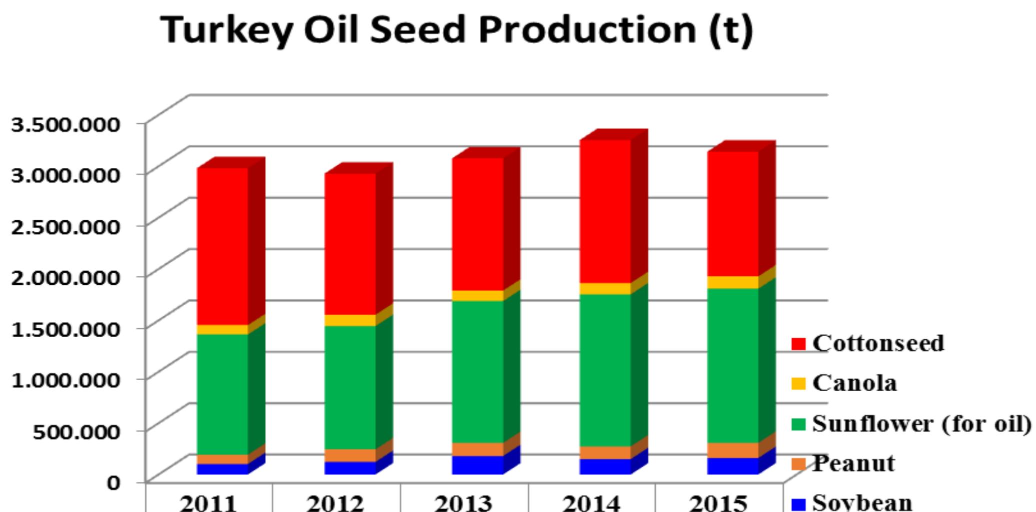
Sunflower is the raw material of vegetable oils sector in Turkey. Production is not sufficient even for domestic consumption. Therefore, it is necessary to carry out the projects to increase the yield and production areas. This study was carried out in order to identify the relationship between yield of sunflower and climate factors, also to determine the possible effects of the future climate changes on the sunflower yield. In the study, 10 provinces in Marmara region were evaluated. The following materials were used for this study; sunflower production values and meteorological data for the years of 1985-2014, climate projections that are based on HadGEM2-ES Global Climate Model with 20 km resolution, and RCP8.5 scenario that covers the period of 2016-2099. Climate parameters used in this study are number of days that minimum temperature below -5°C, monthly average temperature, number of days that maximum temperature above 35°C, monthly average relative humidity, number of days that average relative humidity above % 70, monthly total sunshine duration, monthly total precipitation. Firstly; single and multiple correlation analyses, the least-squares method with linear regression analyses were conducted between observation values and production data. Then, the potential impact of climate changes, that are projected for the future periods (2016-2040, 2041-2070 and 2071-2099), on yield of sunflower have been put forward with by using the generated high-rate regression equations and climate projection data. According to the results, it was determined that there is an important characteristic effect of climate factors on productivity With reference to the yield prediction analyses, Marmara region will be negatively affected.

Key Words: The yield of sunflower, climate factors, HadGEM2-ES, RCP8.5, the effects of climate change

INTRODUCTION

There are three main groups in human nutrition. These are oils, proteins and carbohydrates. Oils are an important source of calories in the human diet (Hatırlı et al., 2002). Oil seeds are raw material for the vegetable oil industry at the same time also are the raw material of many different sectors. Oilseed meals having relatively high protein content are preferred in animal nutrition (İlkdoğan, 2008). Vegetable oils that are used in food, energy and chemical industries sectors are strategic products (Taşkaya Top and Uçum, 2012).

According to the Association of Vegetable Oil Industries (AVOI) report 2014; while sunflower takes the fourth place after soybean, canola and cottonseed in the world oilseed production, it takes the first place in Turkey (AVOI, 2015). The most intensive sunflower farming region is Marmara region in Turkey.



	2011	2012	2013	2014	2015
Cottonseed	1.527.36	1.373.44	1.287.00	1.391.20	1.213.60
Canola	91.239	110.000	102.000	110.000	120.000
Sunflower (for oil)	1.170.00	1.200.00	1.380.00	1.480.00	1.500.00
Peanut	90.416	122.780	128.265	123.600	147.537
Soybean	102.260	122.114	180.000	150.000	161.000

Figure 19: Turkey oil seed production (tons)

According to the Turkey Statistical Institute (TSI) reports in 2014, the top five most produced oil seed plants are in the order of sunflower, cottonseed, soybean, peanuts and canola (TSI, 2015). The production of 2.7 million tons from these top five plants in 2010 increased by 19% with a production of 3.25 million tons in 2014. In 2010-2014 periods, the sunflower (for oil) production growth rate is approximately realized as % 26.4. In the same period, the rate of increase in sunflower production of the world is approximately 20.3 %. According to the data from USDA published by AVOI, world crude vegetable oil production is around 176 million tones. Crude sunflower oil production in the years 2010-2014 has increased to 15 million tons from 12 million tons (AVOI, 2015).

Table 1: Turkey sunflower oil production data (TSI, 2016)

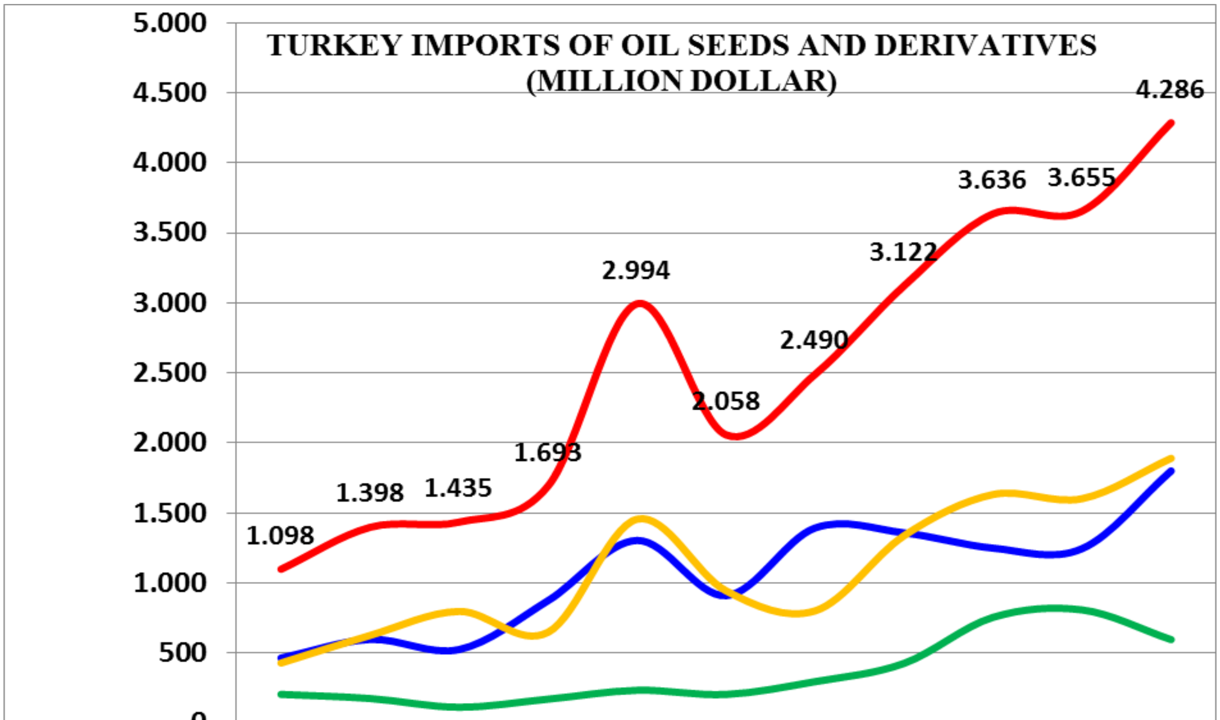
Year	Area(da)	Product(t)	Yield(kg/da)
2006	5,100,000	1,010,000	198
2007	4,857,000	770,000	159
2008	5,100,000	900,387	177
2009	5,150,000	960,300	186
2010	5,514,000	1,170,000	212
2011	5,560,000	1,170,000	210
2012	5,046,160	1,200,000	238
2013	5,202,600	1,380,000	265
2014	5,524,651	1,480,000	269
2015	5,689,013	1,500,000	264

During the last decade of sunflower cultivation (2006-2015), an increase of approximately 12% in the harvested areas, % 48.5 in the amount of production and 33% in the yield has been achieved. Turkey continuously increases the supply for increased consumption of crude vegetable oil production but it is not enough to cover domestic demand. The most important raw material in crude oil production industry has been provided from the production of sunflower oil in Turkey. But a serious vulnerability exists due to domestic consumption and exports vegetable oil in our country. Therefore, every year, vegetable oil imports are made.

Table 2: Crude sunflower oil balance of supply-demand for the season 2015/2016

Sunflower oil production from the domestic harvest	**430 thousand tons**
Sunflower oil consumption in Turkey	900 thousand tons
Turkey sunflower oil exports	500 thousand tons
Total sunflower oil demand	1,400 thousand tons
Deficient of based on sunflower	970 thousand tons

According to the Trakya Birlik sources, we have a deficient of approximately 970 thousand tons of sunflower oil on an annual basis (Tekçe, 2015). The main strategy of our country is to produce demanded oily seeds and to become a self-sufficient state by reducing imports as much as possible (Kolsarıcı et al, 2015).



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Oil seed	464	597	525	874	1.304	910	1.393	1.358	1.249	1.245	1.800
Crude oil	429	626	797	648	1.456	944	801	1.338	1.632	1.602	1.890
Oil cake	205	175	113	171	234	204	296	426	755	808	596
TOTAL	1.098	1.398	1.435	1.693	2.994	2.058	2.490	3.122	3.636	3.655	4.286

Figure 20: Turkey imports of oil seeds and derivatives (million dollar)

According to the Association of Vegetable Oil Industries report; imports of oilseeds and their derivatives were 4,286 million dollars in 2014. Due to increasing demand, the rate of imports has been increasing every year.

Sunflower (*Helianthus annus* L.) has a large natural habitat in various parts of our country. At sunflower cultivation (for oil) dry farming is applied extensively in our country. In regions where irrigation opportunities are available, a significant increase in yield can be achieved. Sunflower can grow in all geographies and adapt to different climatic conditions, however it also can be affected by changing climate conditions. Today, especially last quarter of the 20th century, climate change has become an important problem worldwide. The rising in global mean temperatures since 1850s is the most important indicator of climate change.

According to the World Meteorological Organization (WMO) resource; the global average surface temperature in 2015 broke all previous records by a strikingly wide margin, at 0.76±0.1° Celsius above the 1961-1990 average. Fifteen of the 16 hottest years on record have all been this century, with 2015 being significantly warmer than the record-level temperatures seen in 2014. Underlining the long-term trend, 2011-15 is the warmest five-year period on record. The record temperatures over both land and the ocean surface in 2015 were accompanied by many extreme weather events such as heatwaves, flooding and severe drought (WMO, 2016).

According to "State Of The Climate in Turkey in 2015" report; Turkey annual mean temperature in 2015 has been 14.3°C. This value is 0.8°C above from 1981-2010 normal (13.5°C). This makes 2015 the fifth warmest year since 1971 (TSMS, 2016).

TSMS published as a report which name is "Climate Projections with New Scenarios for Turkey and Climate Change (TR2015-CC)" in 2015. This report includes temperature and precipitation projections of three Global Climate Models (GCM) based on scenarios of RCP4.5 and RCP8.5.

In this study, the results of HadGEM2-ES, which is one of the three GCMs mentioned above, will be shared. HadGEM2-ES projections based on scenarios of RCP8.5 shows that;

- Average temperature of overall Turkey is expected to increase between 0.9-7.1°C and an average of 3.6 °C in the period of 2016-2099.
- Positive anomalies are expected at the amount of precipitation based on RCP8.5 by the end of 2035 but it is also estimated that decreases may occur in subsequent periods (Akçakaya et all., 2015).

This study was carried out in order to determine the possible effects of the future climate changes on the sunflower yield.

MATERIAL and METHODS

Material

Sunflower Production Data

10 provinces, with intensive production of sunflower in the Marmara region, were evaluated (TSI, 2015). Evaluated 10 provinces are: Balıkesir, Bilecik, Bursa, Çanakkale, Edirne, İstanbul, Kırklareli, Kocaeli, Sakarya ve Tekirdağ. In order to confirm the relationship between climate factors and the yield the period of 1985-2014 (30 years) have been analyzed.

The Meteorological Parameters

Climate, sometimes understood as the "average weather," is defined as the measurement of the mean and variability of relevant quantities of certain variables (such as temperature, precipitation or wind) over a period of time, ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). Therefore, 30 years of meteorological parameters are preferred in order to determine relationship between crop yield and meteorological parameters. In the study, the parameters that are thought to have an effect on the yield of sunflower were selected. The data of selected meteorological parameters were obtained from TSMS. In order to determine the relationship between yield – climatic factors;

- The number of days daily minimum temperature < -5 ° C,
- Monthly Average Temperature (° C)
- The number of days daily maximum temperature > 35 ° C,
- Monthly average relative humidity (%)
- The number of days daily average relative humidity > %70,
- Monthly Total Sunshine Duration (hour)
- Monthly Total Precipitation (mm) parameters are preferred.

Projection Data of HadGEM2-ES Global Climate Model

Climate modeling is the most important work for predicting the future climate (Demircan et all., 2014). Nowadays climate modeling studies are performed in order to determine the possible effect of climate change in future periods. Turkey is located in the eastern Mediterranean basin, one of the most vulnerable regions to climate change as stated in the IPCC report (Gürkan H. et all., 2015). In Turkey, climate modeling studies have been conducted within TSMS and the final results have been shared in 2015.

HadGEM2-ES GCM projection data based on RCP8.5 for the chosen meteorological parameters' has been published as a report titled "Climate Projections with New Scenarios for Turkey and Climate Change". In this study, these projection data is used.

According to sources at TSMS; HadGEM2-ES is the second generation Global Climate Model which is developed by the Hadley Centre that is related with UK Meteorological Service-Met Office (TSMS 2013).

Methods

Correlation Analysis

In the first section of study, the relationship between meteorological parameters that occurred between the years 1985-2014 and the sunflower yield values between these years were determined by the method of multiple correlation analysis.

r: Correlation Coefficient
X: Independence Variable
Y: Dependence Variable

$$R_{Y.X_1X_2} = \sqrt{\frac{r^2_{YX_1} + r^2_{YX_2} - 2r_{YX_1}.r_{YX_2}.r_{X_1X_2}}{1 - r^2_{X_1X_2}}}$$

Regression Analysis

In the second part of the study, first of all, provinces based regression equations were established using selected seven climate parameters and sunflower yield values between the years 1985-2014 with the method of least squares (LSM) for 10 provinces. Secondly, the potential impact of climate changes that are projected for the future periods (2016-2040, 2041-

2070 and 2071-2099), on yield of sunflower have been put forward with using the generated high-rate regression equations and climate projection data.

In the study, analysis of the regression equation generated by LSM as follows:

y = As + Bp+Ch+Dk+Et+Fm+Gv+H

Dependence Variable;
y = Yield

Independence Variables;
s = Monthly Total Sunshine Duration (hour)
p = Monthly Total Precipitation (mm)
h = Monthly average relative humidity (%)
k = The number of days daily average relative humidity > %70
t = Monthly Average Temperature (° C)
m = The number of days daily maximum temperature > 35 ° C
v = The number of days daily minimum temperature < -5 ° C

A, B, C, D, E, F, G, H = Coefficients

The coefficients of the linear multiple regression equation generated on a provincial basis obtained by solving the following matrix formed by the method of least squares.

$Z*X = W$
$Z^{-1}*W = X$ X matrix: Coefficients

Table 3: Parameter matrix used in the least squares method

Z matrix									W matrix		X matrix
$\sum s_i^2$	$\sum p_i s_i$	$\sum h_i s_i$	$\sum k_i s_i$	$\sum t_i s_i$	$\sum m_i s_i$	$\sum v_i s_i$	$\sum s_i$		$\sum s_i$		A
$\sum s_i p_i$	$\sum p_i^2$	$\sum h_i p_i$	$\sum k_i p_i$	$\sum t_i p_i$	$\sum m_i p_i$	$\sum v_i p_i$	$\sum p_i$		$\sum p_i$		B
$\sum s_i h_i$	$\sum p_i h_i$	$\sum h_i^2$	$\sum k_i h_i$	$\sum t_i h_i$	$\sum m_i h_i$	$\sum v_i h_i$	$\sum h_i$		$\sum h_i$		C
$\sum s_i k_i$	$\sum p_i k_i$	$\sum h_i k_i$	$\sum k_i^2$	$\sum t_i k_i$	$\sum m_i k_i$	$\sum v_i k_i$	$\sum k_i$		$\sum k_i$		D
$\sum s_i t_i$	$\sum p_i t_i$	$\sum h_i t_i$	$\sum k_i t_i$	$\sum t_i^2$	$\sum m_i t_i$	$\sum v_i t_i$	$\sum t_i$		$\sum t_i$		E
$\sum s_i m_i$	$\sum p_i m_i$	$\sum h_i m_i$	$\sum k_i m_i$	$\sum t_i m_i$	$\sum m_i^2$	$\sum v_i m_i$	$\sum m_i$		$\sum m_i$		F
$\sum s_i v_i$	$\sum p_i v_i$	$\sum h_i v_i$	$\sum k_i v_i$	$\sum t_i v_i$	$\sum m_i v_i$	$\sum v_i^2$	$\sum v_i$		$\sum v_i$		G
$\sum s_i$	$\sum p_i$	$\sum h_i$	$\sum k_i$	$\sum t_i$	$\sum m_i$	$\sum v_i$	n*		$\sum v_i$		H

*****Number of the years

RESULTS AND DISCUSSION

In the first part of the research, multiple correlation analyses were conducted between the yield and meteorological parameters, due to the effect of meteorological parameters on yield as a whole. According to the results of multiple correlation analysis; the highest correlation between yield - meteorological parameters in Bilecik (0.62) and the lowest correlation have been identified in the province of Sakarya (0.36).

In the second part, it is aimed to assess the quality of the relationship between variables with using the method of regression analysis. Regression analysis that were performed with LSM; the highest value in Kırklareli (0.80) and the lowest value is determined in Sakarya (0.60). This situation is an indicator that the relationship between yields - climate factors can be modeled and can be converted to the equation.

Table 4: Provincial-based multiple correlation and multiple regression analysis

Provinces	Multiple Correlation	Multiple Regression
Balıkesir	0.55	0.74
Bilecik	<u>0.62</u>	0.79
Bursa	0.49	0.70
Çanakkale	0.56	0.75
Edirne	0.55	0.74
İstanbul	0.39	0.62
Kırklareli	0.65	<u>0.80</u>
Kocaeli	0.38	0.62
Sakarya	<u>0.36</u>	<u>0.60</u>
Tekirdağ	0.51	0.65

In the last part of the research, the potential impact of climate changes, that are projected for the future periods (2016-2040, 2041-2070 and 2071-2099), on yield of sunflower have been put forward with by using the generated high-rate regression equations and climate projection data.

As climate projection data, HadGEM2-ES Global Climate Model data (20 km resolution) based on RCP8.5 were used which is belongs to named "Climate Projections with New Scenarios for Turkey and Climate Change" released by TSMS.

Table 5: Provincial based sunflower (for oil) yield predictions

SUNFLOWER (FOR OIL) YIELD PREDICTIONS				
Provinces	Yield of Reference Period (kg/da)	Yield Change in Future Periods (%)		
	1985-2014	2016-2040	2041-2070	2071-2099
Balıkesir	111	15	-5	-28
Bilecik	107	15	19	-41
Bursa	147	-24	-14	-23
Çanakkale	171	-22	-9	19
Edirne	170	26	55	85
İstanbul	171	53	32	-33
Kırklareli	164	0	6	26
Kocaeli	129	-16	-9	-7
Sakarya	136	-21	9	31
Tekirdağ	179	-26	-41	-51

CONCLUSION

There is a high correlation between climatic factors and yield. Due to lack of individual determining factor, single correlation analysis is not very meaningful between climatic factors-yield. Therefore, level of relationship between climate factors-yield can be determined in a healthy way with multiple correlation analysis (Bulut et all., 2016).

In Marmara region; According to the assessment results of the researched 10 provinces; the region is expected to be affected adversely by climate changes in the future periods. Correspondingly, a decrease in the average yield of sunflower is estimated in the future. Increase in the number of days daily maximum temperature > 35 ° C is estimated to have a negative effect on yield by adversely affecting the pollination period of plants.

According to compared results of the yield prediction analysis performed on a regular basis with average yield values of the period of 1985-2014;

- In the period 2016-2040; decrease in 5 provinces, increase in 4 provinces and there will be any change in 1 province,
- In the period 2041-2070; decrease in 5 provinces, increase in 5 provinces,
- In the period 2071-2099; decrease in 6 provinces and increase in 4 provinces expected.

The province of Edirne is expected to be positively affected by possible climate changes in the future periods. Besides, the province of Tekirdağ is expected to be negatively affected by possible climate changes in the future periods.

As a result, it has been revealed that climate factors although they are not the sole determining factor, have significant effects on yield of sunflower. According to the results of this analysis, it is concluded that particularly temperature and humidity parameters have serious impact on the yield of sunflower.

According to yield estimates that using HadGEM2-ES global climate model projections which is based on RCP8.5 scenario; sunflower farming regions will be affected by climate changes likely to occur in future periods.

The results of this research can be used as a substrate in studies to determine the relationship by taking all the factors affecting the yield of sunflower. Also the results of this research can be used in future product planning across the country or on a regional basis and in the determination of regions that can be encouraged.

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NEW SEED TREATMENT SOLUTIONS FOR PLASMOSPORA RESISTANCE MANAGEMENT IN SUNFLOWER

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ABSTRACT

Seed treatment products help to assure a good crop establishment and reduce primary systemic infections from soil born zoospores of *Plasmopara halstedii* which result in plant loss or stunted plants. Downy mildew fungi are considered as high risk pathogens in term of becoming resistant to fungicides and therefore special attention has to be paid to minimize risks using different control methods like resistant sunflower varieties, reducing disease risk via crop rotation sunflowers and using seed treatments. Currently there are molecules from the chemical classes of phenylamides and strobilurins used as seed treatment in sunflowers. As the pathogen and as well as the chemicals are known to be at high risk to develop resistance there is a need to find new chemicals with different mode of actions to maintain high level of downy mildew control under field conditions. Field trials were set up in a number of countries in Europe, LATAM and USA to evaluate the level of activity in randomized complete block small plot trials. While Mefenoxam good protection of the young plants against downy mildew in field where *P. halstedii* was sensitive to phenylamides, Mefenoxam did not provide sufficient control in fields where *P. halstedii* was resistant to phenylamides. Two new molecules, each one with a new mode of action, were tested in the field under conditions of either sensitive or resistance *P. halstedii* races. In both cases a significant higher level of control *P. halstedii* over Mefenoxam alone was observed in all geographies. A combination of the new mode of actions with resistant sunflower traits will provide the best level of *P. halstedii* control while ensuring a sustainable approach to *P. halstedii* resistance management.

Key Words : Plasmospara seed treatment resistance management

MODELING SUNFLOWER FUNGAL COMPLEX TO HELP DESIGN INTEGRATED PEST MANAGEMENT STRATEGIES

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ABSTRACT

Sunflower is submitted to several major pathogens. Modeling is a key tool to help design Integrated Pest Management strategies to control them. A new qualitative modelling approach is currently under progress using the IPSIM platform (Aubertot and Robin, 2013) for sunflower. It aims at predicting injury profiles on sunflower as a function of cropping practices, soil, weather, and the surroundings of the considered field. Based on a literature review and expert knowledge, hierarchical deterministic bayesian networks were developed. Independent datasets were used to assess their quality of prediction. This communication will present: i) a first draft of IPSIM-Sunflower; ii) the evaluation of its predictive quality; iii) examples of simulation to help design IPM strategies to control the disease; iv) a discussion on the limits and benefits of the approach, along with perspectives.

Key Words : *Helianthus annuus, Phoma macdonaldii, Phomopsis helianthi, Plasmopara halstedii, Sclerotinia sclerotiorum*, cultural control

APPROPRIATE NITROGEN (N) AND PHOSPHORUS (P) FERTILIZER REGIME FOR SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN THE HUMID TROPICS

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ABSTRACT

Application of fertilizer at the appropriate rate and time is very germane to sustainable production of crops. Two field trials were conducted on the Research Farm of the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Nigeria during the late cropping seasons (June – Nov.) of 2014 and 2015 to evaluate the agronomic performance of four recently released sunflower varieties (SAMSUN-1, SMASUN-2, SAMSUN-3 and SAMSUN-4) to three fertilizer regimes: Control, Split application of 30 kg N + 28 kg P_2O_5 at 3 week after sowing, WAS and at anthesis and Single application of 60 kg N and 56 kg P_2O_5 at 3WAS. The experiment was laid out in a randomized complete block design using a 3× 4 factorial arrangement and replicated three times. Data were collected on phenology, height at flowering (R5) and physiological maturity (R9), grain yield and yield attributes. Varietal effect was only significant in 2015 with SAMSUN-2 recording significantly (*P<0.05*) higher head weight than the other varieties. Application of N and P fertilizer either as split or single significantly (*P<0.05; F - test*) affected plant height at R5 and R9, 100 achene weight, achene weight per head and grain yield in both years. Single application resulted in significantly (*P<0.05*) higher grain yield in 2014 than the split and control and was on par with split, and superior to control in 2015. Therefore, single application of N and P fertilizers at 21 WAS is recommended for adoption in the humid tropics for the newly released four sunflower varieties.

Keywords: grain yield, nitrogen (N), phosphorus (P), regime, sunflower

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a major contributor to edible vegetable oil in the world market (Thavaprakash *et al.*, 2002). As at January, 2016, the total world area under sunflower was 24.7 m ha with an average yield of 1.67 tonnes per ha (NSA, 2016). The three leading world sunflower producers were Ukraine, Russia and European Union. However, sunflower grain yield had been static at 1.68 tonnes/ha between 2013/14 and

2014/15 and the area under sunflower cultivation also reduced by 6% during the same period (NSA 2016). The non-significant increase in grain yield despite the use of different inputs (improved seeds, inorganic and organic fertilizers e.t.c) could be partly attributed to inappropriate use of some of the inputs. Sunflower is not a common oilseed crop in the tropics even though it is a very rustic crop that can produce optimally under diverse agro-ecological conditions. Its production potential had however, been confirmed in the forest – savanna transition zone of the humid tropics (Olowe *et al.,* 2005a; Olowe and Adeyemo, 2009). Commercial fertilizers are usually used to boost the yield output of sunflower. According to Heffer (2013), the global application of fertilizers to oilseed crops was estimated at 19.0 Mt or 11.0% of the world consumption. The breakdown of this consumption stood at 7.3%, 14.7% and 19.8% of the world's total consumption of nitrogen, phosphorus and potassium fertilizers, respectively. However, it is very important that farmers apply the fertilizers at the appropriate rate and time in order to get the maximum output from the commodity being produced. The utilization of nutrients by sunflower varies depending on the stage of development of the crop. Sunflower utilizes the bulk of applied nitrogen from beginning of terminal bud appearance (R1 – R2) to end of anthesis (R6), phosphorus from emergence (VE) to R6 and potassium from R1 to ripening (Ustimenko-Bakumovski, 1980).

Research results have demonstrated increased productivity of sunflower through the application of mineral fertilizers that contain the major plant nutrients (nitrogen, phosphorus and potassium) in balanced quantities (Singh *et al.*, 1977; Noor-Mohammed and Ehdaie, 1979 and Ogunremi, 1984 and 1986; Nassim *et al.,* 2012a, 2012b) and organic fertilizers (Rasool *et al.*, 2013; Oshudiya *et al.*, 2014). The optimum rates of the major nutrients especially nitrogen vary across different ecological zones such as 90kg N/ha in the lowland areas of Nigeria (Ogunremi, 2000) and 60 kg N/ha in the derived savanna zone of Nigeria (Olowe *et al.*, 2005), 80 kg N/ha in India (Faisul-ur-aRasool *et el.*, 2013), 150 kg N/ha at Islamabad, Pakistan (Bakht *et al.*, 2010), and 180 kgN/ha at Faisalabad, Pakistan (Nasim *et al.,* 2012b). The application of different fertilizers (inorganic and organic) to sunflower either as single or split vary depending on agro-ecology and farming system being practiced. From literature, fertilizers have been applied to sunflower at planting (Zubriski and Zimmermann, 1974; Ogunremi, 1984), as basal application before planting (Bahl *et al.*, 1997), basal application of phosphorus and potassium and nitrogen at four weeks after sowing (Ogunremi, 2000), three weeks after planting to coincide with first weeding (Ogunremi, 1984 & 1986; Olowe *et al.,* 2005; Oshundiya *et al.,* 2014) or at advanced vegetative stages (Yousaf *et al.*, 1986). Earlier study on the appropriate timing of nitrogen and phosphorus fertilizers to sunflower in the forest – savanna zone revealed that single application at 21 days after sowing was optimal for local and two exotic varieties of sunflower. This study was carried out to evaluate the agronomic response of four newly released sunflower varieties (SAMSUN-1, SAMSUN-2, SAMSUN-3 and SAMSUN-4) by NASC (2013) to single and split application of nitrogen and phosphorus fertilizers in the forest-savanna transition zone of the humid tropics.

MATERIALS AND METHODS

Two field trials were carried out at the Institute of Food Security Environmental Resources and Agricultural Research (IFSERAR) Farm of the Federal University of Agriculture, Abeokuta (7^o 23´ N, 3^o 39´ E, altitude 139 m above sea level) in south western Nigeria on a loamy sand soil between June and November, 2014 and 2015. The soils belonged to the loamy sand textural class and were low in nitrogen, medium in phosphorus and potassium based on the rating of Anon (1989). The months of September and October were the two wettest months in both years. The coolest and hottest months were August (25.3 & 26.3^{o}C) and November (27.5 & 28.6^{o}C) in 2014 and 2015, respectively. Relative humidity was slightly above 70% during the wettest months (September and October) of both years, except 2015.

The trials were a 4 × 3 factorial arrangement laid out in randomized complete block design and replicated three times. The factors were variety: SAMSUN-1, SAMSUN-2, SAMSUN-3 and SAMSUN-4 and fertilizer regime: control, split application (30 kgN/ha + 28 kgP_2O_5/ha at 21 days after sowing, DAS and at anthesis, and single application of 60 kg N/ha + 56 kgP_2O_5/ha at 21 DAS. Each plot measured 4m x 1.8m (7.2m2) and consisted of four rows.

In each year of experimentation, the site of the experiment was ploughed twice and harrowed once. Sunflower seeds were sown at a spacing of 60 cm x 30 cm giving 56,000 plants/ha. Sowing was done on June 27, 2014 and August 7, 2015 during the late cropping seasons. Thinning to one plant per stand was done at two weeks after sowing (WAS). The sources of fertilizers used in the study were urea fertilizer (46%N), single superphosphate (18.5% P_2O_5) and muriate of potash (62%K_2O). The recommended rate of 100 kgK_2O (Ogunemi, 2000) was applied on all the fertilized plots along with N and P fertilizers at 21 DAS. Weeds were controlled manually at 3 and 6 WAS and no herbicides were sprayed in order to simulate the growing conditions of the resource-constrained farmers.

After the first weeding at 3 WAS, five randomly selected plants were tagged in the two middle rows for plant height and yield attributes measurement at maturity. Parameters measured on plot basis were number of phonological days to flowering (R5) and physiological maturity (R9) as described by Schnieter and Miller (1981), plant height (cm) at R5 and R9, head diameter (cm), head weight (g), number and weight (g) of seeds per head, 100 seed weight (g), Shelling percent (5) and seed yield (kg/ha).

All data collected on plot basis were analysed using the MASTAC package (Freed *et al.*, 1989). The treatment means of the main effects and interactions that were found significant were then separated using the least significant difference method (LSD) at 5% probability level.

RESULTS

Effect of nitrogen (N) and phosphorus (P) fertilizer regime on phenology and height characteristics of four sunflower varieties

Fertilizer regime significantly ($P \leq 0.05$; F-test) affected plant height of sunflower at flowering and physiological maturity in 2014 and 2015. Application of N and P fertilizers either as split or single dose significantly ($P \leq 0.05$) increased sunflower plant height at flowering and physiological maturity relative to the control treatment in both years. However, fertilizer regime had no significant effect on number of phonological days to flowering and physiological maturity of sunflower in both years. Similarly, variety and Variety × Fertilizer regime effects were not significant on number of phonological days to flowering and physiological maturity and height at R5 and R9 in both years (Table 3).

Effect of nitrogen (N) and phosphorus (P) fertilizer regime on seed yield and yield attributes of four sunflower varieties

Fertilizer regime significantly ($P \leq 0.05$; F-test) number of seeds per head, seed weight per head, 100 seed weight and seed yield of sunflower in both years and average head diameter and head weight, and threshing percent of sunflower in 2015 (Table 4 and 5). Split and single application of N and P fertilizers to sunflower resulted in significantly ($P \leq 0.05$) higher values for the parameters relative to the control treatment, except seed yield in 2014. Fertilizer regime had no significant effect on head diameter, average head weight and threshing percent of sunflower in 2014. Variety effect was only significant ($P \leq 0.05$; F-test) on average head weight, number of seeds per head and 100 seed weight of sunflower in 2015. However, in 2014, variety effect was not significant on any trait measured. Similarly, Variety × Fertilizer regime effect did not affect seed yield and any yield attribute of sunflower significantly in both years.

DISCUSSION

Adoption of the appropriate fertilizer regime is very crucial for successful sunflower cultivation and the performance of the crop depends largely on the prevailing weather conditions. The late cropping season of 2014 was wetter (610.2 mm) than that of 2015 (370.0 mm). This scenario apparently contributed to the better overall performance of sunflower in 2014 than 2015. Application of N and P fertilizers either as split or single regime significantly ($P \leq 0.05$; F-test) enhanced plant height of sunflower relative to the control at R5 and R9. The availability of N on the fertilized plots apparently boosted plant growth. No significant variety effect was recorded in 2014 for sunflower on seed yield and yield attributes. All the four new varieties were able to express themselves very well under the wetter growth conditions of 2014 than 2015. In an earlier trial where two exotic varieties (Record and Isaanka) and Funtua (locally adapted variety) were subjected to similar fertilizer regimes, Funtua grew taller than the exotic varieties (Olowe *et al*., 2005b). However, during the hotter and drier late cropping season of 2015, the varieties were significantly ($P \leq 0.05$; F-test) different for head weight , number of seeds per head and 100 seed weight. SAMSUN-1 and SAMSUN-2 recorded significantly ($P < 0.05$) higher head weight and number of seeds per head than SAMSUN-4. However, these differences did not translate to significant seed yield among the varieties.

Among the yield attributes evaluated in our study, split and single application of N and P significantly ($P \leq 0.05$; F-test) enhanced only 100 seed weight relative to the control in

2014. However, in 2015 all the yield attributes were significantly ($P \leq 0.05$; *F*-test) enhanced by split and single application of N and P fertilizers with the split application regime resulting in higher values for most traits. According to earlier reports, application of N up to 60 kg N/ha either as split or single significantly ($P < 0.05$) increased head diameter, seed weight per head and 1000 seed weight (Olowe *et al.*, 2005b) and 112 kg N/ha head diameter (Yousaf *et al*., 1986).

According to Robinson (1978), the seed yield of sunflower is highly dependent on number of heads per hectare, number of seeds (achene) and weight per head. The fertilizer regimes evaluated in our study significantly affected these traits in both years, except number of heads per hectare which was not calculated in our study. The seed yield values (1246 – 1994.2 kg/ha) recorded in our study during the wetter and more favourable 2014 compared very well with Nigerian (1000 kg/ha), African (812 kg/ha) averages (Olowe *et al.*, 2013) and world average (1520 kg/ha) according to USDA (2012), and the more recent forecast (1410 kg/ha) for 2012/2013 by NSA (2016). However, the imposed fertilizer regimes under drier and hotter 2015 conditions resulted in seed yield values at par with only the African average (812 kg/ha). The seed yield values recorded under split and single application of N and P fertilizers were at par in both years with the split regime resulting in slightly higher value in 2015. This trend also corroborated the results of earlier experiments on sunflower (Singh *et al*., 1977, Noor-Mohammed and Ehdaie, 1979, Ogunremi, 1984 and 1986, Olowe *et al*., 2005b).

On average, the superior performance of the sunflower varieties grown on the fertilized plots over those on the control plots suggest that they had access to the three major macronutrients (N,P and K) and these nutrients apparently contributed to their growth and development on the relatively fertile experimental soils. Lack of significant Variety × Fertilizer regime interaction in this two year study suggest that the two factors were independent of each other.

CONCLUSION

The results of this two year study indicate that the growth and seed yield responses of four newly released sunflower varieties were at par when N and P fertilizers were applied as split or single regime, and were superior to plants on the control plots. Consequently, it is recommended that single regime application of fertilizers at three weeks after sowing be adopted in the forest – savanna transition zone of the humid tropics.

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Table 1: Number of phonological days to flowering (R5) and physiological maturity (R9), and plant height of sunflower as influenced

by variety and fertilizer regime in 2014 and 2015

Treatment	2014				2015			
	Days to		Height (cm) at		Days to		Height (cm) at	
	R5	R9	R5	R9	R5	R9	R5	R9
Variety (V)								
SAMSUN-1	60.7	103.0	99.6	148.6	70.6	109.7	161.6	174.8
SAMSUN-2	60.9	103.2	107.3	147.2	71.1	109.4	148.9	161.8
SAMSUN-3	60.2	103.0	114.2	164.9	71.0	110.1	155.3	173.7
SAMSUN-4	60.3	102.7	106.4	158.9	70.2	110.8	157.2	174.3
LSD 5%	ns	ns	ns	ns	ns	ns		
Fertilizer Regime (FR)								
Control	59.8	102.2	98.6	144.0	71.0	109.9	141.7	156.6
Split	60.9	103.1	115.6	168.9	70.4	109.8	164.8	180.7
Single	60.9	103.5	106.3	151.7	70.7	110.3	160.7	176.2
LSD 5%	ns	ns	13.31*	20.32*	ns	ns	8.16**	10.79**
Interaction								
V × FR	ns	ns	ns	ns	ns	ns	ns	ns

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

Table 2: Sunflower seed yield and yield attributes as influenced by variety and fertilizer regime in 2014

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Seed weight per head (g)	100 seed weight (g)	Threshing percent (%)	Seed yield (kg/ha)
Variety (V)							
SAMSUN-1	12.4	326.8	442.4	39.4	6.2	16.2	1746.9
SAMSUN-2	11.4	365.5	410.9	34.2	4.9	9.0	1527.4
SAMSUN-3	12.0	347.8	341.9	36.8	4.7	8.7	1652.2
SAMSUN-4	11.1	357.4	423.4	36.3	4.5	10.6	1595.5
LSD 5%	ns	ns	ns	ns	ns	ns	ns
Fertilizer Regime (FR)							
Control	11.1	296.5	352.4	27.8	3.9	10.3	1246.9
Split	12.3	361.8	411.8	36.7	5.8	10.2	1650.4
Single	11.9	389.9	449.8	45.5	5.6	12.9	1994.2
LSD 5%	ns	ns	79.19*	9.97**	1.54*	ns	425.94
Interaction							
V × FR	ns	ns	ns	ns	ns	ns	ns

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

Table 3: Sunflower seed yield and yield attributes as influenced by variety and fertilizer regime in 2015

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Seed weight per head (g)	100 seed weight (g)	Threshing percent (%)	Seed yield (kg/ha)
Variety (V)							
SAMSUN-1	8.4	22.3	440.2	10.8	2.5	49.5	506.1
SAMSUN-2	7.8	22.9	413.6	12.0	3.0	50.2	506.7
SAMSUN-3	7.5	16.5	442.5	11.3	3.1	63.9	606.5
SAMSUN-4	6.8	17.1	192.6	8.0	4.2	46.2	599.3
LSD 5%	ns	4.80*	163.99*	ns	1.19*	ns	ns
Fertilizer Regime (FR)							
Control	6.6	13.5	227.3	6.7	2.8	41.4	361.9
Split	8.5	26.3	463.3	14.2	4.0	60.9	704.9
Single	7.8	19.2	426.0	10.6	2.8	55.1	597.0
LSD 5%	1.04**	4.16**	142.0**	2.71**	1.04*	13.09*	126.67**
Interaction							
V × FR	ns	ns	ns	ns	ns	ns	ns

Notes: **, * Significant at P $\leq$ 0.001 and 0.05, respectively, ns – non-significant

INTERACTIVE EFFECTS OF DIFFERENT INTRA-ROW SPACING AND NITROGEN LEVELS ON YIELD AND YIELD COMPONENTS OF CONFECTIONERY SUNFLOWER (*HELIANTHUS ANNUUS* L.) GENOTYPE (ALACA) UNDER ANKARA CONDITIONS

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ABSTRACT

This research was conducted at the experimental field of Department of Field Crops, Faculty of Agriculture, University of Ankara in 2007 and 2008. Experiment was carreied out to study the effects of different intra-row spacing and N (nitrogen) levels on yield performence of confectionery sunflower genotype. Seeds of Alaca genotype and ammonium sulfate (%21 N) were used as materials. The aim of the research was to determine the effects of different intra-row spacing (20, 30 and 40 cm) and N levels (0, 40, 80 and 120 kg ha^{-1}) on yield and yield components of confectionery sunflower genotype (Alaca). The experiment was laid on “Randomized Complete Block Design” as split plots with three replications. The highest seed yield obtained from 20 cm intra-row spacing and 120 kg ha^{-1} and the score were 243.3 kg da^{-1} and 315.3 kg da^{-1} in 2007 and 2008. N level increased the 1000 seed weight. In the year with irregular rainfall (2007) in the vegetation stage the highest 1000 seed weight score was obtained as 129.6 g in 40 kg ha^{-1} N treatment whereas in the year with normal rainfall distrubution the highest 1000 seed weight score was obtained as 113.4 in 80 kg ha^{-1}. Results revealed that; decreasing intra-row spacing led to decrease in seed yield per head but increase of the seed yield. However, increasing plant population caused to small seeds and this feature is not required for confectionery varieties. For this reason, 30 cm intra-row spacing and 80 kg ha^{-1} N is appropriate for Alaca genotype.

Key words: Confectionery sunflower, plant population, N doses

INTRODUCTION

Confectionery sunflower is one of the most common crop cultivated in Cenral Anatolia that has a larger head size compared to oilseed sunflower. The total cultivation area of confectionery sunflower is 104.992 ha in Turkey and 35.783 ha of this cultivation area is in Central Anatolia. It is an important cash crop due to its used for birdfeed and human consumption. The impact of plant density and N supply on sunflower yield and yield component have been studied previously with the aim to determine appropriate plant population and N levels for sunflower production (Zubriski and Zimmerman 1974, Kıllı 2004). Several researchers observed that plant spacing has an importance to enhance the yield of sunflower (Robinson et al. 1980, Redy et al. 1997, Jahangir et al. 2006). N one of the limiting factor in sunflower growth play an important role on yield (Montemurro and De Giorgio 2005). Inadequate N supply in the soil has an negative impact on vegetative and generative growth and induces premature senescence which leads yield loss (Narwal and Malik 1985, Khokani et al. 1993, Legha and Giri 1999, Tomar et al. 1999). Contrarily, high N supply may delay crop maturity and reduce seed yield (Farah et al. 1981, Hocking et al. 1987, Özer et al. 2004). Also overfertilization with N is one of the main contamination reason of groundwater with nitrates (Magdoff et al. 1997; Strong, 1995, Scheiner et al. 2002). It is important to adjust N for different varieties and species to avoid excessive N fertilization.

In Central Anatolia, confectionery sunflower is grown under irrigated or rainfed conditions. Confectionery sunflower yield (83 kg da^{-1}) under rainfed condition is very low (Day and Kolsarıcı, 2014) compare to average yield (109 kg da^{-1}) of confectionery sunflower under irrigated conditions. However agro-techniques used in the region under irrigated conditions are comparatively poor. Plant density and proper fertilizer application to soil are necessary for optimum yield of crops. There is very limited information on confectionery sunflower (*Helianthus annuus* L.) response to different intra-row spacing and N in comparison to oil type sunflower. However, there is no published data available on plant population and N rate response on yield of confectionery sunflower in Central Anatolian region. Keeping in view, the present study was designed with objectives to investigate the role of different intra-row spacing and N levels on yield and yield components of confectionery sunflower genotype Alaca.

MATERIALS AND METHODS

The experiment was carried out at the experimental field of Department of Field Crops, Faculty of Agriculture, University of Ankara in 2007 and 2008, in Turkey. Long term average precipitation for this area was 337.6 mm. The field soil in the experiment was clay loam (25% sand, 40% clay, 35% silt), alkaline, low in organic matter, moderately calcareous (Table 2). Confectionery sunflower seeds of Alaca genotype were procured from Trakya Agricultural Research Institute. Three intra-row spacing (R) (R_1=20, R_2=30 and R_3=40 cm) and four different levels of nitrogen (N) (0 (N_0), 40 (N_1), 80 (N_2) and 120 kg ha^{-1} ($N_{3.}$)) were used in field experiment. N was applied at two different stages in equal amount by using Amonium sulfate. First application of N was made at the time of land preparation and second was applied to soil at the R-1growth stage of (The terminal bud forms a miniature floral head rather than a cluster of leaves) described by Schneiter and Miller (1981). The planting was done manually in both 2007 and 2008. The experiment was laid on randomized complete block design as split plots with three replicates. An individual plot size were 21.84 m^2 (5.2 × 4.2 m).

At the harvest time, 10 plants were selected at random from each plot. Plant height, head diameter, 1000 seed weight, harvest index, hull ratio, seed yield per plant, protein content, oil content and seed yield per decare of confectionery sunflower genotype Alaca was measured and recorded. 1000 seed weight calculated according to ISTA (8 replications of 100 weighed seperately, calculated average weight of 100 seeds and multiplied by 10). Protein content was determined with kjeldahl method (Akyıldız 1968), Oil content determination was done with hexane extraction (Akyıldız 1968). Harvest index was calculated by using this equation HI=Ye/Yb.100 (Gholinezhad et al. 2009).

HI = Harvest index
Ye = Economical yield
Yb = Biological yield

Data pertaining plant height and different yield contributing characters were analyzed using statistical analysis by MSTAT-C and Duncan’s Multiple Range Test was used for post hoc tests. All data transformed into percentages were subjected to arcsine transformation (Snedecor and Cocharan, 1967).

Table 1. Average precipitaition, temperature and relative humidity of the 2007 and 2008.

Months	Precipitation(mm)			Temperature (°C)			Relative Humidity (%)		
	Long term average	2007	2008	Long term average	2007	2008	Long term average	2007	2008
January	33.1	39.0	20.1	0.7	1.2	-4.0	76.5	76.0	76.3
February	38.1	16.4	6.5	0.7	2.5	0.1	73.1	68.5	68.9
March	24.5	37.5	54.9	6.4	7.2	10.1	63.0	59.5	57.6
April	39.8	23.8	32.7	12.6	9.1	13.7	57.8	53.7	54.8
May	47.9	17.9	45.4	16.1	20.4	15.5	56.6	41.1	50.9
June	20.5	31.7	10.3	20.1	22.6	22.0	50.5	45.0	41.0
July	8.8	3.9	0.0	23.5	26.7	24.9	45.9	29.8	35.7
August	6.3	9.8	0.7	23.4	26.3	26.6	46.5	37.1	34.5
September	6.8	0	61.6	20.4	20.9	19.9	46.4	35.0	50.3
October	29.0	14.1	18.6	14.9	16.7	13.3	59.1	49.4	63.8
November	49.6	66.7	43.6	5.7	6.7	8.7	72.1	66.6	72.1
December	33.2	44.4	28.8	0.9	2.0	2.0	78.0	75.7	78.6
Tot./Ave.	337.6	305.2	323.2	12.2	13.5	12.7	60.3	53.1	57.0

*Turkish State Meteorological Service. Ankara 2009.

Table 2. Physical and chemical characteristics of soil where the experiment was conducted

Years	Depth (cm)	Soil Texture	Saturation (%)	Salinity (%)	pH	$CaCO_3$ (%)	Available P_2O_5 (kg da^{-1})	Available K_2O (kg da^{-1})	Total N (%)	Organic Compound (%)
2007	0-20	Clay-loam	50	0.085	8.0	10.34	8.65	245	0.08	1.01
	20-40	Clay-loam	53	0.087	8.0	8.31	11.02	190	0.17	1.14
2008	0-20	Clay-loam	54	0.084	7.8	9.00	7.85	160	0.06	1.25
	20-40	Clay-loam	60	0.088	8.0	10.00	6.45	125	0.15	1.02

RESULTS AND DISCUSSION

In this study, plant height, head diameter, 1000 seed weight, harvest index, hull ratio, seed yield per plant, protein raito, oil ratio and seed yield per decare of confectionery sunflower genotype Alaca was investigated under different intra-row spacing and N doses.

The data of the 2-year experiment was subjected to statistical analysis. The average precipitation for 2008 (323.2 mm) was higher than that observed in 2007 (305.2 mm). Interestingly, rainfall in May of 2007 (17.9 mm) was below than the 2008 and was least for the last 50 years (Table 1).

Table 3. Summary of the analysis of variance for several variables of confectionery sunflower genotype grown under different intra-row spacing and N doses

	Plant Height	Head diameter	1000 seed weight	Harvest Index	Hull ratio	Seed yield per plant	Seed Protein ratio	Seed Oil ratio	Seed yield
Year	**		**		**	**		**	**
R					*	*		*	**
N	**		**	**		**		**	**
R×N					*			**	
R×Y						*			**
N×Y						*	*	**	*
R×N×Y		*							**

*, **:Significant at the 0.05, 0.01level. (R: Intra row spacing, N: Nitrogen doses, Y: Year)

PLANT HEIGHT

Results on plant height clearly showed the non significant effects of intra-row spacing. Average plant height of two years ranged from 153.5 to 162.1 cm. However significant effects of N doses were observed. Average plant height of two years ranged from 148.4 to 163.6 cm with maximum plant height obtained from N1. Further levels of N resulted in slight decline in plant height but that was non significant. Results further revealed that increase in plant height during 2008 compared to 2007 irrespective of row spacing and N doses. Moreover, interactive effect of R × N on plant height was non significant. Average plant height for two years ranged from 144.0 to 168.5 cm. The increase in plant height due to the N application was also reported by Tahir (1996), Ali et al. (2004) and Özer et al. (2004).

HEAD DIAMETER

Head diameter is one of the major yield components in sunflower and the size of confectionery type sunflower is of immense importance. Results clearly indicated that impact of intra-row spacing was non significant with the scores ranged from 18.4 cm to 19.6 cm. Impact of N levels on head diameter was also non significant and average head diameter of two years ranged from 18.5 cm to 20.1 cm. Response of head diameter R × N was non significant and the average of two year differed between 17.1 cm and 20.4 cm. Apart from our results Kıllı (2004) determined that the lowest plant density resulted in increase of head diameter and significantly increase in head diameter with the high level of N. Robinson et al. (1985) also stated that head diameter significantly decreased with the increasing plant density.

Results of combined ANOVA also showed that head diameter scored at different treatments did not influenced by year and the scores were 19.1 and 19.0 for 2007 and 2008 respectively. Results further indicated that interactive effect of Y × R × N was found significant ($P < 0.05$). Head diameter ranged 15.5-21.5 cm the highest head diameter was obtained from R2 × N3 in 2007.

1000 SEED WEIGHT

1000 seed weight is one of the most important yield component in sunflower and environmental factors have an important impact on this character. Results of combined ANOVA showed that 1000 seed weight scored at different treatment influenced by N doses and years significantly.

N doses showed the positive effects on 1000 seed weight compared to control. Average 1000 seed weight ranged from 102.6 g to 121.0 g. Maximum 1000 seed weight was recorded from N2 and further increase of N doses resulted in slight decline in 1000 seed weight.

Average results of two years differed and 1000 seed weight obtained in 2007 was higher compared to 2008. Whereas, interactive effect of R × N was found non significant. Average 1000 seed weight for two years ranged from 98.4 g to 127.7 g. Increase in 1000 seed weight due to the more access to absorb nutrients, supported by Zaman and Das (1991), Fathi et al. (1997) and Gholinezhad et al. (2009) who concluded that increasing level of N led to significant proliferation in 1000 seed weight.

Table 4. Impact of different intra-row spacing and N doses on plant height, head diameter and 1000 seed weight of the confectionery sunflower.

Intra-row	Plant height (cm)			Head diameter (cm)			1000 seed weight (g)		
Spacing (R)	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
R1	141.8	165.3	153.5	18.6	18.3	18.4	122.8	98.7	110.8
R2	150.4	173.9	162.1	20.2	19.0	19.6	128.7	110.4	119.5
R3	144.7	174.6	159.6	19.2	19.9	19.2	124.5	107.2	115.8
N doses									
N0	135.7	161.2	148.4b**	20.7	19.4	20.1	114.8	90.4	102.6b**
N1	147.8	179.3	163.6a	19.1	18.8	18.5	129.6	105.9	117.7a
N2	151.4	171.2	161.3a	18.9	18.7	18.8	128.5	113.4	121.0a
N3	147.7	173.2	160.0a	18.6	19.3	18.9	128.3	112.0	120.2a
Years	145.4b	171.3a**	158.4	19.1	19.0	19.1	125.3a	105.4b**	115.4
R × N									
R1 × N0	137.3	150.7	144.0	20.6a	19.0a-c*	19.8	115.0	81.7	98.4
R1 × N1	144.3	165.3	154.8	20.1ab	16.8b-d	18.5	127.3	100.0	113.7
R1 × N2	141.7	167.3	154.5	18.3a-d	18.5a-d	18.4	126.0	113.3	119.7
R1 × N3	143.7	177.7	160.7	15.5cd	18.8a-d	17.1	122.7	100.0	111.3
R2 × N0	138.7	163.0	150.8	20.9a	19.1a-c	20.0	117.7	95.3	106.5
R2 × N1	149.0	188.0	168.5	19.3ab	19.8ab	19.6	133.7	115.7	124.7
R2 x N2	156.7	174.7	165.7	18.9a-c	18.6a-d	18.7	136.3	114.7	125.5
R2 × N3	157.3	170.0	162.3	21.5a	18.5a-d	20.0	127.0	116.0	121.5
R3 × N0	131.0	170.0	150.5	20.6a	20.2ab	20.4	111.7	94.3	103.0
R3 × N1	150.0	184.7	167.3	15.2d	19.8ab	17.5	127.7	102.0	114.8
R3 × N2	155.7	171.7	163.7	19.5ab	18.9a-c	19.2	123.3	112.3	117.8
R3 × N3	142.0	172.0	157.0	18.5a-d	20.5ab	19.5	135.3	120.0	127.7

*, **:Significant at the 0.05, 0.01 level. There were no significant differences between the mean values shown with the same letters in 0.05 and 0.01 level. R1: 20 cm, R2: 30 cm, R3: 40 cm; N0: 0 kg N da^{-1}, N1: 4 kg N da^{-1}, N2: 8 kg N da^{-1}, N3: 12 kg N da^{-1}

HARVEST INDEX

Harvest index indicated the relative distribution of photosynthesis yield between economical yield and the biological yield of the plant. The effect of intra row spacing on harvest index was non significant and the scores varied between 39.4 % and 39.5 %. Harvest index was significantly influenced by N levels and the avarage of two years were in the range of 36.2 % to 44.3 %. The maximum harvest index was obtained from N3 and the minimum was recorded from N0. In our research increased level of N had positive impact on harvest index and the results of this study showed contradiction with the Singh et al. (1996), Gholinezhad et al. (2009).

HULL RATIO

The data of hull ratio subjected to statistical analysis was significantly influenced by intra row spacing, year and the R × N interaction. But the hull ratio did not influenced by N doses. Average hull ratio of two years ranged from 44.5 % to 47.3 % with maximum hull ratio was obtained from R3.

Results on impact of N doses on hull ratio had non significant variation and the average of two year was in the range of 45.3 % to 47.2 %. Results also revealed that more hull ratio in 2007 compared to 2008 irrespective of intra row spacing and N doses. However results related the impact of the interaction between R × N found significant on hull ratio and the values ranged from 42.8 % to 49.2 %. The minimum hull ratio was recorded from R1 × N1 and the maximum was obtained from R3 × N1. In contrast to our data, Baldini and Vannozzi (1996) reported that increasing of hullability with the N.

SEED YIELD PER PLANT

Seed yield per plant significantly showed the significant effects of intra-row spacing. Average seed yield per plant of two years ranged from 84.9 to 99.1 g plant^{-1} with minimum seed yield per plant which was recorded from 20 cm intra row space.

Results on N doses showed the positive effects on seed yield per plant and the average was in the range of 80.1 - 99.6 g plant^{-1}. The maximum seed yield per plant was observed in N2 and the minimum was obtained from control.

Effects of different N doses on the seed yield per plant was significantly differed during experiment years. Increasing N levels led to increase in seed yield per plant in both years but in 2008 N levels impact on seed yield per plant showed higher results compared to 2007. The seed yield per plant was 79.2 and 103.8 g plant^{-1} in 2007 and 2008 respectively.

The interactive effect of R × N was not statistically significant and the average of two year was in the range of 68.7-105.5 g plant^{-1}. In previous studies similar results were reported by Aless et al. (1997) and Gholinezhad et al. (2009). Also Marinkovic (1999) observed that decrease in single plant grain yield of sunflower due to decreasing nutrient space of every plant with the increasing plant density.

Table 5. Impact of different intra-row spacing and N doses on harvest index, hull ratio and seed yield per head of the confectionery sunflower.

Intra-row Spacing (R)	Harvest index (%)			Hull ratio (%)			Seed yield per plant (g plant $^{-1}$)		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
R1	39.8	39.3	39.5	47.9	43.1	45.5b**	80.2bc	89.6b*	84.9b*
R2	39.5	39.3	39.4	44.7	44.3	44.5b	73.6c	108.8a	91.2ab
R3	39.1	39.9	39.5	48.9	45.8	47.3a	85.3bc	113.0a	99.1a
N doses									
N0	37.1	35.3	36.2c**	48.2	46.3	47.2	70.8d	89.5bc*	80.1b**
N1	37.3	37.2	37.3c	46.1	44.4	45.3	79.7cd	109.0a	94.3a
N2	39.8	40.7	40.2b	46.3	44.3	45.3	92.2b	106.9a	99.6a
N3	43.7	44.9	44.3a	48.1	42.5	45.3	76.0d	109.8a	92.9a
Years	39.5	39.5	39.5	47.2a	44.4b**	45.8	79.2b	103.8a**	91.5
R × N									
R1 × N0	34.1	34.0	34.1	50.0	46.7	48.4ab*	69.3	68.0	68.7
R1 × N1	36.7	36.2	36.5	45.1	40.5	42.8d	79.3	86.0	82.7
R1 × N2	41.9	41.2	41.6	45.2	43.0	44.1b-d	99.0	95.3	97.2
R1 × N3	46.4	45.8	46.1	51.5	42.2	46.9a-c	73.0	109.0	91.0
R2 × N0	38.0	34.5	36.2	46.4	45.9	46.2a-d	68.7	97.7	83.2
R2 × N1	37.7	37.8	37.8	45.0	42.6	43.8cd	73.7	120.3	97.0
R2 × N2	40.3	40.5	40.4	44.3	44.7	44.5b-d	78.3	113.7	96.0
R2 × N3	41.9	44.3	43.1	43.2	44.0	43.6cd	73.7	103.3	88.5
R3 × N0	39.1	37.3	38.2	48.1	46.4	47.3a-c	74.3	102.7	88.5
R3 × N1	37.4	37.7	37.6	48.2	50.2	49.2a	86.0	120.7	103.3
R3 × N2	37.1	40.4	38.7	49.6	45.2	47.4a-c	99.3	111.7	105.5
R3 × N3	42.8	44.5	43.7	49.6	41.4	45.5a-d	81.3	117.0	99.2

*, **:Significant at the 0.05, 0.01 level. There were no significant differences between the mean values shown with the same letters in 0.05 and 0.01 level. R1: 20 cm, R2: 30 cm, R3: 40 cm; N_0: 0 kg N da^{-1}, N_1: 4 kg N da^{-1}, N_2: 8 kg N da^{-1}, N_3: 12 kg N da^{-1}

SEED OIL RATIO

Results on seed oil ratio clearly showed the significant effects of intra row spacing ($P < 0.05$) N doses and interactive effect of R × N ($P < 0.01$). Average oil ratio of two years ranged from 43.4 % to 46.0 % with maximum oil ratio obtained from 20 cm space.

The positive effect of N doses was observed on seed oil ratio compared to control. Average seed oil ratio ranged from 40.9 % to 47.4 %. Maximum oil ratio was recorded from N3 and further increase of N doses resulted in slight incline in seed oil ratio.

Results also revealed higher seed oil ratio during 2008 compared to 2007 irrespective of row spacing or N dose. The low oil ratio probably caused by the diversity of precipitation between two years. Özer et al. 2004 also reported that low rainfall during the vegetation stage of sunflower may lead to decline in oil concentration. Interactive effect of R × N was found significant and average seed oil ratio for two years ranged from 39. 7 % to 48.6 %. Maximum oil ratio was observed in the combination of R3 × N3. Contrarily, minimum oil was recorded from R3 × N0. Our results showed contradiction with Zubriski and Zimmerman (1974), Özer et al. (2004) and Al thabet (2006) who implied that negative effect of N on oil ratio. However efficiency use of N by sunflower plant is possible with the N uptake from the soil and remobilization of stored vegetative N accumulated before the flowering stage. Steer et al. (1984) and Ruffo et al. (2003) also reported that when N uptake of sunflower is after the flowering stage, N negatively impacts the oil ratio. Therefore in this research application of N before sowing and at R-1 growth stage might led to increase in oil ratio comparing to control.

SEED PROTEIN RATIO

Protein content one of the most important compenent of confectionery sunflower seeds. Results on seed protein ratio clearly showed the significant effect of N and Y × R × N. But the impact of intra-row spacing was statistically non significant.

Results of two years average about intra-row spacing on seed protein ratio was in the range of 28.3 % to 30.0 %. The minimum and the maximum scores were obtained from 20 cm and 40 cm respectively.

Results on N doses revealed that the significant effect of N doses on protein ratio. The scores were in the range of 27.9 % to 29.5 %.

Results further revealed that non significant effect of R × N on seed protein ratio and scores varied between 26.6 % and 31.2 %. The results are in line with the previous results of Blamey and Chapman (1981), Steer et al. (1986) and Özer et al. (2004).

SEED YIELD

Results of combined ANOVA showed that seed yield significantly affected by intra row spacing and N doses. Seed yield differed significantly within the years ($P < 0.01$). In 2008 when the precipitation was higher, the average seed yield was higher than 2007. The scored seed yield for 2007 and 2008, was 204.5 and 247.4 g da^{-1} respectively.

Increasing number of plant with the 20 cm intra-row spacing led to considerable increase in seed yield. The average of two year observed was in the range of 198.6 kg da^{-1} to 263.0 kg da^{-1}. N had a significantly effect on seed yield and the average of two year varied between 202.7 and 244.0 kg da^{-1}.

Interactive effects of R × N × Y had significant effects on seed yield. Every increasing level of N caused increase in all intra-row spacing (20, 30 and 40 cm). The highest seed yield within years obtained from R1 intra-row spacing and N3 treatment (Table 6). By plant density and N increase, seed yield per area became more due to the increase in the number of plants and N level per area. The results obtained from our research are in line with Ruffo et al. (2003), Jahangir et al. (2006), Beg et al. (2007) and Day and Kolsarıcı (2014) who reported that seed yield of sunflower influenced by plant density.

Table 6. Impact of different intra-row spacing and N doses on protein ratio, oil ratio and seed yield of the confectionery sunflower.

Intra-row Spacing (R)	Protein ratio (%) 2007	Protein ratio (%) 2008	Protein ratio (%) Mean	Oil ratio (%) 2007	Oil ratio (%) 2008	Oil ratio (%) Mean	Seed yield (kg da^{-1}) 2007	Seed yield (kg da^{-1}) 2008	Seed yield (kg da^{-1}) Mean
R1	28.6	28.0	28.3	43.7	48.4	46.0a*	224.9b	301.0a**	263.0a**
R2	30.8	29.2	30.0	43.2	46.6	44.9ab	198.6cd	234.0b	216.3b
R3	29.2	28.6	28.9	40.6	46.2	43.4b	190.0d	207.2c	198.6c
N doses									
N0	30.3	28.7	29.5a*	39.7d	42.0cd**	40.9c**	187.2e	218.2d*	202.7d**
N1	30.6	28.4	29.5a	40.7cd	48.4ab	44.6b	197.1e	245.1c	221.1c
N2	28.0	27.8	27.9b	43.0c	49.8a	46.4ab	214.7d	257.2b	235.9b
N3	29.2	29.5	29.4a	46.6b	48.1ab	47.4a	219.0d	269.0a	244.0a
Years	29.5	28.6	29.1	42.5b	47.1a**	44.8	204.5b	247.4a**	226.0
R × N									
R1 × N0	31.0a-c	27.5d-g*	29.3	41.9	44.5	43.2cd**	202.3f-h	274.7b**	238.5
R1 × N1	29.6a-g	27.5c-g	28.6	43.3	52.6	48.0ab	212.3e-g	313.3a	262.8
R1 × N2	27.0e-g	28.6b-g	27.8	42.9	51.1	47.0a-c	241.7cd	300.7a	271.2
R1 × N3	26.6fg	28.4b-g	27.5	46.7	45.4	46.1a-c	243.3cd	315.3a	279.3
R1 × N0	29.8a-g	29.3a-g	29.6	41.2	38.4	39.8d	182.0ij	215.3ef	198.7
R2 × N1	32.3a	28.0b-g	30.2	41.2	48.6	44.9a-c	194.7g-i	229.0de	211.8
R2 × N2	30.5a-d	27.9c-g	29.2	44.8	50.3	47.6ab	205.7fg	242.7cd	224.2
R2 × N3	30.7a-d	31.7ab	31.2	45.6	49.1	47.4ab	212.0e-g	249.0c	230.5
R3 × N0	30.1a-e	29.2a-g	29.7	36.1	43.2	39.7d	177.3ij	164.7j	171.0
R3 × N1	29.8a-f	29.8a-g	29.8	37.5	44.1	40.8d	184.3hi	193.0g-i	188.7
R3 × N2	26.4g	26.8e-g	26.6	41.2	47.9	44.6bc	196.7f-i	228.3de	212.5
R3 × N3	30.3a-e	28.5b-g	29.4	47.5	49.7	48.6a	201.7f-h	242.7cd	222.2

*, **:Significant at the 0.05, 0.01 level. There were no significant differences between the mean values shown with the same letters in 0.05 and 0.01 level. R1: 20 cm, R2: 30 cm, R3: 40 cm; N_0: 0 kg N da^{-1}, N_1: 4 kg N da^{-1}, N_2: 8 kg N da^{-1}, N_3: 12 kg N da^{-1}

CONCLUSION

Different level of intra row spacing and N had different impacts on plant. Among the most important results obtained about these treatments significant increase in yield at 20 cm intra-row spacing × 120 kg ha^{-1} observed. With plant density increase, decrease in 1000 seed yield was observed which means that small sized seeds were more. These results suggests that 30 cm intra row spacing and 80 kg ha^{-1} N treatment is suitable for Alaca genotype under Ankara conditions.

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EFFECTS OF DIFFERENT ORGANOMINERAL AND INORGANIC COMPOUND FERTILIZERS ON SEED YIELD AND SOME YIELD COMPONENTS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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ABSTRACT

This research was carried out to determine the effects of different organomineral and inorganic compound fertilizers on seed yield and some yield components of sunflower (*Helianthus annuus* L.) in 2013. The experiments were conducted using Tunca MR LG 5580 oil type sunflower hybrid in Randomized Complete Block Design with 4 replications at Trakya Agricultural Research Institute in Edirne, Turkey. In the research, 5 different treatments; 1) Check 0 kg/ha no fertilizer, 2) 250 kgs/ha organomineral fertilizer of Hexaferm® 8.21.0 3) 250 kgs/ha organomineral fertilizer of Hexaferm® 6N.10P.10K 4) 250 kgs/ha inorganic compound granule fertilizer of 15N.15P.15K (farmers apply) and 5) 250 kgs/ha inorganic compound granule fertilizer of 20N.20P.0K kgs/ha (farmers apply) were evaluated. Before sunflower planting, the fertilizers were applied by hand spreading in each plot's surface uniformly and mixed well with the soil. In this research beside seed yield, oil content, oil yield, 1000 seed weight, test weight, plant height, head diameter, time to flowering, and time to physiological maturity were evaluated. The seed yield of sunflower was significantly affected by the different organomineral and inorganic compound fertilizers under natural rainfed conditions. Based on statistical analyses results; the highest sunflower seed yield with mean of 3282 kgs/ha was obtained at 250 kgs/ha the organomineral fertilizer application of Hexaferm® 6N.10P.10K.

Key words: sunflower, organomineral, fertilizer, yield, oil content

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the important edible vegetable oilseed crop in Turkey and the world. It has strong demand as a healthy vegetable oil due to their low level of saturated fats, making it popular as a cooking vegetable oil and for use in processed foods (Schneiter, 1997; Süzer, 2014).

World sunflower planted area accounts for 25.590.104 ha, production 44.753.264 ton, and yield is about 1750 kg/ha. However, Turkey sunflower planted area accounts for 609.784 ha, production 1.523.000 ton, and yield is about 2500 kg/ha (FAO STAT 2013). Turkey has around 3.4 % ratio of sunflower production comparing to world (Süzer, 2015).

Sunflower is one of the main crops in the rotation system in Trakya region of Turkey and it provides to around 46% of edible vegetable oil. The majority of Turkey's sunflower production area is located in Trakya-Marmara (%75) region and it is also grown in central Anatolia (7 %), the black sea cost (7 %), the Çukurova (7 %), the Aegean coast (3%), and the South East Anatolia (1%) regions of Turkey (Süzer, 2015).

An annual plant, sunflower need to grow such as fertile soil, water, air, light and temperature. Fertile agricultural soils usually have more than 3% organic matter for high yielding sunflower production. In fertile soils, sunflower plants require at least 16 elements for normal growth and to get high seed and oil yield from per hectare. Therefore some essential plant nutrients need to grow high yielding sunflower such as carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, chlorine, iron, manganese, zinc, copper and molybdenum (Hocking and Steer, 1983; Danke et al., 1992; Schneiter, 1997; Süzer, 1998; Kacar ve Katkat, 1999; Süzer, 2010 a; Süzer, 2012; Süzer, 2013).

These elements used in the largest amounts for growing sunflower crop, carbon, hydrogen and oxygen, are non-mineral elements supplied by air and water and the other 13 elements are taken up by plants only in mineral form from the soil. The sunflower plants need large amounts of nitrogen, phosphorus, potassium and referred to as primary nutrients. Those nutrients are the ones most frequently supplied to grow sunflower plants in fertilizers. The three secondary elements, calcium, magnesium, and sulfur, are required in small amounts than the primary nutrients for growing sunflower. The micronutrients are boron, copper, chlorine, iron, manganese, molybdenum, zinc that occur in very small amounts in both soils and plants, but their roles are equally as important as the primary or secondary nutrients. A deficiency of one or more of the micronutrients on sunflower plant can lead to severe depression in growth, and seed and oil yield (Robinson, 1978; Blamey et al., 1987; Schneiter 1997; Süzer, 2015)

However in sunflower production areas, some soils do not contain sufficient amounts of these nutrients to meet the plant's requirements for good growth, seed and oil yield from per hectare. In such cases, supplemental nutrient applications in the form of organomineral and inorganic compound fertilizers applications must be made to get high seed and oil yield from per hectare. But, it's continuous using of inorganic fertilizers can cause nutrient in-balance and soil pH level. Only using of either organic or inorganic fertilizers cannot met the expected in increasing crop yield. In this aspect, the combined use of in organic chemical fertilizers and organomineral fertilizer can be suggested in sunflower production in order to increase seed and oil yield from per hectare. Therefore it is essential that the combined use of organic and inorganic fertilizers (organomineral fertilizer) should be encouraged and introduced to farmers in order to achieve their yield expectancy of their sunflower crop production (Schneiter, 1997; Makinde et al., 2010; Olaniyi et al., 2010; Süzer, 2010a, 2010b; Süzer, 2012; Süzer, 2013; Süzer, 2014; Süzer 2015)

Because of the importance of sunflower as one of the major oilseed crop in Turkey, the objective of this research was to determine the responses of sunflower to different organomineral and inorganic compound fertilizers.

MATERIALS AND METHODS

This experiment was carried out in rotation with wheat crop under rain fed conditions during the 2013 sunflower growing season. The experiment field is located on latitude 41.68° N and longitude 26.56° at elevation 62 meters above sea level in Edirne, Turkey. Main properties of soil used in the field experiments are presented in Table 1. As seen in Table 1, soil texture was silty clay and organic matter was low. Edirne's climate is classified as warm and temperate, slightly continental. The average annual temperature of Edirne is 13.5 °C and the rainfall averages 597 mm. Climate data of Edirne during sunflower growing season in 2013 are presented in Table 2.

The experiments were conducted using Tunca MR LG 5580 oil type sunflower hybrid in Randomized Complete Block Design with 4 replications at Trakya Agricultural Research Institute in Edirne. In the research, 5 different treatments; **1)** Check 0 kg/ha no fertilizer, **2)** 250 kgs/ha organomineral fertilizer of Hexaferm® 8N.21P.0K **3)** 250 kgs/ha organomineral fertilizer of Hexaferm® 6N.10P.10K **4)** 250 kgs/ha inorganic compound fertilizer of

15N.15P.15K (farmers apply) and **5)** 250 kgs/ha inorganic compound fertilizer of 20N.20P.0K (farmers apply) were evaluated.

Table 1. Soil analyses data of experiment field Edirne in 2013.

Year	Depth (cm)	PH	CaCO3 (%)	P2O5 (kg/Ha)	K2O Available (kg/ha)	Total Salt (%)	Sand (%)	Silt (%)	Clay (%)	Organic Matter (%)	Texture Class
2013	0-20 20-40	6.30 6.25	1.62 1.44	320.0 270.0	674.0 586.0	0.040 0.035	36.2 32.5	36.6 38.4	27.2 29.1	1.4 1.2	Silty clay

*: Soil tests are done by Edirne commodity exchange.

Table 2. Climate data of Edirne during the 2013 sunflower growing season.

Month	Rain (mm)	Rainy days	Humidity level (%)	Temperature (^oC)		
				Minimum	Maximum	Mean
April 2013	51,0	9	73,2	4,0	32,0	12,7
May 2013	11,0	3	66,7	4,9	32,9	20,8
June 2013	26,6	7	70,1	11,4	36,2	23,3
July 2013	14,4	4	53,6	15,0	36,1	25,5
August 2013	0,0	0	48,7	16,6	36,9	26,7
Total	103.0	23	62.46	4,0	36,9	21,8

*: Climate data is received from Edirne's meteorological station.

Plot size in planting 7 .5 x 2.8 m = 21.0 m^2, and plot size in harvest 1.4 x 4.4 m = 6.1 m^2. The intro-row spacing was 30 cm, in rows spaced 70 cm apart. Before sunflower planting, the fertilizers were applied by hand spreading in each plot's surface uniformly and mixed well with the soil. The experiments were sown in the first week of May in three years. The seeds were over planted per hill and thinned to one plant per hill three weeks after sowing. Weed control was accomplished by using both chemicals and cultural practices.

In this research beside seed yield, oil content, oil yield, 1000 seed weight, test weight, plant height, head diameter, time to flowering, and time to physiological maturity were evaluated and analyzed using ANAVO. All statistical analyses of data were performed using the JMP 5.0.1 statistical software package (SAS Institute, 2002), and the differences between means were compared using a least significant difference (LSD) test at the 0.05 probability level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The effects of different organomineral and inorganic compound fertilizers on seed yield and some yield components of sunflower are presented in Table 3. As seen in Table 3, all different organomineral and inorganic compound fertilizers affected significantly sunflower seed yield. In the experiment, Hexaferm® 6N.10P.10K organomineral fertilizer of 250 kgs/ha application gave the first rank highest seed yield (3282 kgs/ha) and oil yield (1438 kgs/ha) comparing the other four different organomineral and inorganic compound fertilizers. The other Hexaferm® 8N.21P.0K organomineral fertilizer of 250 kgs/ha application gave the second rank highest seed yield (3145 kgs/ha) and oil yield (1358 kgs/ha) in the experiment.

On the other hand compound 15N.15P.15K inorganic fertilizer of 250 kgs/ha farmers apply gave the third rank highest seed yield (3034 kgs/ha) and oil yield (1314 kgs/ha) comparing the other four different organomineral and inorganic compound fertilizers. Compound 20.20.0 inorganic granule fertilizer of 250 kgs/ha application also gave the fourth rank highest seed yield (3004 kgs/ha) and oil yield (1328 kgs/ha) comparing the other four different organomineral and inorganic compound fertilizers. The last check 0 kg/ha no fertilizer gave the fifth rank seed yield (2609 kgs/ha) and oil yield (1124 kgs/ha) comparing the other four different organomineral and inorganic compound fertilizers.

Table 3. Mean seed yield and yield components of sunflower as affected by five different organomineral and inorganic compound fertilizers.

Entry No	Aplications	Seed Yield (kg/ha)	Oil In Seed (%)	Oil Yield (kg/ha)	Plant Height (cm)	Head Dia-meter (cm)	Time To Flowe-Ring	Time To Phsiolo-gical Maturity	1000 Seed Weight (g)	Volume Weight (kg/hl)
1	Kontrol (No fertilizer)	2609 B	43.1	1124	155	16	8.07.2013	15.08.2013	48.9	39.6
2	Hexaferm 8.21.0 250 kgs/ha	3145 A	43.2	1358	160	19	8.07.2013	15.08.2013	50.1	39.9
3	Hexaferm 6.10.10 250 kgs/ha	3282 A	43.8	1438	160	19	8.07.2013	15.08.2013	50.0	39.8
4	15.15.15 250 kgs/ha	3034 A	43.3	1314	160	17	8.07.2013	15.08.2013	49.3	39.0
5	20.20.0 250 kgs/ha	3004 A	44.2	1328	160	17	8.07.2013	15.08.2013	50.3	38.7
	LSD (0.05)	309.4**								
	C.V. (%)	6.66								

**: 0.01 different significantly at 1 % probability level.

The result of the seed and oil yield of sunflower as affected by the inorganic and organomineral fertilizer applications are presented in Table 3. The response of sunflower to the four different organomineral and inorganic compound fertilizers varied slightly for the seed and oil yield. However, the sole application of 250 kgs/ha Hexaferm® 6N.10P.10K organomineral fertilizer performed favorably well in terms of seed and oil yield of sunflower.

Despite the environmental and other yield constraints encountered by the crop during the growth production period, the overall assessment showed that it is essential to considered the main commercial fraction like the seed yield performance of sunflower in choosing the level of organomineral and inorganic fertilizers for use in sunflower production. But, it's continuous using of inorganic fertilizers can cause nutrient in-balance and soil pH level. Only using of either organic or inorganic fertilizers cannot met the expected in increasing crop yield. In this aspect, the combined use of in organic chemical fertilizers and organomineral fertilizer can be suggested in sunflower production in order to increase seed and oil yield from per hectare (Schneiter, 1997; Makinde et al., 2010; Olaniyi et al., 2010; Süzer, 2010a; Süzer, 2012; Süzer, 2013; Süzer, 2014).

CONCLUSIONS

Sunflower is the important edible vegetable oilseed crop in Turkey and the world. In the current drive by Turkey to achieve vegetable oil sufficiency in sunflower production in near future, improved yield could be achieved by the use of organomineral and inorganic fertilizers. The results of this research showed a positive influence of organomineral and inorganic fertilizers on growth and yield components of sunflower plant over the control. Yield parameters in terms of seed yield and 1000 seed weight were found to be higher at all organomineral and inorganic fertilizers' treatment application than the control. Consequently, considerable increase in term of grain yield was brought about by applying before planting the sole application of 250 kgs Hexaferm® 6N.10P.10K organomineral fertilizer performed favorably well in terms of seed and oil yield of sunflower in dry land conditions in Edirne-Turkey. On the other hand, for balanced fertilization in sunflower the combined use of in organic chemical fertilizers and organomineral fertilizer can be suggested in sunflower production in order to increase seed and oil yield from per hectare.

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EFFECTS OF MICRO NUTRIENTS (FE, ZN, B AND MN) ON YIELD AND YIELD COMPONENTS OF TWO SUNFLOWER (*HELIANTHUS ANNUUS* L.) CULTIVARS IN URMIA CONDITION

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ABSTRACT

Appropriate soil fertility is necessary to obtain higher seed yield and quality of the crop. Application of chemical fertilizers as N, P and K in Iran is very high and often more than crop needs. One of the most important issues about increase of crop yield and improving the quality of agricultural products is balanced plant nutrition. Many researches indicated a positive influence of micronutrient application in increase of yield and quantitative parameters of crops. As well as, identification and accessing to cultivars which have high yield should be implemented. The aim of the study was to determine the effect of micronutrients on yield and yield components of two sunflower cultivars in Urmia condition. The trial was carried out at Nakhjavani Agricultural Research Center in Urmia, West Azerbaijan Province, Iran, using a randomized complete block design with split-plot arrangement in four replications, with cultivars in two levels (Golshid and Record) as main plot and application of fertilizer treatments in five levels (T_1: N+P+K+Mg; T_2: N+P+K+Mg+Fe; T_3: N+P+K+Mg+Fe+B; T_4: N+P+K+Mg+Fe+B+Mn; T_5: N+P+K+Mg+Fe+B+Mn+Zn) as subplot. The results showed that there were significant differences between two cultivars for all traits as: head diameter, seed yield, biologic yield, harvest index and thousand seed weight. Seed yield, harvest index and thousand seed weight, were significantly affected by fertilizers application. Cultivar and fertilizer application interactions have significant effects on seed yield, biologic yield, head diameter and thousand seed weight.

Keywords: Micronutrient, Cultivar, Sunflower, Urmia.

INTRODUCTION

Plants, like all other living things, need food for their growth and development. All green plants have the ability to manufacture their own food by using energy derived from the sun to combine chemical elements, taken up in the inorganic ion form, into a multitude of organic compounds. Lack of an important chemical element may slow a plant's growth or make the plant more susceptible to disease or even death. Seventeen elements are considered essential for plant growth. Some of these nutrients combine to form compounds which compose cells and enzymes. Others must be present in order for certain plant chemical processes to occur. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level, plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper amount of application and the placement of nutrients are important (Silva and Uchida, 2000; Rahimi, 2002).

Sunflower (*Helianthus annuus* L.) is quite responsive to micronutrients. The significant effect of micronutrient application on the growth of sunflower, in terms of plant height, number of leaves and dry matter production per plant can be interpreted in terms of enhanced metabolic function of micronutrients in the plant (Siddiqui et al., 2009). Application of high analysis NPK fertilizers and very limited use of farmyard manure cause micronutrient depletion in soils, which appears to have special role in influencing the test weight and seed filling (Tufail *et al*. 1990). The functions of B: necessary in the synthesis of one of the bases for RNA formation and in cellular activities, to promote root growth, essential for pollen germination and growth of the pollen tube, associated with lignin synthesis, activities of certain enzymes, seed and cell wall formation, and sugar transport. The functions of Fe: essential in the heme enzyme system in plant metabolism, part of protein ferredoxin and required in nitrate and sulfate reductions, essential in the synthesis and maintenance of chlorophyll, and strongly associated with protein metabolism. The functions of Mn: part of the plant enzyme system, activating several metabolic functions, a constituent of pyruvate carboxylase, oxidation-reduction process in photosynthesis, necessary in Photosystem II, and activates indole acetic acid oxidase. The functions of Zn: required in the synthesis of tryptophan, an essential component of several metallo-enzymes in plants, the enzyme carbonic anhydrase is specifically activated by Zn, and a role in RNA and protein synthesis.

(Silva and Uchida, 2000).

Positive effects of micronutrients on sunflower were reported in several studies by Rahimizadeh et al. (2010), El-Fouly et al., (2001), El-Fouly *et al.* (1990) and Abdalla and Mobarak (1992). Sunflower is also one of the most sensitive crops to low boron supply and deficiency and first symptoms appear on the younger leaves, which develop a bronze color and become hardened, malformed and necrotic, the stem becomes corky, the capitulum deformed, and poor seed set results (Blamey et al., 1987). Application of adequate fertilizers led to increase the crop yields, improved the nutrient element concentrations in plant tissue and soil macro and micronutrient status (Adediran et al., 2004). Keeping in view the key role played by Fe, Zn, B and Mn nutrition in plant growth, this study was designed to enhance the productivity of sunflower, by using micronutrients like B, Zn, Mn and Fe, under soil and environmental conditions of West Azerbaijan Province, Iran.

Materials and Methods

The trial was carried out at Nakhjavani Agricultural Research Center in Urmia, West Azerbaijan Province, Iran, using a randomized complete block design (RCBD) with split-plot arrangement in four replications, with cultivars in two levels (Golshid and Record) as main plot and application of fertilizer treatments in five levels as subplot is an follows:

T_1: N+P+K+Mg

T_2: N+P+K+Mg+Fe

T_3: N+P+K+Mg+Fe+B

T_4: N+P+K+Mg+Fe+B+Mn

T_5: N+P+K+Mg+Fe+B+Mn+Zn

The soil of the experimental field was loam sand in texture. It was low in organic carbon (0.63%), pH=7.7, the percentage of T.N.V=3.3%, Pava.=7.9 ppm, Kava.=130 ppm, Feava.=4.24ppm, Mnava.=3.9ppm, Znava.=1.32ppm, Bava.=1.16ppm. A uniform application of 350 kg ha^{-1} urea-N, 100 kg ha^{-1} P_2O_5 as triple super phosphate (TSP), 200 kg ha^{-1} K_2SO_4 and 100 kg ha^{-1} MgSO4 was given to all the plots. Fe as Iron sulphate (200 kg ha^{-1}), Zn as Zinc sulphate (40kg ha^{-1}), Mn as Manganese sulphate (30kg ha^{-1}) and B as Boric acid (30kg ha^{-1}), were were supplied as per treatment.the seeds were cultivated on 20 May and harvested on 23 September. Weather was satisfactory during the experiment for normal growth of the crop.

RESULTS AND DISCUSSION

The results showed that there were significant differences between two cultivars for all traits as: head diameter, seed yield, biologic yield, harvest index and thousand seed weight. In terms of all characteristics the Golshid (an Iranian hybrid) is better than Rcord (Table 1.). Seed yield, harvest index and thousand seed weight, were significantly affected by fertilizers application. In terms of seed yield, harvest index, and thousand seed weight, T_4 (41.79 g/plant), T_4 (25), and T_5 (48.64 g) are the best respectively (Table 2.). Interactions among cultivars and fertilizer applications have significant effects on seed yield, biologic yield, head diameter and thousand seed weight. In terms of seed yield, biologic yield, thousand seed weight, and head diameter, a_1b_4 (50.68 g/plant), a_1b_3 (188.13 g/plant), a_1b_3 (58.22 g/plant), and a_1b_4 (16.21 cm) are the best respectively (Table 3.). Rahimizadeh *et al.,* (2010) showed that micronutrient treatments increased the head diameter, seed per head, seed yield and oil percentage. El-Fouly *et al.,* (2001), showed that the number of leaves and the leaf area were increased by addition of Fe, Mn and Zn. Root size was increased by addition of Fe and Mn. Stem and root lengths were increased by Mn only.

Table 1. Effect of cultivars on seed yield, biologic yield, HI, 1000-seed weight and head diameter

Cultivars	Seed Yield/PL (g)	Biologic Yield/PL (g)	HI	1000-Seed Weight (g)	Head Diameter (cm)
Golshid	42.94 a	172.55 a	24.64 a	52.28 a	15.81 a
Record	29.74 b	150.27 b	19.96 b	38.50 b	12.27 b

Table 2. Effect of different nutritional elements on seed yield, biologic yield, HI, 1000-seed weight and head diameter

Fertilizers	Seed Yield/PL(g)	Biologic Yield/PL (g)	HI	1000-Seed Weight (g)	Head Diameter (cm)
T_1	28.89 c	158.92	18.47 c	42.41 c	14.63
T_2	33.55 bc	150.82	22.07 b	43.44 c	14.49
T_3	38.56 ab	163.71	22.87 ab	48.10 ab	14.12
T_4	41.79 a	164.50	25.00 a	44.36 bc	14.68
T_5	38.90 ab	169.08	23.07 ab	48.64 a	14.77

Table 3. Effect of different cultivar (A) and fertilizer (B) interactions on seed yield, biologic yield, HI, 1000-seed weight and head diameter

Interactions	Seed Yield/PL (g)	Biological Yield/PL(g)	HI	1000-Seed Weight (g)	Head Diameter (cm)
a_1b_1	31.61 de	148.65 ab	21.25	45.86 b	15.05 ab
a_1b_2	40.58 bc	173.98 a	23.27	48.21 b	16.02 a
a_1b_3	49.91 a	188.13 a	26.24	58.22 a	16.07 a
a_1b_4	50.68 a	185.67 a	27.32	54.86 a	16.21 a
a_1b_5	41.89 b	166.28 ab	25.10	54.36 a	15.67 a
a_2b_1	26.18 e	169.19 ab	15.69	38.96 cd	14.22 bc
a_2b_2	26.53 e	127.66 c	20.86	38.66 cd	12.96 de
a_2b_3	27.22 e	139.29 c	19.50	37.98 cd	12.17 e
a_2b_4	32.89 cde	143.33 c	22.69	33.87 d	13.14 cde
a_2b_5	35.90 bcd	171.87 a	21.03	43.03 bc	13.87 cd

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GLOBAL CHANGE ADAPTATION: WHAT FUTURE FOR SUNFLOWER CROPS AND PRODUCTS? A FORESIGHT STUDY FOR OILSEED CHAINS AT 2030 HORIZON

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ABSTRACT :

A foresight study was carried out to 2030 horizon (15 years), to shed light on the opportunities that will draw the oilcrops and grain legumes, and the areas of growth for the vegetable oil and protein sector. The thinking was organized in four different scenarios, illustrating different logical evolutions of the context and related key issues, under the pressure of demographic, economic and socio-political constraints. The economic value of the protein fraction is a key aspect of the future of oilseeds such as sunflower. However, a saturated market for oils falls within the trend but is not a certainty.

Keywords: Sunflower, oil and protein markets, vegetable oils, Vegetable proteins, oil crops, grain legumes, food demand, foresight, scenarios.

INTRODUCTION

What will be the outlets that pull the oil and protein crops in 2030? What will be the areas of growth for the oilseed sector? The reflection was launched by the French sector of oilseed crops and grain legumes, wondering about the recent evolutions in the relative economic value of oil and protein fractions in oilseeds, rebalancing the economic interest of the two co-products, oil and oilseed cakes.

Questioning "vegetable oils and proteins" brings back to the fundamental historical development of oil and protein crops in Europe, which is still very dependent on imported vegetable protein (Visser, 2013). But with a major change: when soy is still the market leader in plant proteins, now palm is leader on oils. Given this dynamic competitor from Asia, which produces more than 4 tons of oil per hectare per year when a sunflower crop produces about 1t/ha, the protein fraction is obviously part of the future of the oilseed crops. But the question needs to be reformulated in view of the demand both in quantities and qualities. Oils and vegetable proteins (and their origin commodities) are among the most traded agricultural commodities in the world: over 50% of global oilseed production is exchanged, when only a third of the sugar and 10% of cereals are (Mittaine and Mielke, 2013). The question must therefore be addressed, for part at global scale and at regional scale, since "regional" policies can strongly direct productions, as seen in the case of biofuels.

A working methodology based on the analysis, and a synthesis in the form of scenarios

The reflection was organized along the lines of strategic foresight methods (Godet M. 2007). A first step was to describe the "prospective system", by situating the heart of the vegetable oil and protein system in its context. The experts group developed a representation of the flow diagram of vegetable oils and proteins and their products, linking 21 elements of the agro-industrial system of oils and proteins, in a surrounding context described through 13 environment factors, or "regulators". Then, the various elements of this system were the subject of an information review. The analysis of past and present dynamics led the working group to make assumptions (145 in total) for 2030, in the trend or in rupture, for each factor or key variables.

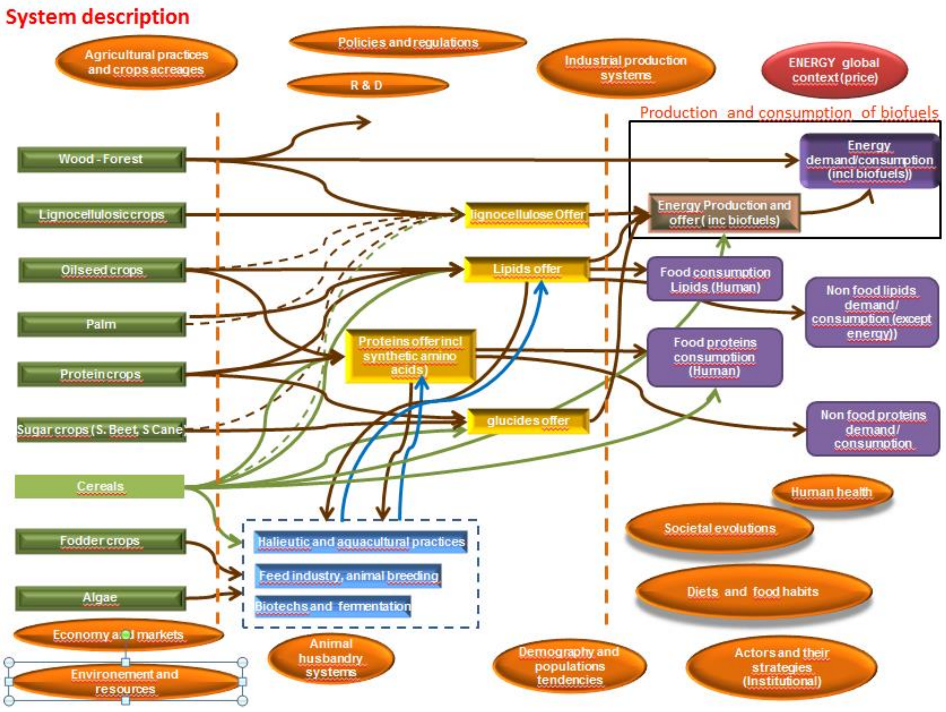

Figure 1: the protein-oil system and its context

Table 1 driving and main secondary assumptions

MAIN ASSUMPTIONS	2013	SC1 Chaos	SC2 Blocks	SC3 Trust	SC4 Climate rupt
Population	7,2	8,9	8,4	7,9	8,9
agricultural yields progress		stagnation	weak	moderate	stagnation
Per capita animal proteins consumption		low	moderate	high	low
Political behaviours regarding global change		passivity, everyone for himself	blocks policies	cooperation	cooperation
Economic growth		weak	moderate	high	moderate
petroleum price $/ barel // $/ton	105 //770	50-70 // 365-511	60-80 // 450-610	135/150 // 950-1100. contrasts between regions	135/150 // 950-1100 . contrasts between regions
animal protein consumption g/cap/day					
China	37	39	46	46	41
India	14	20	21	36	18
Africa	14	16	26	26	18
Europe	67	49	54	65	36
USA	70	55	61	66	43
World	31	29	34	39	29
Palm oil for food consumption MT/yr	41	"200MT"	42 à50MT	50MT	
nutritional recommendations are taken into account	0	no or poorly	yes	yes --> oméga3	yes --> oméga3
EU policies on biofuels	0	biofuels not mandatory	energy directive maintained/ biofuels mandatory	energy directive maintained/ biofuels not mandatory	
reinforced regulations regarding sustainability	0	no	carbon tax in Europe	yes, standardization	carbon tax and standardization
GMO regulations		deregulated	no crops no use in Europe	constraints lifted	constrainsts partially lifted
antibiotics uses in feed		free	prohibited	prohibited	?
green chemistry, biorefinery	0	stagnating	strong develpt	strong develop	strong develop

The construction of the structure of the scenarios was done using "morphological analysis," by assembling assumptions about different dimensions or variables by empirical judgment of the consistency, each scenario being based on one or more driving assumptions on key factors for the demand evolution. Table 1 shows notably the first 5 levels of assumptions assembly, which determine the overall level of demand and the socioeconomic tone, giving the thread of each scenario. The scenarios were then written in text form, as a first step of consistency check. A quantitative assessment was then carried out to check the consistency of the assemblies of assumptions made on variable estimates. These four scenarios, which illustrate different logics of context evolution and major issues, are summarized in the box below.

FORESIGHT STUDY 2030

VEGETABLE OILS AND PROTEINS

4 scenarios as thinking framework

Scenario 1: "Towards Chaos": Economic and political crisis, food tensions, competitions and growing inequalities

Facing the strong world population and the tangible effects of climate change, the situation is tense to meet food demand. The economic crisis, generating a climate of tension, insecurity and general impoverishment, does not allow the adoption of international agreements on long-term policies (resource conservation, environment, renewable energy, health ...). Animal proteins are a luxury: their consumption is declining in Europe (where the vegetable proteins are better accepted) and tops out elsewhere. With depressed energy prices, biofuels of first generation remain only to sell the oil surplus from palm and soy. The rising cost of food leads to increased use of plant proteins. Regarding vegetable oils, palm oil, abundant and inexpensive, dominates in the food business.

Scenario 2: "The might of the blocks": Regional Policies and bilateralism

Climate change leads to contrasting effects between regions: due to divergent interests, international negotiations are blocked. Europe and the most affected countries implement unilateral policies against climate change, in a latent protectionism atmosphere. Yields - and global production – increase slowly, for a population that is growing by 15% between 2013 and 2030. The economy keeps pace with the population and the standard of living is maintained on average. In Europe, society's demands on sustainability and health led States to develop renewable energy (including biofuels), to better exploit the potential of territories and to regulate: restrictions on greenhouse gas emissions and carbon tax. Biorefinery at regional scale and non-food uses of agricultural resources are essential. Veganism rises in Europe while consumption of animal protein progresses in China and Africa. Palm oil is used in chemistry, especially in Southeast Asia, and for biofuels.

Scenario 3: "Trust": International cooperation in preventing climate change

The Nations sense the threat of climate change and integrate it in their policies, creating an international cooperation to address climate, food and energy challenges, while maintaining free trade. Green Growth is launched, based on advanced R & D and the establishment of trading standards (on products, processes and production conditions) and accompanying measures, where Europe plays leader. European consumers are aware of the nutritional recommendations and of the carbon impact of production and consumption modes, and are turning to a low-impact diet. Quite the opposite, the improvement of living conditions linked to moderate population growth and economic affluence leads to increased consumption of animal protein in many countries (Africa, China, but also India) blowing the demand for animal feed. Soy is widely grown for feeding livestock. The oleochemistry and biofuels, driven by R & D and high energy prices, are growing strongly worldwide, especially in Asia on palm oil basis.

Scenario 4: "Climate rupture": Measures for savings and forced cooperation because of climate and food tensions

The strong growth of the world population and the effects of climate change put agricultural production under pressure and cap yields. This leads states to negotiate and cooperate in emergency as on environmental policies and at the level of technology transfer and of the distribution of economic efforts between the South and the North. Constraining measures target carbon balances and GHG, playing both on production processes through standardization and on consumption through a generalized carbon tax. Energy is taxed to finance the development of alternative energies. Advances in R & D are put forward to meet the constraints and generate green growth, opening applications to GMOs, green chemistry, the development of a circular economy with local bio-refinery. Initially driven by economic growth, the development of animal protein consumption proves unsustainable and quickly reaches limits in Africa and Asia. European consumers, made aware of issues of sustainability and health by the authorities, opt for a diet less rich in animal protein.

What developments for vegetable oils and plant proteins outlets?

In terms of vegetable oils, the increase in food demand remains relatively limited, from 133 Mt (million tons) in 2013 to 156-165 Mt in 2030, an absolute increase of 23 to 32Mt, relatively limited compared to the growth capacity of the palm oil production. We can therefore expect strong competition in the vegetable oil market with two heavyweights: the palm oil supported by its strong competitiveness in production cost per ton, and soybean oil, driven by the strong demand for protein for animal feed or food.

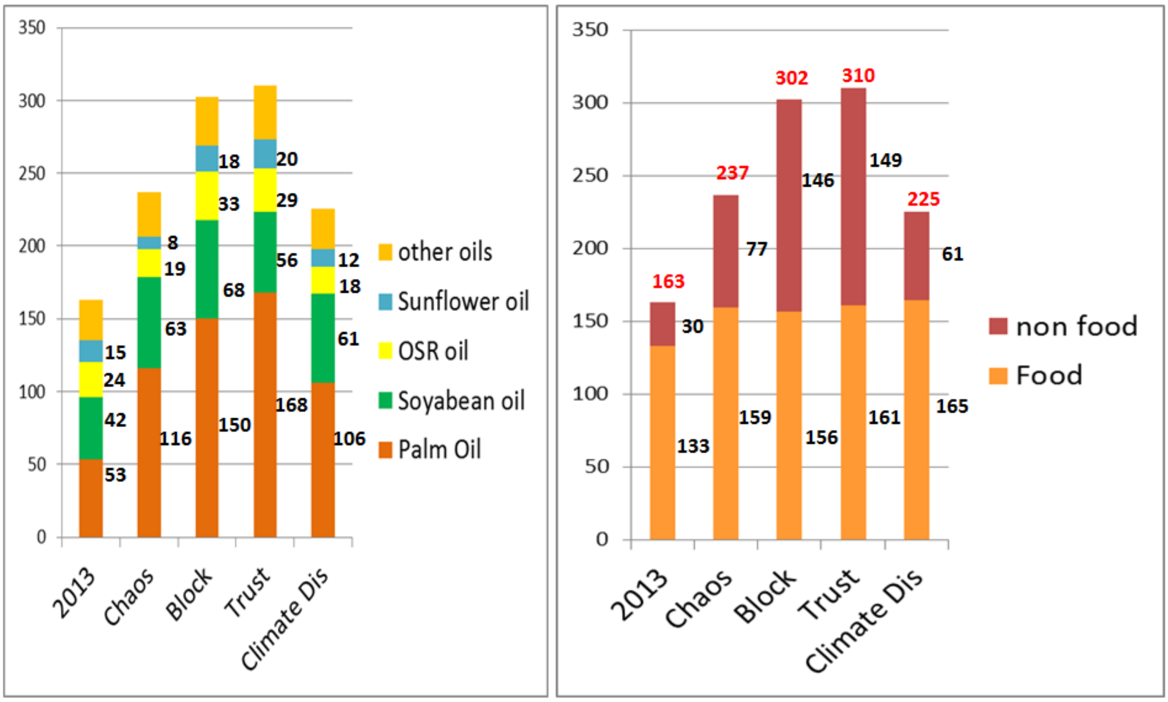

Figure 2: Global production and use of vegetable oils

The conditions for the development of non-food uses of oils are very different between scenarios: excess oil may be real, with need to dispose of surpluses for cheap non-food outlets (biofuels in Sc. 1 " chaos "), or artificial in case of real economic dynamics of non-food uses, either from a high energy market (Sc. 3" Trust "), or from technological innovation and / or incentives policies (Sc. 2 "Blocks"). In the case of Sc. 4 "climate rupture" excess oil over the food needs is relatively limited in a context where the resources scarcity, actual or of regulatory origin, makes nonfood uses economically attractive. This shows that if the strong growth of oil production seems to be a trend, the excess of the production is obvious in Sc. 1 only, where uses at low price only are possible, due economic depression. In other scenarios, noble non-food uses ensure alternatives for consumption and growth in an unbalanced world between scarce resources and the needs of an active economy. However, in the context of Sc. 1 depressed market, the development of palm could be challenged by soybean oil, as co-product from the production of protein for livestock. In scenarios with high oil prices and encouraging biobased products, palm development could be based on green chemistry, provided production is compatible with constraints related to climate change, at least in regulated scenarios (Sc.2, 3 and 4).

That said, the various oils are not completely substitutable and their technical and nutritional characteristics must also be taken into account. For example, the needs in short chains omega 3 fatty acids (alpha linolenic acid) are probably not covered today by soyabean and rapeseed production, or just covered taking into account other sources. In future, covering alpha-linolenic needs seems to be no difficulty only in scenario 3, with the lowest population.

The overall growth of food proteins of animal origin is estimated between 11 and 32 million tons of (pure) protein depending on the scenario, 26 to 39% more than in 2013. The multiplier effect of the consumption of animal products appears very clearly because of the conversion of animal proteins into vegetable proteins needed to produce them: from +52 to +141Mt (including fodder) or +16 to +41% depending on the scenario. Whatever the scenario, the growth of plant proteins for animal feed is high and exceeds the human food destination, but much more pronounced in Sc.2 and 3, more demanding in animal protein, than in Sc. 1 and 4, where the increase in materials rich in protein (fodder excepted) is almost evenly distributed between feed and food.

Table 2: Quantities of vegetable protein to meet demand in the four scenarios

	2013	SC1	SC2	SC3	SC4
Million tons of protein	**Present**	**Chaos**	**Blocks**	**Trust**	**Climate rupt**
Feed fodder	112	153	148	162	129
Feed "rich in proteins"	**227**	**264**	**315**	**316**	**261**
Food	**139**	**174**	**159**	**146**	**168**
ratio Food/(Feed rich. + Food)	**0,38**	**0,40**	**0,33**	**0,32**	**0,39**

Regarding vegetable protein for human nutrition, Sc. 3, which combines economic growth, low population growth and “meat” dietary habits shows the lowest increase (+5.2 %), followed by Sc. 2 (+ 14%). In Sc. 1 and 4, the increase exceeds 20%. The ratio "Food" proteins/ Protein concentrated "Feed + Food" proteins shows a discrepancy between scenarios 1 and 4 on the one hand, where the relative weight of vegetable protein for human consumption increases, and scenarios 2 and 3, where it decreases.

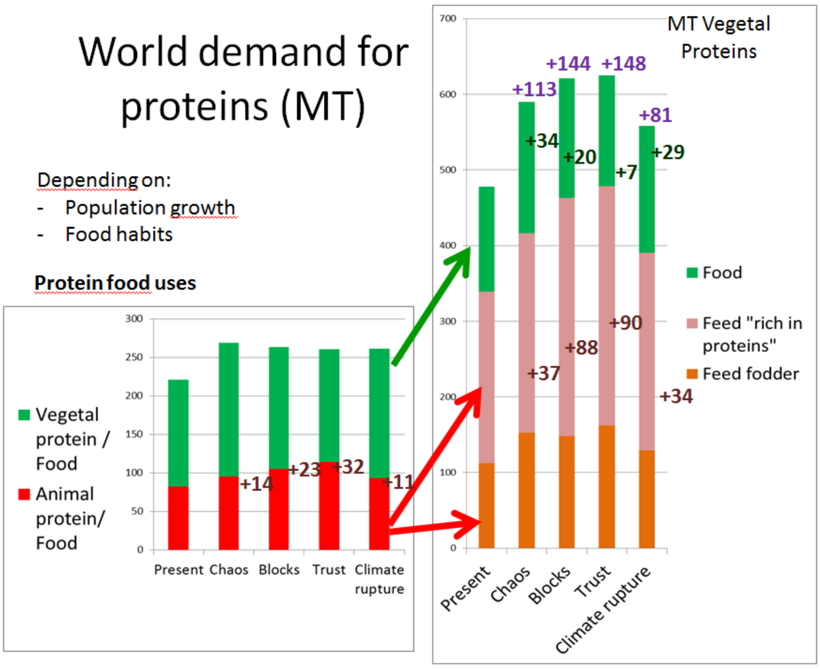

Figure 3: Evolution of demand for proteins in the 4 scenarios

The vegetable proteins that would be provided in the various scenarios are not targeted to the same uses or in the same proportions, and in rather different market conditions: Sc. 3 "Trust" demands masses of proteins for animal feed, without differentiation on the GMO origin regarding Europe, but with more regular qualities, notably because of the disappearance of antibiotics in animal production. The growth of plant proteins for food is the lowest, but also more qualitative from a nutritional point of view, and more "technological" with an R & D driven by the needs of wealthy clients and / or with special needs (elderly, athletes). The vegetable protein is desired for nutritional and technological properties and image. Sc. 2 "blocks" demands for livestock protein masses too, but this time with differentiation of Europe, on the GMO origin and on the nutritional quality through technically more restricted feed system. The growth of plant protein for food is higher than in scenario 3 but with the same "nutritional and technological" profile globally. Sc. 1 "Chaos" demands protein masses for breeding, but for animal feeding systems with few constraints on technical practices, guided mainly by production costs reduction. As for vegetable protein for food, their development is driven by the preoccupation to offer cheap alternatives to animal proteins to impoverished populations, either as raw or minimally processed vegetable products, either as vegetable industrial products or combining animal and vegetable proteins. The role of plant protein is primarily economic. In Sc. 4 "climate rupture," the technical constraints on animal feeding are at an intermediate level and above all guided by the carbon balance sheets. Regarding food, the quality / price ratio is more strongly driven by the dietary and nutritional considerations and health concerns, and respect for the environment (image). At last, the development of aquaculture, with specific protein needs, is a constant of the scenarios.

Will the production be able to follow the demand?

The assessment of the demand in different contexts is not enough: we must ensure that supply can follow, taking into account the constraints on production. The calculations allowed us to assess the needed acreage to meet the demand for our scenarios in 2030(table 3).

Table 3 *orders of magnitude* of cultivated acreage development required in the 4 scenarios

Acreages in million ha	2013	SC1	SC2	SC3	SC4
world cultivated acreage, foddder crops excluded	1287	1461	1472	1362	1457
world cultivated acreage, fodder crops included	1534	1767	1764	1656	1731
world cultivated acreage variation, fodder crops excluded		**174**	**185**	**75**	**170**
cultivated acreage variation fodder crops included		**233**	**229**	**122**	**197**

Given the assumptions, between 75 and 185 million more hectares would be needed to meet the needs for "monogastric" quality feed, and from 122 to 233 including forage crops. The continuation of the pace for land reclamation observed between 1961 and 2000 (rate of 3.75Mha/yr on average) would make 67.5 million hectares by 2030 (18 years). The reverse calculation shows that the land reclamation rate required for the consistency of each scenario would be respectively 3.5, 3.4, 1.7 and 2.9 times the rate of past decades. The likelihood of those figures is subject to discussion, especially with depressed economy. The limit of these extensions of cultivated acreage also lies in the deforestation and greenhouse effects, even if part of the effort can be done without deforestation (INRA CIRAD, 2009). Pursuing further the reflection shows that balancing supply and demand always questions the development dynamics and sometimes asks to reconsider some assumptions, particularly in terms of ambition on improving the diets protein content. The strategic aspect of improving yields at world level (particularly protein yields) is highlighted, and the importance of climate risk in terms of global average yields evolution.

Meeting the needs will be much harder for vegetable proteins than for oils and fats, and will require to play on all levers: food consumption level, waste reduction, productivity.

So it is very clear that protein production is an important part of the future competitiveness of oilseed crops, among them sunflower.

How changing context might affect the competitiveness of different oil & protein crops?

The scenarios highlight issues and technical and scientific challenges that the different crops and agro-industrial sectors can meet more or less easily. We suggest in table 5 an interpretation of the specific characteristics of sunflower as strengths or weaknesses in the different scenarios, i.e. as existing advantages or areas of progress through R&D or value chain organization.

Table 4: composition, protein and oil yields for major crops

Composition, yields, oil and protein yields for main crops/ yields						World (FAO)			Europe (FAO)		
Crop	%	% on product for use				Average yield 2009-2013	aver. oil yield	aver. protein yield	Average yield 2009-2013	aver. oil yield	aver. protein yield
	DM	starch	oil	protein	others	t/ha					
soya	89%	5,7%	18,9%	35,2%	29%	2,5	0,5	0,9	2,65	0,50	0,93
sunflower	93%	1,2%	44,5%	15,4%	32%	1,2	0,5	0,2	2,33	1,04	0,36
rape	92%	3,1%	42,6%	19,3%	27%	1,9	0,8	0,4	3,56	1,51	0,69
pea	87%	44,4%	1,0%	20,7%	22%	1,6		0,3	3,82		0,79
maize	87%	63,7%	3,6%	7,9%	12%	5,2	0,2	0,4	9,36	0,33	0,74
wheat	86%	59,3%	0,0%	10,8%	15%	3,1		0,3	7,15		0,77
Forage and Silage alfalfa	20%	0,0%	0,0%	4,0%	16%	22,0		0,9	42,50		1,70
Forage and silage, maize	23%	3,5%	0,6%	1,9%	17%	34,6	0,2	0,7	39,60	0,24	0,75
Forage and silage, sorghum	28%	0,0%	0,5%	2,3%	25%	20,4	0,1	0,5	35,20	0,19	0,81
Forage and silage, rye grass	17%	0,0%	0,0%	2,5%	14%	10,3		0,3	9,60		0,24
Forage and silage, clover	17%	0,0%	0,5%	4,2%	12%	34,1	0,2	1,4	23,20	0,11	0,97

Table 5: Sunflower characteristics, Strenghts (S) and Weaknesses (W) in scenarios (N = Neutral)

Sunflower characteristics	***level***	**SC1 Chaos**	**SC2 Blocks**	**SC3 Trust**	**SC4 Climate rupt**
Dependance on nitrogen	medium	**N**	**S**	**S**	**S**
Dependance on pesticides	medium	**N**	**S**	**N**	**S**
Rusticity	high	**S**	**S**	**N**	**S**
Compensation capacities	weak	**W**	**N**	**N**	**W**
Protein digestibility/ feed	high (dehulled)	**S**	**S**	**S**	**S**
protein digest & quality/ food	???	**S**	**N**	**N**	**S**
ability to dehulling	good	**S**	**S**	**S**	**S**
miw oil and protein specy	44%oil/15%Pi	**W**	**N**	**S**	**S**
of fatty acids profiles	yes	**S**	**S**	**N**	**N**
yield level	relatively low	**W**	**W**	**W**	**W**

Some issues are common to all scenarios: it is the case for the protein economy, i.e. both protein productivity and efficiency of use of the produced proteins. The protein yield per hectare is a fairly discriminating criterion between species, which will play depending on the relative performance of crops in the different parts of the world. Only forage legumes such as clover or alfalfa today exceed a ton of protein per hectare. If these species are now mostly devolved to ruminant animals, protein extraction can change things and forage legumes competitiveness could increase, both in the field of conventional feed and in the area of concentrates and protein isolates. Then come pulses and soybeans, which reach protein yields of around one ton/ha, followed by rapeseed (0.4 to 0.7 t/ha) and sunflower (0.2 to 0.4). Their global competitiveness will also come from their co-product, oil or starch. In this regard, sunflower is not very competitive: global yields are the first priority, before a specific focus on protein yields.

In the scenarios that show a significant development of the biorefinery (Sc. 3 and 4), the different species ability to easy extraction of vegetable protein may be an advantage. From this point of view, the pulses already fall in well-established industrial processes, while the extraction of protein from oil crops species will require changes in industrial processes, to avoid the protein fraction degradation in the present crushing-oil extraction process.

The efficiency of proteins use in animal feed is already a strong competitiveness criterion whose importance is expected to increase, both for economic and environmental reasons. Sunflower progressed in this aspect by including dehulling in the process and developing cultivars more adapted to dehulling. Alternative biorefinery processes for soft and direct oil and protein extraction would be an area of progress for sunflower.

The functional and technological properties of proteins from different species will be a determining criterion, especially as uses will be advanced in nutrition (health food: Sc.3 and 4) and / or technology (use of vegetable protein in food industries for their functional qualities and as substitute for animal protein: Sc.1, 2 and 4). Today the characterization of plant proteins of species grown in Europe, including sunflower, is still limited. These qualitative aspects also play in the ability of different species to meet the needs of aquaculture.

As for oil crops, fatty acids profiles could contribute to differentiate species on the edible oils market. Sunflower remains an oil crop first, and the past and current works for cultivars with specific fatty acids profiles, like High Oleic, or High Stearic High Oleic, or low saturated profiles, etc… will certainly play significantly in its future competitiveness. Regarding human nutrition, minor compounds like tocopherols are also a way to develop the sunflower attractiveness as edible oil.

Other issues and challenges relate to some of the scenarios only. Thus, the production of vegetable protein for human consumption is much higher in Sc. 1 and 4, and should quite naturally benefit pulses and soya, which are already current in the eating habits of many countries, like India, which may well become a structural importer. The fact that sunflower seeds do not content anti-nutritive or toxic compounds gives good opportunities for food uses, even if its amino-acid profile is low in the essential amino-acid lysine. Perhaps more attention could be given to proteic and amino-acids profiles, like for amino-acids until now.

Sc. 2 "blocks" presents a huge challenge for supplying Europe with non-GMO protein, which would lead to make better use of the European territory with the most suitable species and production systems to this objective. Sunflower could well contribute to this challenge, due to a large set of non GMO cultivars and to its rusticity or ability for cropping in contrasted conditions.

The synthetic nitrogen fertilizer requirements for agricultural production would penalize rapeseed, and sunflower too, to a lesser extent, and would favour grain legumes, forage legumes and soybeans in scenarios setting either carbon taxes (Sc. 2 and 4) or restrictive production standards on nitrogen and carbon energy (Sc. 3). Sunflower is relatively nitrogen efficient, and developing this characteristic would be advantageous in 3 scenarios at least.

Developments related to climate change will play in contrasting ways in different parts of the world. In Europe, more stressful conditions are expected. Heat peaks and drier prolonged periods in spring and summer would disadvantage spring crops in rainfed conditions.

Sunflower has the relative advantage of some rusticity, but its compensation capabilities are limited by the nature of its yield components.

The future competitiveness of different crop species depends on many factors (economic, political, climatic, social ...), who will play differently depending on the regions of the world, and whose the result is difficult to imagine. We venture to offer a synthesis of the outlook for different species according to their current characteristics and without assuming the future success of any current or future research and development measures (Table 5).

Table 6: Crops potential progression by 2030, based on their current features.

Crops potential progression by 2030	SC1 Chaos	SC2 Blocks	SC3 Trust	SC4 Climate rupture
WORLD				
Rapeseed	-	++	+	-
sunflower	-	+	+	-
Soyabean	++	+++	++	++
Grain legumes	++	+++	++	+
EUROPE				
Rapeseed	-	-	=	--
sunflower	-	--	-	--
Soyabean	+++	+++	++	+++
Grain legumes	+	+++	+++	+++

Table 7: Challenges for Sunflower crop chain	**SC1 Chaos**	**SC2 Blocks**	**SC3 Trust**	**SC4 Climate rupt**
Crop adaptation to climate change				
Yield T/ha & economic competitiveness				
Protein yield/ha				
Nutritional quality of oil				
Soft process for protein and oil extraction / biorefinery				
Uses of proteins for human nutrition and food industries				
priority level	*secondary*	*medium*	*high*	

This outlook may appear as pessimistic for sunflower; it shows the importance of the challenges. Compared to other sources of oil and/or proteins, sunflower is actually disadvantaged by its yield level. But we may consider that it has two main categories of assets, which are on one hand its rusticity, which makes it suitable to make profit of very diverse conditions (relatively dry, short seasons, double seasons, etc…), where other species are not suitable or not more profitable, and on the other hand specific characteristics regarding quality for oil and probably for proteins. We may attempt to propose priorities between the main challenges for sunflower in the 4 scenarios, as a preparatory step for further reflections for elaborating R&D strategies (table 7).

Conclusions: Is the protein fraction the future of oilseeds?

It seems clear that the economic value of the protein fraction is a key aspect of the future of oilseeds such as sunflower. The future tension for proteins at world scale appears quite certain. At the first level of approach, the yields and protein yields of the different crops will determine their competitiveness for mass uses, including animal feed. At the second level, the issue of nutritional and functional properties of proteins from oilseeds must be considered, with a vast field of exploration to enhance uses with higher added value, in human nutrition, feed, and technology. From this point of view, soy is much more advanced than rapeseed and sunflower and grain legumes. The effective use of proteins from sunflower will also require technological research and adaptations of industrial extraction processes.

That said, the scenario of the oil flood is a trend ... but not absolute certainty, especially if oleochemistry shows economic developments in Asia. Vegetable oils are noble natural materials which may be used in many ways, depending on their fatty acids profiles, the first one remaining food for which sunflower oil has well-established qualities.

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ESCAPE TO TINY BUG (*NYSIUS SIMULANS* STÅL) ATTACK ACROSS PLANTING DATE ADJUSTMENT IN SUNFLOWER HYBRID SEED CROPS FROM SOUTHERN BUENOS AIRES PROVINCE, ARGENTINE.

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ABSTRACT

During 2014-15 growing season, tiny bug (*Nysius simulans* Stal.) became a serious plague in the Southern Buenos Aires Province, Argentine. The insect reach an incidence level >900 individuals per head (i/head) and seriously decreased the yield of sunflower hybrid seed. Insecticides could reduce pollinator activity during R4-R6 stage, and did not reach the floral involucres at R7-R9 stage. A sample of 32 commercial plots (≈1000 ha, 5 female lines) with early (EP = October) or late (LP = November) planting dates was studied. At the peak of plague attack, during last week of January, the EP crops showed R7 stage and incidence was > 75 i/head. At the same time, the LP crops showed R4 stage, incidence was < 50 i/head and never overcome this level. In spite of average 2-3 insecticide applications, hybrid seed yield of EP crops was (**) less than a half of LP (1.1 t/ha). This fact was associated with increase (> 10%) of seed set (*) and seed biomass (**). In spite the bug herbivory did not affect the tetrazolium test (> 94%), it produces small holes which decreases germination across a reduction of normal seedlings. Germination of EP seed (88%) was 9% less (**) with respect to LP. At planting time, the field emergence of hybrid seed obtained by EP was 17% less (**) than the obtained with LP (87%). Under plague attack risk, it is recommended to escape the tiny bug peck by means of planting date adjustment.

Key words: *Nysius* sp., Seed quality, Pest escape.

INTRODUCTION

The valley of Colorado River, in southern Buenos Aires province (VBRC), is a healthy area which constitutes the main sunflower seed production area from Argentina (Cantamutto et al. 2008). The valley comprises ca. 90,000 ha with gravitational watering, devoted to onion and forage crops (Lucanera et al. 2014). Sunflower hybrid seed production comprises around 10% of the irrigated acreage.

In South America, tiny bug, *N. simulans* Stål (Hemiptera: *Lygaeidae*) is distributed in Paraguay, Uruguay, Peru, Brazil and Argentina. This polyphagous species was registered feeding several crops and broadleaf weeds in Argentina (Molinari and Gamundi 2010). While the tiny bug had been present in the VBRC for more than a decade ago, no history was documented about its direct impact on crops (Dughetti et al. 2015).

Nysius simulans is a polyphagous suctorial insect that draws water and nutrients. Their saliva transmits toxins and spreads pathogens (Dalazen et al. 2014). Usually, the plague invades crops after host senesce at the end of summer (Demirel and Cranshaw 2006, Charleston 2013), as had been observed on the *Conyza* sp./soybean complex in Brazil (Dalazen et al. 2014). At northern and central regions of Argentina, tiny bug attacks generally account during early crops stages of soybean or sunflower (Molinari and Gamundi 2010). The *Nysius* sp. attacks at advanced growth stages of sunflower had been registered in Australia (Forrester and Saini 1982) and Pakistan (Kakakhel and Amjad 1997).

During December 2014, the VBRC was suddenly affected by this new biotic threat to regional crops. Although the tiny bug attack was first observed feeding horticultural crops, soon it became extremely notorious on sunflower crops. This paper examines the seasonal effect of *N. simulans* on sunflower hybrid seed production and seed quality during the spring-summer cycle 2014-15.

MATERIALS AND METHODS

The population dynamic of *N. simulans* was monitored on two sunflower crop planted at early (EP = October 12 2014, 39°24´S, 62°38´W) or late (LP = November 15 2014, 39°18´S, 62°32´W) dates. Both crops were sampled at weekly intervals since pre-flowering (R4, Schneiter and Miller 1981) until physiological maturity (R9), during January to April 2015. Sampling was done on thirty plants, randomly selected in each crop. Adults and nymphs of *N. simulans* were separated from the heads by hand and the number recorded as individuals per head (i/head).

The impact of plague feeding on sunflower hybrid seed production and quality was measured on 32 commercial lots during 2014-15 growing season. The sunflower hybrid seeds lots were produced under controlled conditions for private companies. The geographical distribution of the studied lots was representative of the VBRC agroecological conditions (Fig. 1). Planting date, insecticide applications and unitary yield of each lot (kg ha^{-1}) were registered. The study comprises 5 female lines, with 20 to 100 ha per lot surface, totalizing ≈1000 ha. After physiological maturity a samples of heads were random hand harvested (n = 8), air dried and threshed in the laboratory. Each head were evaluated for 1000-seeds weight (14% moisture basis) (ISTA, 2013). Achenes were manually separated into empty and nonempty (filled). Seed setting efficiency (seed set) were calculated according eq. 1.

Seed set = (nonempty achenes / (nonempty + empty achenes)) x 100 (eq. 1)

Germination was evaluated immediately after harvest, during February to March of 2015. Nonempty (filled) seeds were submitted to method for dormancy breaking. Achenes were dried at ambient condition (28°C±2°C; 72 h) and soaked 24 h between towels wetted with a gibberellic acid (GA_3) solution at 0.05% in water (Seiler 1998). Germination test was carried out in sand in groups of 100 seeds (n = 3) in a climate-controlled chamber at 20°C during the 12 h dark period and 30°C during the 12 h light period (ISTA, 2013). Final value of germination was measured at 10 days.

At the same time, seed viability was estimated by tetrazolium test on samples of 50 achenes (n = 3). Embryos were separated from achenes after 17 h of water hydration. Embryos were placed in a 0.5% tetrazolium solution during 4 h and classified as completely dyed (viable), partly dyed, or not dyed (inviable) seeds. Location, size of undyed areas, and intensity of dyeing was considered according to ISTA (2013). Small undyed spots of some tissues due by *Nysius* damage were registered.

The seed were stored at 10±2°C (≈ 50% H°) since harvest up to planting season during seven months (October 29 2015). Thereafter, field emergence was assessed in a sandy loam soil (pH = 7.5, soil organic matter = 1.2 %, available P Bray & Kurtz = 24 mg kg^{-1}) at field capacity (21%) located in Hilario Ascasubi Experimental Station. One hundred seeds were manually sown at 30 mm deep in single row plots, 1.5 m long and 0.2 m apart, under a randomized block design with three replicates. Emergence (V2 stage) was counted at 8 and 14 days after sowing.

Analysis of Variance (ANOVA) considering early (EP = October) and late (LP = November) planting dates factors was performed using InfoStat software (2014). The relationship between valuable parameters was analyzed by regression analysis (GraphPad 6.0, San Diego, California, USA).

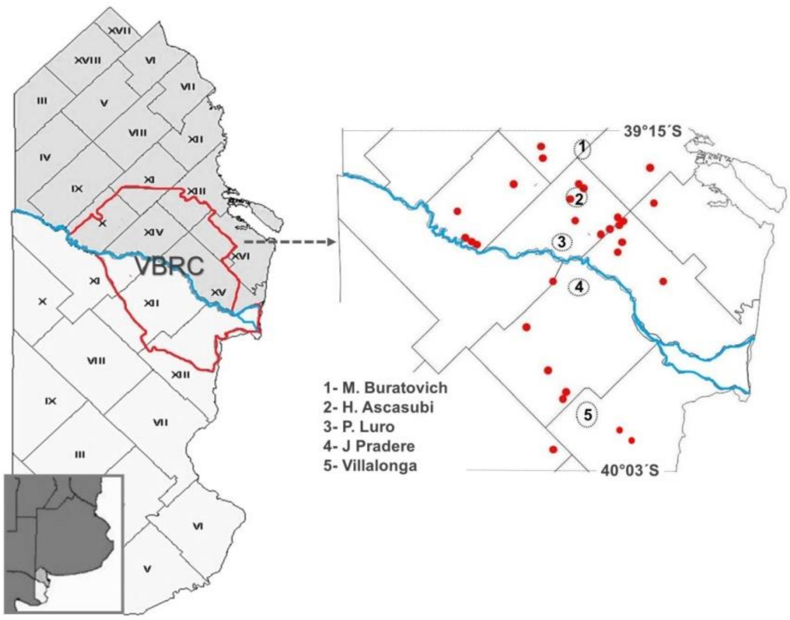

Figure 1. Geographical distribution of the sunflower hybrid seed production lots studied in the VBRC during 2014-15 growing season.

RESULTS AND DISCUSSION

During 2014 winter only 17 frosts at ground level were recorded (Renzi et al. 2015). This value was equivalent to less than half of the observed in the previous two winters, which not tiny bug attacks was happened. The fewer frost number could have reduced the field mortality of winter resistant individuals. Moreover, the conditions for winter growth of annual weeds, with 28% more rainfall in relation to the historical average (1960-2013) were excellent. Thus, an initial high population size at the end of the winter could have been possible the extreme values observed and outbreak of the pest. *Nysius* sp. is highly mobile, and can migrate from alternative crops or no-cultivated habitats to sunflower and congregate upon them causing significant injury (Demirel and Cranshaw 2006).

The tiny bug was detected on sunflower during the first half of December 2014 and the highest incidence of pest was recorded during January and early February 2015. The highest density of pest individuals was concentrated in the head, reaching extremes values over 900 i/head. Individuals mainly refuge between paleas of disk flowers. To a lesser extent, individuals were located between head bracts, upper leaves and in the stem segment near the head.

The infestation pattern dynamic of *N. simulans* on the sunflowers in the VBRC was consistent with those described by Smith and McDonald (1982). According Charleston (2013) the damage threshold ranks between 10-50 adult bugs per plant, depending of growth stage. In the VBRC, during 2014-15 season adults invaded the sunflower at the flowering stage and suddenly overcome these values in EP crops. During seed filling period (R6-R9) of EP crop the plague reached incidence levels over 75 i/ head, but it was less than 25 i/head at LP (Figure 2). As the plants senesce and dry off, there was a general incidence declination. Presumably adults began to disperse away searching for overwintering refuges, in response to the photoperiod and temperature decreases (Smith and McDonald 1982). Understanding the lifecycle of *Nysius* sp. is extremely necessary to adjust the chemical control decisions (Charleston 2013).

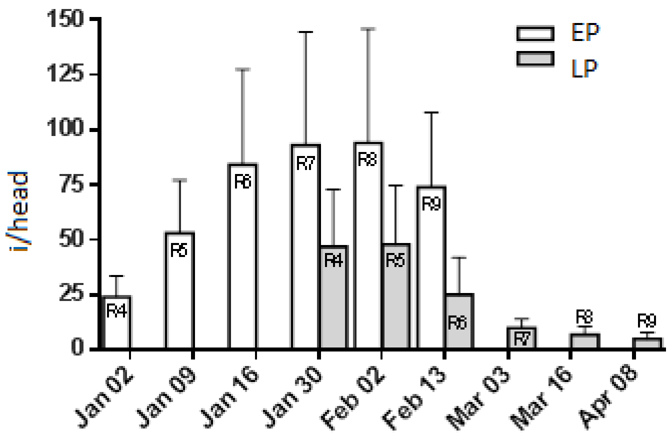

Figure 2. Incidence of *Nysius simulans* (Stål) on sunflower heads (i/head) under EP (October 12 2014) or LP (November 16 2014) planting dates. Rn means sunflower growth stages (Schneiter and Miller 1981)

Given the re-infestation of the plague, it was recorded cases with more than three insecticides applications during the R5-R6 stages, with a higher number of applications under EP (Table 1). The insecticide applications slightly reduced the set efficiency (R^2 = 0.04 *), probably due for the insecticide effect on pollinators activity. It was observed a general improvement of hybrid seed yield with LP dates (November). This improvement was associated with a declination of pest density during the flowering and fruit filling stages (Figure 3). With the delay of planting date (November), the yield improvement was associated with an increase of seed set and 1000-seed weight (Table 1).

The tiny bug feeding reduced the development of the embryo and achene, affecting germination (Kakakhel et al. 2000). However in this evaluation, bug herbivory did not affect the tetrazolium test (> 94%), but produces small holes which decreases germination value due a reduction of normal seedlings. Germination of EP seed (88%) was 9% less (**) with respect to hybrid seed harvest in plots planted during November (Table 1). Also the field emergence at 8 and 14 days after planting was higher when hybrid seed was harvest on LP crops.

Due climate change, tiny bug might challenge sunflower hybrid seed production activity in the near future. It was observed a general improvement of yield and seed quality at late planting date (November), possibly because the flowering occurred when the population pest density decreased. Under plague attack risk, it could be recommended to escape the tiny bug population peck by means of planting date adjustment.

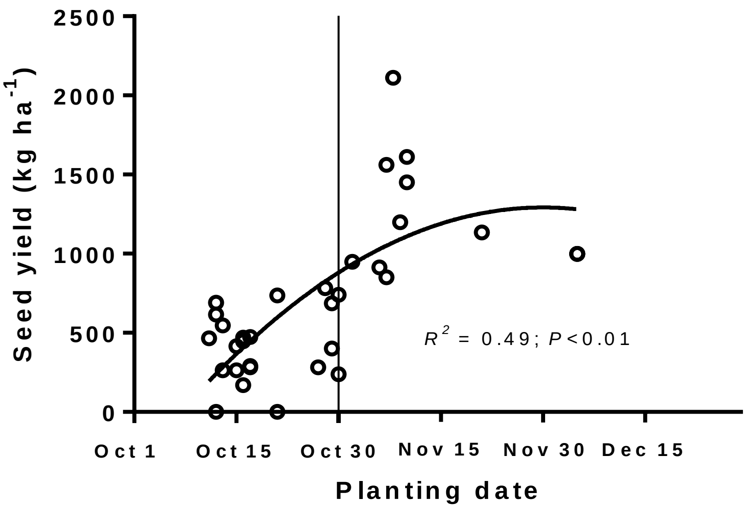

Figure 3. Effect of planting date on the yield of a sample of hybrid sunflower seed lots harvested in the VBRC during 2015. Vertical line (—) show the limit between early (= October) and late (= November) planting date.

Table 1. Effect of planting date on the seed yield, yield components and seed quality of sunflower hybrid seed

Traits	Planting date		
	EP (October)	LP (November)	
Seed production lot			
Insecticides applications (n)	3.3	2.5	**
Seed set (%)	38	47	*
1000-seeds weight (g), at 14% H°	65	79	**
Seed yield (kg ha^{-1})	460	1147	**
Produced seed			
Viability - tetrazolium test (%)	94	99	ns
Germination (%)	88	97	**
Field emergence, 8 days after sowing (%)	70	87	**
Field emergence, 14 days after sowing (%)	79	91	**

*, ** significant differences between planting dates at P < 0.05 and 0.01; ns not significant

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SUSTAINABILITY OF SUNFLOWER PRODUCTION FROM THE POINT OF PRODUCERS

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ABSTRACT

Vegetable oil consumption has constantly increased due to both rapid population growth and increased consumption per capita in Turkey. However, considering the charecteristics of climate and soil, though the production of oil seeds has a big potential, sufficient increase in sowing area and production has not occured. Because of insufficient production to meet consumption, the gap that has gradually increased in the important amounts of vegetable oil has met by importation. The most produced oil seed in Turkey is the sunflower because of its 85% pay in the consumption of vegetable oil and its high oil content. However, although the support that closes the gap in sunflower production and provides sustainability of production, the production increase desired is not provided since the parity between sunflower and wheat is in favor of wheat and the sunflower costs are much more than those of alternative crops. Thus, only 34% of the total supply of sunflower oil is produced from the sunflower seed domestically. Therefore, sunflower seed for oil is the most important crop to decrease the gap of vegetable oil. In this study, the factors that sunflower producers consider to increase/sustain their production and the necessary factors for them in a support policy are analysed by Best-Worst method. The results of the face to face surveys of 264 producers in 5 provinces who produce 69.3% of sunflower seed for oil in Turkey are used in the study.

Key Words : Sunflower oil, Sustainability, Support, Best-Worst Analysis

EVALUATION OF APPLICATIONS OF THE SUPERVISION PRICE AND CUSTOMS DUTY IN SUNFLOWER FOREIGN TRADE

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ABSTRACT

Oilseeds and vegetable oils have the biggest foreign agicultural trade gap in Turkey. Insufficient production to meet consumption is the main cause of this situation. Moreover, the increasing need of vegetable oil increases this gap further. To decrease this so-called gap and dependence on foreign trade, the oilseeds production that is source of raw materials in vegetable oil production should be increased. Sunflower for oil that is the most produced crop and have the big share in oil consumption in Turkey is the most privileged crop to decrease the gap of vegetable oil. However, the sunflower seed produced domestically meets only18% of the total vegetable oil demand. The rest of it is met by the importation of seed and raw oil. This situation cause Turkey to be among importing countries, processing industry to be depenedent on imported products. Therefore, the applications of supervısıon prıce and custom duty ın raw sunflower oil foreign trade are important to protect the domestic production from lower prices and sustain the production of it. In this study, the aim is to evaluate the impacts of the applications of supervısıon price and custom duty to protect producers on sunflower foreign trade and other sectors and to develop suggestions.

Presenting author : Dr. Kemalettin TAŞDAN

Key Words : Vegetable Oils, Sunflower, Supervision Price, Customs Duty

DETERMINATION OF THE YIELD AND YIELD COMPONENTS PERFORMANCE OF SOME SUNFLOWERS (*HELIANTHUS ANNUUS* L.) UNDER RAINFED CONDITIONS

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ABSTRACT

The objective of this study was to determine the yield and yield components of oilseeds sunflower cultivars in semi-arid conditions. The study was conducted at the experimental field of Ahi Evran University in a randomized complete blocks design with three replications during the years of 2012 and 2013 in Kırşehir. Ten sunflower cultivars grown in semi-arid conditions (Bosfora, Hornet, Sanbro, Sanay, Tunca, Transol, Oliva, Tarsan, Sirena, ve Reyna), were used in the experiment. The characters investigated were days to flowering, physiological maturity, plant height, head diameter, thousand seeds weight, oil content, seed yield, hull-kernel ratio, protein rate and crude oil yield. According to the results of this study plant height, physiological maturity, plant seed yield per plant of the varieties changed between 107.6 - 137.7 cm, 130 - 134 days and 35.9 - 52.8gr/plant respectively. Tunca had the highest seed yield with 152.8 kg/da. The highest crude oil ratio (53.7%) was observed from cultivar Sirena, while the lowest one (49.3%) was observed from cultivar Transol. Crude oil yield ranged from 60.2 kg/da (Sirena) to 82.0 kg/da (Bosfora). In considering with the seed and crude oil yield, cultivar Transol, Tunca and Bosfora can be recommended for the semi-arid conditions.

Key words: Sunflower, Helianthus annuus L., yield, crude oil rate

INTRODUCTION

Sunflower is the most widely cultivated oilseed plant in Turkey. To meet the rapidly growing demand for vegetable oil, the production of oilseed plants, and especially of sunflower, has been increasing countrywide. In 2015, sunflower seed production in Turkey was approximately 1.5 million tons, with 570,000 hectares of land dedicated to the cultivation of this crop. Owing to its high adaptability to arid conditions, sunflower cultivation is fairly widespread in the Central Anatolian region of Turkey, with 292,960 tons of sunflower seeds being produced over 71,890 hectares of land within this region in 2015 (Anonymous, 2016). Although sunflower is a highly adaptable plant, varieties might exhibit different responses in different ecologies, leading to considerable variability in terms of both yield and yield characteristics (Baydar, 2000).

Nearly all of the sunflowers cultivated in Turkey for oilseed production are hybrid varieties. As hybrid sunflowers varieties show greater stability than non-hybrid varieties, they also exhibit a lower degree of genotype-environment interactions, thus ensuring higher and more stable yields. The use of hybrids consequently allows higher levels of production by increasing yield per unit area (Göksoy, 1999). However, despite the availability of varieties with high yield stability, it is also necessary and important to conduct studies investigating regional varieties with high seed and oil yield as well as high pest and disease resistance that are well adapted to local environmental conditions (Karaaslan, 2001; Tunçtürk et al., 2005; Yılmaz and Kınay, 2015). As with the cultivation of other plants, the use of sunflower varieties suitable to a particular region is an important factor that affects yield and quality during sunflower cultivation. Various studies performed in different regions and ecologies of Turkey have shown that sunflower yield levels vary between 76 to 650 kg/da, while seed oil content varies between 33 to 48% (Arslan et al, 2003; Karaaslan et al., 2010; Kara and

Başalma, 2011; Çil et al., 2011; Karakaş and Arslanoğlu, 2013). The fact that sunflower is considerably affected by regional conditions during cultivation leads to significant variability between different varieties in terms of yield and yield characteristics.

As the oilseed plant species with the highest level of adaptability, sunflower can easily adapt to many different environmental conditions. The climate and soil characteristics of the Kırşehir province in Turkey are particularly suitable for sunflower cultivation. The mechanization of maintenance and harvesting activities, as well as the implementation of methods for ensuring adequate yield for per unit area, have helped promote sunflower cultivation in the region, and enabled sunflower agriculture to grow and expand rapidly. Recent incentive programs for oilseed plants have rendered the cultivation of these plants more attractive, while the use of hybrid varieties have enabled producers to obtain higher yields per unit area. In 2015, sunflower was planted in nearly 21,384 decares of land in Kırşehir, and 3,874 tons of sunflower seeds were produced, corresponding to a yield of 181 kg/da (Anonymous, 2016).

Private companies supply numerous different types of commercially produced hybrid sunflower varieties to market. Various regional studies are conducted to determine which varieties provide superior characteristics, and the results of such studies are routinely shared with producers and the industry. This study aimed to determine the performance under semi-arid conditions (rainfed) of hybrid varieties that are recommended for agricultural areas lacking adequate irrigation potential.

MATERIALS AND METHODS

The study was conducted at the experimental field of Ahi Evran University in a randomized complete blocks design with three replications during the years of 2012 and 2013 in Kırşehir. Trials were performed using 10 different hybrid sunflower varieties developed by private companies that are suitable for the region’s arid conditions. As fertilizer, 8 kg/da of nitrogen, 6 kg/da of potassium and 6 kg/da phosphorus was applied to all trial parcels. Seeds were planted to the 4.2 m to 3.5 m parcels in five rows at 70 x 30 cm intervals on the second week of April (13 April 2012 and 15 April 2013).

The following parameters were evaluated within the scope of the study: days to flowering (day), physiological maturity (day), plant height (cm), head diameter (cm), thousand seeds weight (gr), oil content (%), seed yield (kg/da), hull-kernel ratio(%),protein rate (%) and crude oil yield (kg/da). Variance analysis was performed on the obtained data according to the random blocks method (Düzgüneş, 1987). The Duncan test was employed to determine the significance of the differences between the trials. All statistical calculations and the variance of data was analyzed by MSTATC software and the means were compared by Duncan’s Test. Soil characteristics were generally argillaceous loamy soil with moderate salinity, moderate calcareousness and low organic content (Table 1).

Table 1. Soil properties of the experimental field at 0-30 cm depth

Saturation%	pH	EC (mmhos/cm)	Tuz (%)	Absorbable P (%)	$CaCO_3$ (%)	Absorbable K (ppm)	Organic matter (%)
55	7,59	0,58	0,021	0,19	21,8	63,78	1,39

Table 2. Meteorological data for the study period of 2012-2013 and long term mean.

	Mean monthly								
	Relative humidity (%)			Precipitation (mm)			Temperature (°C)		
	1970-2013	2012	2013	1970-2013	2012	2013	1970-2013	2012	2013
January	83.70	78.00	83.70	43.60	97.10	29.10	-0.20	-2.20	1.30
February	79.80	74.50	74.40	34.60	30.90	39.40	1.10	-2.70	4.70
March	68.40	67.60	63.00	35.90	36.20	14.20	5.40	2.40	7.10
April	50.30	63.80	63.20	45.60	20.10	46.20	10.60	13.30	11.90
May	66.50	61.00	50.70	43.90	109.50	15.10	15.30	15.40	18.00
June	47.70	54.30	41.10	34.50	11.90	1.00	19.60	21.60	20.40
July	38.80	48.40	41.20	6.70	1.40	6.60	23.10	25.30	22.70
August	42.00	48.70	39.70	5.00	0.00	0.20	22.80	23.00	23.10
September	39.40	53.20	50.00	11.80	1.20	32.00	18.20	20.60	16.80
October	63.00	63.70	52.90	29.20	59.30	20.50	12.40	14.70	10.50
November	82.50	73.00	67.10	37.90	41.70	40.00	6.20	7.40	7.60
December	84.60	78.60	75.70	48.60	90.10	10.40	2.00	3.30	-2.31
Total				377.30	499.40	254.70			
Mean	62.23	63.73	58.56				11.38	11.84	11.82

Relative humidity between the months of April and September (the period the study was conducted) was close to the long-term annual averages in 2012, and slightly below the long-term annual average in 2013. Annual precipitation was 499.40 kg/m^2 in 2012, which was above the long-term average precipitation values. On the other hand, annual precipitation was 254.70 kg/m^2 in 2013, which was considerably below the long-term average precipitation values. Total monthly precipitation was observed to be irregular during the months of sunflower cultivation. Precipitation was 109.5 kg/m^2 in April 2012; although this level of precipitation might appear to have a positive impact on the total level of annual precipitation, irregular precipitation in the other months have the potential to adversely affect yield. Temperature values during the cultivation period were above the long-term average for the region. In sunflower cultivation, climatic factors have an important effect on yield and yield characteristics, especially in rainfed agricultural areas.

RESULTS AND DISCUSSION

Data analysis showed that observed parameters during the two years were significantly ($p<0.01$) difference between years. In arid regions, climatic condition during the cultivation period have a significantly effect on yield and the yield components. Differences between the varieties in terms of the time to flowering, time to physiological maturation, plant height and head diameter were significant ($p<0.001$), while differences between the varieties with respect to BDA were not significant (Table 3).

Table 3. Analysis of variance for sunflower cultivars under rainfed conditions.

Source	DF	Time to flowering (day)	Time to physiological maturation (day)	Plant height (cm)	Head diameter (cm)	Thousand seed Weight (gr)
Replication	2	0.117ns	0.017ns	0.113ns	0.329ns	75.819ns
Year	1	749.067**	984.150**	3,523.601**	45.763**	3,412.695**
Cultivars	9	3.748**	14.350**	481.318**	3.224**	25.587ns
Year*Cultivars	9	0.215ns	0.780ns	51.495ns	0.415ns	47.689ns
Error	38	0.731	2.859		0.435	42.148
CV (%)		1.27	1.28	5.06	4.89	13.58

* Significant at 5% level; ** significant at 1% level; ns: not significant.

The date of flowering, date of physiological maturation, plant height and head diameter ranged between 66.33 to 68.83 days, 129.5 to 134.3 days, 107.60 to 137.60 cm, 12.52 to 14.85 cm and 44.48 to 50.90 gr, respectively (Table 4).

The longest time to flowering (68.83 days) was observed with the Hornet variety, while the shortest time to flowering (66.33 days) was observed with the Tunca variety. Under arid conditions, late flowering (i.e. a longer time to flowering) enhances the negative effects of warmer and drier conditions. Although significant differences were noted between the studied varieties in terms of their times to flowering, all varieties actually flowered within a period of two days. In parallel to the time to flowering, the Hornet variety exhibited the longest time to maturation (134.30 days), while the Tunca and Transol varieties exhibited the shortest time to maturation (129.50 days). In studies performed across different regions, researchers have reported physiological maturation periods ranging from 90 to 137 days (Kaya et al., 2009; Evci et al., 2011; Kara, 1991). The highest plant height was observed with the Bosfora variety (137.60), while the lowest was observed with the Reyna variety (107.60 cm). Higher plant height negatively affects conventional and mechanical harvesting procedures. In this study where irrigation practices were not used, it was observed that precipitation was an important factor affecting growth, and that the growth of sunflower varieties were limited by insufficient water. Varieties with longer vegetation period were generally taller than varieties with shorter vegetation periods. The head diameter of the varieties displayed a pattern similar to one observed with plant height, with the Bosfora variety having the largest head diameter (14.58 cm), and the Reyna variety having the smallest head diameter (12.50 cm).

Table 4. Mean comparisons for time to flowering, time to physiological maturation, plant height, head diameter and thousand seed weight

Cultivars	Time to flowering (day)	Day to physiological maturation (day)	Plant height (cm)	Head diameter (cm)	Thousand seed Weight (gr)
Bosfora	67.83abcd	132.20abc	137.60a	14.85a	50.46
Hornet	68.83a	134.30a	130.60ab	13.53 bcd	49.23
Oliva	68.00abc	132.70ab	123.10 bc	13.53 bcd	44.48
Reyna	67.50abcd	131.50abc	107.60 e	12.50 d	46.25
Sanbro	68.50ab	133.30ab	118.00 cd	14.32ab	47.82
Sirena	67.17 bcd	130.80 bc	119.70 c	13.33 bcd	50.90
Sonay	67.33abcd	131.20 bc	118.40 cd	13.60 bcd	47.82
Tarsan	67.67abcd	131.80abc	117.40 de	12.52 d	47.59
Transol	66.50 cd	129.50 c	119.70 c	13.85abc	45.32
Tunca	66.33 d	129.50 c	109.00 de	13.03 cd	48.11
LSD	1.34	2.647	9.523	1.033	2.650

It was observed that head dimeter and plant yield increased in parallel to the increase in Plant height and vegetation period. In sunflowers, head diameter varies according to various different parameters such as the characteristics of the variety, ecological conditions, growing techniques, soil structure, and irrigation (Gürbüz et al., 2003; Arıoğlu, 2007; Gürbüz and Kınay, 2015). The difference between the varieties in terms of 1000 seed weight was not statistically significant. Weight for 1000 seeds ranged between 44.48 g (Oliva) and 50.90 g (Sirena). For sunflower varieties, weight for 1000 seeds generally ranges between 35 to 120 g, and varies considerably depending on variety and cultivation conditions (İlbaş et al.,1996; Özer et al., 2004).

Significant differences ($P<0.01$) were observed between the years with respect to the kernel:hull ratio, protein ratio, crude oil ratio, yield and crude oil yield. Significant differences were identified between the varieties at a $P<0.01$ level in terms of their kernel:hull and oil yield, and at a $P<0.05$ level in terms of their protein ratio. No significant differences were identified between the varieties with respect to crude oil ratio. Kernel/Hull ratio ($P<0.01$) interacted significantly with year and variety (Table 5).

The highest kernel/hull ratio was observed with Oliva variety (74.72%), which is high in oleic acid, while the lowest kernel/hull ratio was observed with the Bosfora variety (%68.71) (Table 6). For sunflower varieties cultivated for their oil, a high kernel/hull ratio is particularly important for the oilseed industry. It was observed that under arid conditions, the kernel/hull ratio increased despite the decrease in seed size. It is reported that kernel/hull ratio varies between 55.47% to 77.30% depending on variety, cultivation conditions and cultivation practices (Karaaslan et al., 2007;, 1996; Karakaş and Arslanoğlu, 2010).

Table 5. Analysis of variance for sunflower cultivars under rainfed conditions.

Source	DF	Kernel:hull ratio (%)	Protein ratio (%)	Crude Oil ratio (%)	Yield (kg/da)	Crude oil yield (kg/da)
Replication	2	0.408ns	1.259ns	2.202ns	88.541ns	18.042ns
Year	1	30.025**	82.537**	405.179**	18,079.119**	1,731.116**
Cultivars	9	17.848**	8.260*	9.860ns	2,298.985**	507.808**
Year*Cultivars	9	11.322**	5.605ns	8.267ns	106.282ns	71.940ns
Error	38	2.918	3.197	7.584	241.046	67.896
CV (%)		2.39	9.58	5.40	11.51	12.10

* Significant at 5% level; ** significant at 1% level; ns: not significant.

Table 6. Means comparisons for Kernel:hull ratio (%), Protein ratio (%) , Crude Oil ratio (%), Yield (kg/da) and Crude oil yield (kg/da)

Cultivars	Kernel:hull ratio (%)	Protein ratio (%)	Crude Oil ratio (%)	Yield (kg/da)	Crude oil yield (kg/da)
Bosfora	68.71 c	18.68 b	51.53	146.30ab	82.00a
Hornet	71.93 ab	17.80 b	50.71	144.80ab	75.70abc
Oliva	74.72 a	19.31ab	50.27	132.80abc	71.20abcd
Reyna	71.17 bc	21.11a	51.75	93.61 d	60.20 d
Sanbro	70.09 bc	19.80ab	50.31	147.70ab	80.90ab
Sirena	73.03 ab	17.60 b	53.66	131.10abc	74.90abc
Sonay	70.44 bc	19.18ab	51.78	114.00 cd	67.30abcd
Tarsan	72.74 ab	17.86 b	50.78	127.40 bc	64.80 cd
Transol	71.05 bc	17.62 b	49.29	157.70a	80.60ab
Tunca	70.43 bc	17.76 b	49.50	152.80ab	77.00abc
LSD	2.674	2.090		24.31	12.90

The highest seed protein ratio was observed with the Reyna variety (21.11%), while the lowest ratios were observed in the Bosfora (18.68%), Tarsan (17.86%), Hornet (17.80%), Tunca (17.76%), Sirena (17.60%) and Transol (17.62%) varieties. The highest plant seed yield was observed with the Transol variety (157.7 kg/da), while the lowest was observed with the Reyna variety (93.61 kg/da). When exposed to arid conditions, sunflower varieties tend to respond differently to other environmental conditions. In this context, while yield was higher than the regional average, it is was fairly below the levels reported in other studies. The highest oil yield was obtained from the Bosfora variety (83.00 kg/da), while the lowest oil yield was obtained from the Reyna variety (60.20 kg/da) (Table 6). For sunflowers, the crude oil ratio and, by extension, the oil yield can vary depending on the characteristics of the variety, the cultivation techniques employed, and ecological factors (Çil et al., 2011).

The study results demonstrated the importance of variety selection in sunflower cultivation, and highlighted the necessity of choosing varieties according to regional conditions. Furthermore, the study also illustrated the need to perform yield trials when selecting varieties suitable for the climatic and environmental conditions of a particular region, as well as the need to conduct such trials over a long period and in different areas of the relevant region. Yearly variations in climatic factors, and especially the increase in overall temperature and the irregularities in precipitation caused by climate change, present a significant problem for the future.

CONCLUSION

In conclusion, this study – which was performed under rainfed conditions – demonstrated that among 10 different varieties of sunflower cultivated for their oilseeds, the Transol variety had the highest yield with 157.70 kg/da, and that the Tunca (152.8 kg/da), Sanbro (147.7 kg/da), Bosfora (146.3 kg/da) and Hornet (144.8 kg/da) were also high-yield varieties. On the other hand, the lowest yield of 93.61 kg/da was obtained with the Reyna variety. Oil yield, a parameter that is particularly important for the oilseed industry, was the highest in the Bosfora variety (82 kg/da), and the lowest in the Reyna variety (60.20 kg/da). Therefore, for regions with irregular and insufficient precipitation or that lack irrigated conditions; the Transol, Tunca, Sanbro, Bosfora and Hornet hybrid sunflower varieties present better options with respect to yield performance, since they exhibit greater tolerance to negative environmental conditions and stresses.

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MICROBIAL DRESSING OF SUNFLOWER SEEDS WITH TRICHODERMA HARZIANUM KUEN 1585

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For extensive use by arable crops, seed dressing (coating) may be the most convenient concept for supplying a biological agent. Seed coating is used for commercial seed dressings. However, seed coating with PGPR's is often challenging, requiring a long shelf life, and compatibility with other seed dressings. *Trichoderma harzianum* KUEN 1585 (commercial brand name Sim Derma) formulations for wet and dry seed coating are patented (TR/2007/09242, 31.12.2007; EP8866322,4, 13.11.2008; TR/2009/08397, 05.11.2009). Although *Trichoderma harzianum* is commonly known as a fungus with bio-control effects, the strain KUEN 1585 has strong root growth promoting effects. *Trichoderma harzianum* KUEN 1585 colonize roots of the sunflower. The result is longer, stronger, more capillary roots and higher chlorophyll content. In addition *Trichoderma harzianum* KUEN 1585 makes soil micro elements like phosphorus available for the plant. There are two application methods, dry and wet seed coating. By dry coating 1 kg seeds and 10 g *Trichoderma harzianum* Powder are mixed properly in box or bag; by wet seed coating 500 g of Concentrated *Trichoderma harzianum* Powder is solved in 10 L water together with fungicides and insecticides and sprayed homogenously on 400 kg seeds. Field results between 2006 and 2014 in Turkey and Ukraine show that *Trichoderma harzianum* KUEN 1585 application results in strong and early sprouting, stronger and more capillary roots, increased leaf chlorophyll content up to 10% and yield gain up to 15%.

Key Words : microbial seed dressing, Trichoderma harzianum, sunflower

CURRENT SITUATION, PROBLEMS AND SOLUTIONS OF SUNFLOWER IN THE CENTRAL ANATOLIAN REGION

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ABSTRACT

Sunflower, with holding the first position in terms of cultivation area and production of oilseed crops in our country, is the primary oil plant in Central Anatolia Region. It constitutes the 46.7% of the total oil crops production in Turkey. The seed yield is 196.8 $kg.da^{-1}$ in The Central Anatolia Region, where owns 30,3% of cultivation area and 19,5% of sunflower production in Turkey. Konya has the first rank in terms of cultivation area and as well as production amount in the sunflower with 36.8% of cultivation area and 58.7% production amount. Diverse cultivation of sunflower in fallow fields will make great profits to both farmers in the region and country's economy in Central Anatolia Region of Turkey, which has the 30,3% of arable land.

Key words: Sunflower, Oilseed, Confectionary sunflower, Central Anatolia

INTRODUCTION

World annual sunflower production is about 23 million tonnes and of, 1 million production have accomplished each year in Turkey which places it among top ten important sunflower producing country (Anonymous, 2014). There are two major uses of sunflower: oilseed and confection sunflower consumption. Oilseed having black and thin sheath around kernel and which is abundant for linoleic and oleic fatty acid content is a major source for oil production while confection sunflower which is comparably big and has a very thick sheath is mostly used for food consumption and animal feeding (Anonymous, 2007). Sunflower production in Turkey differs in planting region with varying oilseed and confectionary sunflower purposes. Trakya and Marmara regions are the biggest oilseed production areas, however confectionary sunflower production areas mostly localize in Middle Anatolia region of Turkey. Several studies have showed that even under drought conditions, sunflower production can be maintained but with low yield however after even one time irrigation of water may be enough to get high yield of sunflower (Anonymous). Besides, less demand on labour force with very suitability to mechanization makes sunflower a promising crop to increase its production rates in Turkey for near future (Anonymous, 2014).

AGRICULTURAL SITUATION OF MIDDLE ANATOLIA REGION AND PRODUCTION OF THE COMMON OIL CROPS IN THE REGION

Making 20% of whole country land, Middle Anatolia region composes 30.3% of arable area of Turkey and around half of this area has access to proper irrigation (TÜİK, 2015). Precipitation of this region is about 300-400 mm and the least precipitation falls at summer days. Aksaray, Ankara, Cankiri, Eskisehir, Karaman, Kayseri, Kirikkale, Kirsehir, Konya, Nevsehir, Nigde, Sivas and Yozgat- with diverse cultivation areas and crops like potato, apple, bean and sunflower- are the provinces of Middle Anatolia region. About 60% of planting area includes the area for crop cultivation, and nearly 30% is fallow area (Gultekin et al. 2013). Figure 1 shows the main crops produced in Middle Anatolia region and different cultivation areas in terms of only Middle Anatolia and in respect M. A. to Turkey.

a)

	Total area (m da)	**Crop (m da)**	**Fallow (m da)**	**Vegetable (m da)**	**Fruit (m da)**	**Ornamental plants (m da)**
2015 Middle Anotolia	72.602	47.399	21.672	1.532	2.007	1.324
2015 Turkey	239.486	157.377	41.139	8.085	32.838	45.972
Within Middle Anotolia		*65,29*	*29,85*	*2,11*	*2,76*	*1,82*
Middle Anotolia/Turkey	*30,32*	*30,12*	*52,68*	*18,95*	*6,11*	*2,88*

b)

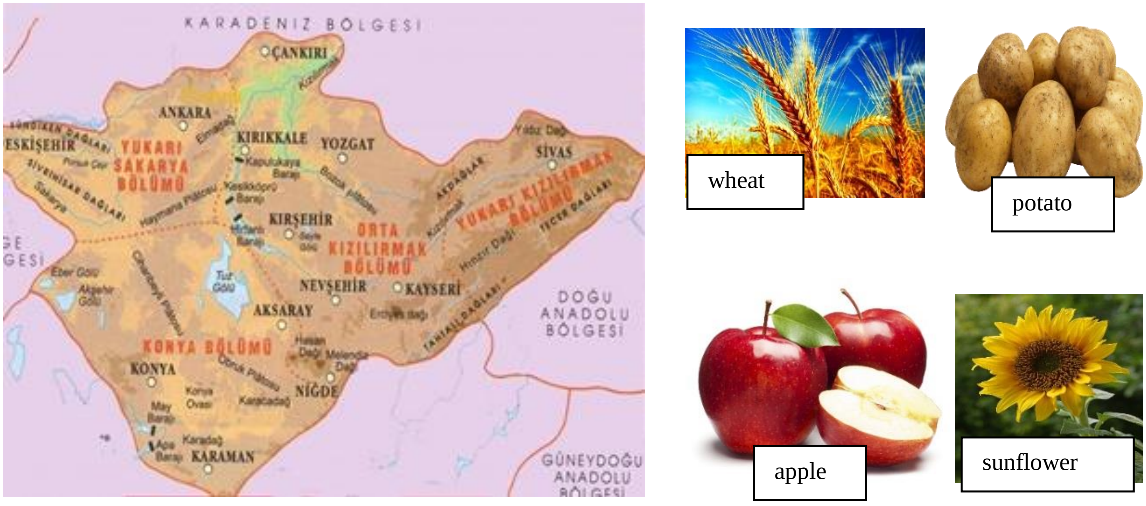

Figure 1.a) Shows the major cultivation areas of Middle Anatolia and Turkey **b)** Shows map of Middle Anatolia Region and its main cultivated crops. M.A.: Middle Anatolia

Besides canola, soybean, cotton seed, oil production from oilseed sunflower constitutes about 70% of total oil production in Turkey with fluctuating planting areas by year however (Caliskan, 2015) Turkey has about 530-690 thousand hectare for oilseed sunflower planting overall with 2.169 kg ha^{-1} yield for 2014. Annual oilseed sunflower production in Turkey is about 900.000 tonnes and mostly Trakya region meets the demand for oilseed sunflower production (Anonymous, 2015).

Sunflower is the second crop after safflower in terms of oil production in Middle Anatolia region as shown in Table1. This region constitute almost 80% of safflower production along with arable area of Turkey. Oil production values from soybean, rapeseed and cotton seed are very low even not forming 0.1% of total production.

Table1. Production of major oil crops in Middle Anatolia region

	Soybean		Safflower		Rapeseed		Sunflower	
	M.A.	Turkey	M.A.	Turkey	M.A.	Turkey	M.A.	Turkey
Planting Area (da)	357	367.323	341.539	431.071	6.194	350.817	719.245	5.689.650
Production (t)	147	161.000	56.201	70.000	1.998	120.000	291.951	1.500.000
Yield (kg da^{-1})	412	440	156	164	218	344	386	264
M.A./Turkey	Area	*0,10*		*79,23*		*1,77*		*12,64*
M.A./Turkey	Production	*0,09*		*80,29*		*1,67*		*19,46*
M.A./Turkey	Yield	*-28*		*-8*		*-126*		*122*

*M.A.= Middle Anatolia

SUNFLOWER PRODUCTION IN CENTRAL ANATOLIA

To increase arable areas for sunflower production in Turkey, attentions to other parts of Turkey have captured specifically Middle Anatolia region with provinces like Konya, Aksaray and Karaman however these regions are partly suitable for confectionary sunflower production (Anonymous, 2015). However, there are also government supported initiatives especially for Middle Anatolia to increase oilseed production to reverse decreasing planting areas, specifically when the climate and soil conditions of Middle Anatolia region are considered, it is thought that this area will be a great opportunity not only for oilseed sunflower production also for safflower and rapeseed (Anonymous, 2015).

By time, both the planting area and production percentages have increased from 2005 to 2015 with small fluctuations between the years as listed in Table 2. The production rates have decreased for two last years, 2014 and 2015 for oilseed while the rates for confection sunflower has increased from 2005 to 2015 gradually in Middle Anatolia. The fluctuation between land and production were consistent with each other for example, from 2012 to 2015, positive or negative change in arable area also reflected the change in production rates. Although, confectionary sunflower production still makes more than half of Turkey production as of 2015, both the production and arable area of sunflower production with respect to confectionary sunflower rates have increased dramatically 44% for area, 41% for production and 36% for area, 10% for production, respectively. The highest production amount for confectionary production recorded at 2015 with 53% while the highest record for oilseed sunflower production happened at 2013 with 19%.

Oilseed sunflower production for Middle Anatolia region was determined as 316.131 tonnes which made up 21.08% of total production in Turkey for 2015. Konya along with the biggest arable area, Aksaray, Eskisehir, Karaman and Ankara were top producers of oilseed production while Nigde with very few production even did not show any statistical information which was followed by Cankiri and Kayseri with comparably very low production value. However, the total sown area over total area in Turkey is too meager with 13.86 %, thus, it promises several advantages in terms of production values. Figure 2 shows oilseed production in Central Anatolia region as of 2015.

Table2. Shows the sunflower production Middle Anatolia region respect to Turkey

	Middle Anatolia		Middle Anatolia		Turkey		Turkey		M.A/Turkey	M.A/Turkey
	Oilseed sunflower		Confectionary sunflower		Oilseed sunflower		Confectionary sunflower		Confectionary	Oilseed sunflower
	Area (da)	Production (t)	Area (da)	Production (t)	Area (da)	Production (t)	Area (da)	Production (t)	Production (t)	Production (t)
2005	259.480	30.988	351.380	40.346	4.900.000	865.000	760.000	110.000	36,68	5,30
2006	266.270	40.809	359.044	41.117	5.100.000	1.010.000	754.000	108.000	38,07	5,22
2007	382.259	65.457	337.812	33.142	4.857.000	770.000	689.778	84.407	39,26	7,87
2008	370.746	66.281	327.022	32.645	5.100.000	900.387	700.000	91.613	35,63	7,27
2009	390.457	79.681	328.030	36.137	5.150.000	960.300	690.000	96.825	37,32	7,58
2010	422.656	83.473	508.532	68.515	5.514.000	1.170.000	900.000	150.000	45,68	7,67
2011	538.819	148.254	612.413	81.715	5.560.000	1.170.000	997.000	165.000	49,52	9,69
2012	865.443	282.713	609.655	79.317	5.046.160	1.200.000	1.000.000	170.000	46,66	17,15
2013	1.031.228	365.494	540.893	64.849	5.202.600	1.380.000	895.239	143.000	45,35	19,82
2014	932.526	353.908	622.900	67.677	5.524.651	1.480.000	1.049.925	157.900	42,86	16,88
2015	719.245	291.951	784.924	97.101	5.689.950	1.500.000	1.163.224	180.700	53,74	12,64

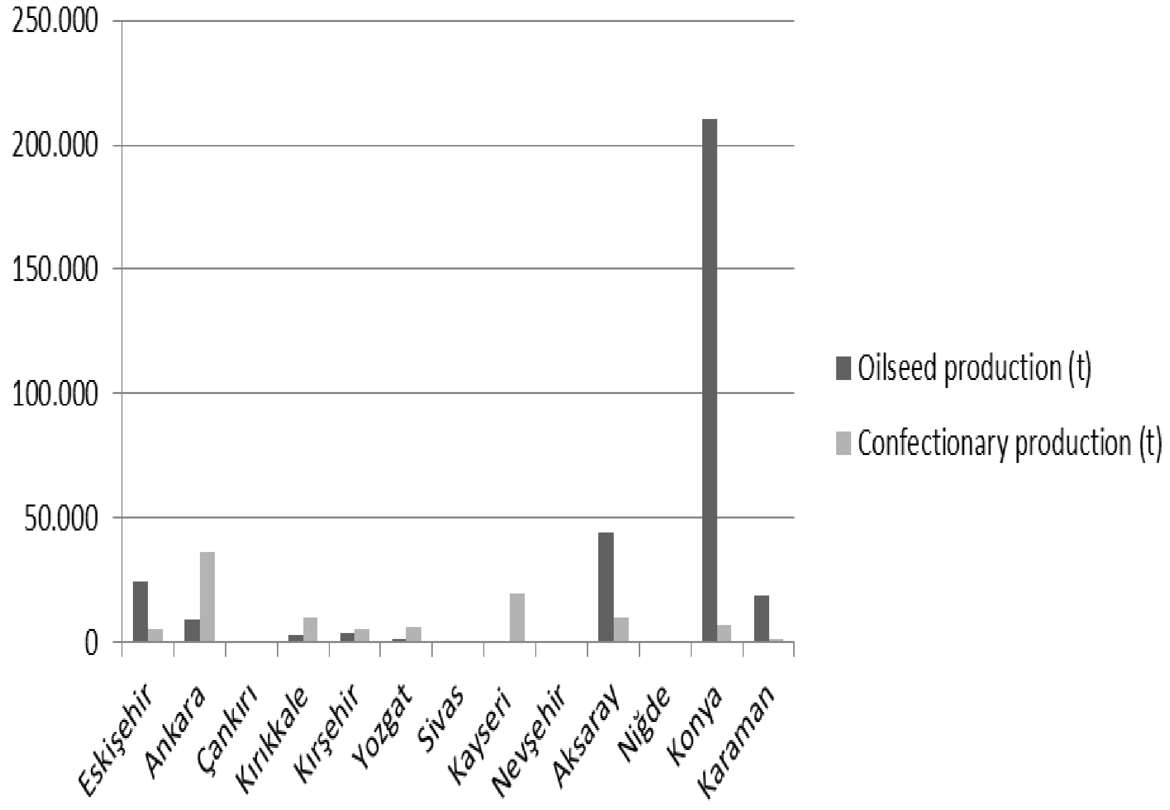

Figure 2. Shows the oilseed and confectionary sunflower production in provinces of Central Anatolia in 2015

Although it is actually, following an increasing trend in sunflower production in Central Anatolia region, not all provinces contribute equally to this percent, because Konya, Aksaray, Eskisehir, Ankara, and Karaman are the most important producers of sunflower production. Konya showed a great increase in sunflower production which makes 68.4% of overall Central Anatolia region and 26.03% of Turkey as of 2014. This makes Konya fourth largest sunflower producer after Tekirdag, Edirne, and Kırklareli. However, there were also notable increase in Aksaray, Karaman, Eskisehir, Ankara and Kırsehir sunflower production through the years. The other cities still need some actions to manage the sunflower production even there are some bare problems having confronted like few irrigation, wide row spacing and not regular appliement of intensive cultivation (Kolsarici et al. 2005).

Despite of relatively important contribution of Middle Anatolia region for oilseed production, this region can produce more than half of confectionary sunflower of Turkey for 2015 as shown in Table 3.

Ankara, Kırıkkale, Kayseri, Kirsehir and Yozgat are having the largest confectionary sunflower production areas in Central Anatolia region, but yield values are not well correlated for sown areas and production like Kırıkkale, which has second largest area, only produced 9.800 tonnes in 130.475 decares when compared with Kayseri with 19.828 tonnes in 97.850 decares. Central Anatolia made up 69.72% and 56.79% of sown areas and confectionary sunflower production of Turkey, respectively. Cankiri and Nevsehir were the least confectionary sunflower producers while Nigde showed no visible production as also happened for oilseed production.

Table3. Shows confectionary sunflower production in Middle Anatolia region

Provinces	Sown areas (decares)	Production (tonnes)	Yield (kg/da^{-1})
Aksaray	47.175	10.288	218
Ankara	344.915	36.295	105
Çankırı	3.230	406	126
Eskişehir	22.886	5.114	223
Karaman	13.714	1.484	108
Kayseri	97.850	19.828	203
Kırıkkale	130.475	9.800	75
Kırşehir	59.929	4.973	83
Konya	26.060	7.327	281
Nevşehir	1.672	204	122
Niğde	-	-	-
Sivas	3.400	514	151
Yozgat	59.734	6.388	107
Total	811.040	102.621	150
Turkey total production	1.163.224	180.700	155
Total/Turkey total production (%)	69,72	56,79	-5

COMMON PROBLEMS AND THEIR POSSIBLE SOLUTIONS FOR SUNFLOWER PRODUCTION IN CENTRAL ANATOLIA REGION

Unlike Trakya and Marmara region especially named after great sunflower production in Turkey, it needs some new areas to eliminate production fluctuation throughtout the years and spesifically Konya and Eskisehir, Ankara, Aksaray and Karaman are promising cities to create new arable areas. It was actually known that Central Anatolia region was really good source of confectionary sunflower production however when it is concerned that Konya ranks fourth in oilseed production, Middle Anatolia region promises a lot for sunflower production for future.

Although the conditions and production for sunflower gets better each year in Central Anatolia, this area is thought to have more potential, thus, some precautions should be taken to improve production in this region:

Problems

- First, it is needed to be clearly understood that the sunflower production is made in dry areas and if irrigation is possible, other crops, like potato, sugar beet and bean, are preferred for that lands,
- Farmers are not well informed both for sunflower, government support, and marketing.
- Yield rates for sunflower production are too low in Middle Anatolia

Solutions

Solutions to these problems begins with;

- teaching farmers the value of sunflower by bringing the awareness.

- mechanization supply should be done properly for each farmer.
- Farmers should be encouraged to plant sunflower to fallow and dry areas.
- The studies in this area should be supported.
- The competency in price rates should be balanced to promote the sunflower cultivation (Caliskan, 2013).

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NITROGEN ECONOMY THROUGH BIO-FERTILIZER IN SUNFLOWER (HELIANTHUS ANNUUS L.)

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ABSTRACT

Field experiment was carried out at G B Pant University of Agriculture & Technology, Pantnagar (India) during spring season of 2013 and 2014 to study the response of biofertilizers on productivity, profitability and nitrogen economy of sunflower in Indo-Gangetic plains of India. The experimental site was loamy in texture with 0.625% organic carbon, 269, 24.6 and 227 kg/ha available nitrogen, phosphorus and potassium, respectively and neutral in soil reaction with 6.85 soil pH. The experiment was laid out in completely randomized block design with 11 treatments i.e. No N (T1), 50% N (T2), 100% N (T3), *Azospirillum (Azos)* seed treatment(T4), *Azotobacter (Azot)* seed treatment (T5), *Azos+Azot* seed treatment (T6), 50% N+*Azos* seed treatment (T7), 50% N *Azot* seed treatment (T8), 50% N+*Azos+Azot* seed treatment (T9), 100% N+*Azos+Azot* seed treatment(T10) and 75% N + *Azos+Azot* seed treatment (T11) in three replication during spring season (February to May). The recommended dose of fertilizers were 120, 60 and 40 kg/ha nitrogen (N), phosphorus (P205) and potassium (K20), respectively. The nitrogen was applied as per treatments including 50% at sowing and 50% at budding stage but total P and K were applied at the sowing time. The crop was grown under recommended agronomy except the treatment variations. The growth and yield attributes, seed yield and yield reduction over 100% N at harvest were affected significantly by bio fertilizer application. The sunflower seed yield was recorded significantly highest at 100% N+ seed treatment with Azot+Azos and was significantly similar to 100% N application during both years and average value was only 4% greater than 100% N application. The seed treatment with Azot was found better than Azos with 6.7% higher average seed yield. Similarly the combined treatment with Azot+Azos gave 6.2% higher seed yield than seed treatment with only Azot. The seed yield was increased when N application was combined with seed treatment either of Azot and Aozs or both. The average seed yield under 100% N+ seed treatment with Azos+Azot gave 6.8 and 2.4% higher yield than 100% N during 2013 and 2014, respectively. The seed yield at 75% N+seed treatment with Azos+Azot was recorded significantly equal to 100% N and 100% N+seed treatment with Azos+Azot in 2013 but was significantly lower in 2014. However the average seed yield under 75% N + seed treatment with Azos+Azot was 7.4 and 11.0% lower than 100%N and 100% N+seed treatment with Azost+Azot. The biofertilizers did not influence the oil content. The gross,net returns and B:C ratio were found significantly higher at 100% N+seed treatment of Azos+Azot but remained significantly equal to 100% N during both years. Similarly the average gross, net returns and B:C ratio were found almost equal at both 100% N and 75% N+ seed treatment with Azos + Azot. It is therefore recommended that 25% N can be saved with seed treatment with Azotobacter only. Hence, 75% N+seed treatment with Azotobacter may be recommended for higher productivity, profitability and N economy of sunflower production in Indo-Gangetic plains of India.

Key Words : Azotobacter, *Azospirillum*, Bio fertilizer, Nitrogen economy, Indo-Gangetic plains

THE EVALUATION OF SUNFLOWER HARVEST WASTE AS SILAGE FEED

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ABSTRACT

This project was carried out to investigate the possibility of sunflower remaining after harvest crops as animal feed (silage) made from the residue left in the field. Sunflower stalks wastes are chopped 3 to 5 cm long grass shredding machine before ensiling process, and then sunflower stalks wastes were ensiled for 60 days in 1 kg vacuum bags. In the study, the pH of the silage dry matter (DM), crude protein (CP), crude ash (CA), acid detergent fiber (ADF), neutral detergent fiber (NDF) content and Fleig points were determined. Offered in silage dry matter content of 16-20%, pH 3.8-3.9, HP 9-10%, NDF 27-28% ADF 22-23%, CA 16-17% ranged. On the other hand, silage Fleig point which is an important parameter in determining the silage quality, this value ranges from 85-90 is located in “very good quality" class. As a result, after the harvesting of sunflower plants can be ensiled alone, to be ensiled with many other high-value crops, especially in terms of energy in order to increase dry matter seems to be appropriate. In this way, it is concluded that the waste product can be effectively used as silage material.

Key Words : Sunflower, harvest waste, Silage, Animal Feed

PATH ANALYSES OF YIELD IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) PARENTAL LINES

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ABSTRACT

Seed yield is very complex trait; it depends on genotype, environmental conditions, on various plant traits etc. Eighteen sunflower commercial parental lines were evaluated for various parameters under field conditions to estimate genetic parameters and path analyses. The ten female and eight restorer line were chosen for the experiment. Observed parameters were seed yield, 1000 seed, seed germination, oil and protein content. Objective of this study was determination of direct and indirect effects by path analysis; to compare given results of path analysis from female lines with results from restorer lines in order to identify research priorities in sunflower breeding. Path coefficient analysis, in observed female lines, indicates that 1000 seed weight has maximum positive and seed germination maximum negative direct effect on yield. In restorer lines, path coefficient analysis indicates that seed germination and 1000 seed weight have negative direct effect on yield, but effect of seed germination was highly significant.

Key words: Sunflower parent lines, Seed and yield components, Path coefficient analysis

INTRODUCTION

Seed yield is a very complex trait, has low heritability and it is very dependent on environmental conditions. It depends on various plant traits and it is very important for plant breeders to find out the association between the traits themselves and with the seed yield (Škorić, 1974; 2012). The main goal in sunflower breeding is to develop hybrids with high seed yield and high oil content and therefore to improve productivity of this important oil crop (Jocković at al., 2015).

As the aproach proved to be ineffective, numerous researchers (Shankar et al., 2006; Darvishzadeh et al., 2011; Radić at al., 2013) concluded that path-coefficient analyses provided information about direct and indirect effetcs of the examined characters on seed yield per plant. Yasin and Singh (2010) also concluded that path-coefficient is helpful in partitioning the correlation into direct and indirect effects. In this way, relative contribution of each component character to the yield can be assessed. In other words, path analysis measures direct and indirect contribution of various independent characters to a dependent character. Using path-coefficient analysis, it is easy to determine which yield component influences the yield substantially. These researchers also concluded that with this information, selection can be based on that criterion in limited time (Farhatullah et al., 2006).

This study was conducted in order to obtain information about interrelationship (direct and indirect effects by path analyses) between seed yield and other observed seed characters as well as to identify research priorities in sunflower breeding.

MATERIAL AND METHODS

Experiment was carried out in field conditions throughout three years on plots where seed production of sunflower parental lines was established. Ten genotypes were examined which represent lines that were based on cytoplasmic mail sterility (CMS). All examined genotypes represent parental components of the best-selling sunflower hybrids of the Institute of Field and Vegetable Crops, Novi Sad, Serbia.

The following parameters were studied:

Seed yield – upon maturity, 10 plants were picked manually, from different locations on the plot, and seed yield per plant was determined. By the application of previously determined plant density *(50.000 plants ha^{-1})*, obtained seed yield per plant was redetermined in kg ha^{-1} with 9% of moisture.

Upon seed drying, specimens were purified and cleaned. Seed for determining the remaining observed parameters were picked from the given specimens:

Seed germination- Standard laboratory method for seed germination testing was used (ISTA, 2014). Examination of seed germination was repeated 4 times. Each time 100 seeds were used. Germination was determined after 10 days. Only naturally formed germed seeds were used for determination of this parameter. Germination was expressed in relative values.

1000 seed weight- Examination of 1000 seed weight was repeated 4 times. Each time 100 seeds were used. Obtained value was applied to 1000 seed weight and was specified in grams.

Oil content- Determined by nuclear - magnetic resonance (NMR) according to Granlund and Zimmerman (1975) and expressed in relative value.

Protein content- Determined by standard Kjeldahl method with the help of VAP-50-Gerhardt apparatus. This parameter is also expressed in relative value.

Analysis of variance of two-factorial experiment, simple correlation coefficient and path-coefficient analysis for examined characters were done using GENSTAT computer program.

RESULTS AND DISCUSSION

The data were processed by the path-coefficient analysis which enabled the partitioning of direct and indirect effects of individual yield components and identification of yield components applicable as selection criteria in sunflower breeding (Table 1 and 2).

Relatively low coefficient of determination (R^2) at trait of sterile lines (0.330) and restorer lines (0.211) level give rise to high residual effects (0.818 and 0.888) meaning that besides parametrs used in this study other causal variables are also responsible for seed yield.

Seed germination, in both traits, had the highest negative direct effect on seed yield (-0,354). Only differences between this two effects was that in restorer traits this effect was more significant (-0,485). These results are in agreement with the studies of Radić et al. (2013). In the study of indirect effects, the existence of negative indirect effects was determined in sterile lines (seed germination *via* 1000 seed weight) while in restorer lines this effect was determined as positive. In both traits this indirect effects were not significant.

The study of direct effects on seed yield showed that the 1000 seed weight had high positive direct effect (0.339) in sterile lines, while in restorer lines this parameter had also high direct effect on seed yield, but this effect was negative. In the study of indirect effects, the existence of positive not significant indirect effects on seed yield was determined. Škorić

(1974) and Joksimović et al. (1999) concluded that is necessary that 1000 seed weight has negative direct effect on restorer lines, since this restorer plant has a lot of branches (purpose of exciting of restorer is to have a lot of polen for polination). These results are in agreement with the studies of Merrien et al. (1982), Marinković (1992) and Dušanić (1998, 2004). These researchers also concluded that 1000 seed weight has higher effect on seed yield than number of filled seed per head and other yield components. Vanishree et al. (1988) and Tahir et al. (2002) concluded that increasing 1000 seed weight may result in higher yield. As opposed to this, Alba and Greco (1978) and Lakshmanrao et al. (1985) reported that 1000 seed weight has significant direct effect on seed yield, but this is, based on their research, a negative effect.

Table 1. Analysis of direct and indirect effects of observed characters on seed yield in sterile lines

Character	Direct effect	Indirect effect:				Total
		Seed germination	1000 seed weight	Oil content	Protein content	
Seed germination	-0.354	-	-0.010	0.015	0.036	-0.313
1000 seed weight	0.339	0.010	-	0.037	0.009	0.395
Oil content	0.221	-0.024	0.057	-	0.010	0.265
Protein content	0.185	-0.068	0.016	0.012	-	0.146

Coefficient of determination R^2=0.330

Oil content had positive direct effect on seed yield and negative indirect effect *via* seed germination on seed yield at both traits. Other indirect effects were positive and also not significant, except indirect effect of oil content *via* 1000 seed weight on seed yield. This effect was negative. Punia and Gill (1994), Husain et al. (1995) and Chikkadevaiah et al. (2002) concluded in their research that oil content had maximum direct effect on seed yield. On the other side, Habib et al. (2007) confirmed positive direct effect of oil content on seed yield. Arshad et al. (2007) and Kaya et al. (2009) found that oil content had negative direct effect on seed yield as well as negative indirect effect *via* plant height.

Protein content had positive direct effect in sterile line traits but also had negative direct effect in restorer line traits. Both effects are not significant. In both traits two negative indirect effects on seed yield were determined. One of them is in sterile line trait *via* seed germination and other one is *via* oil content in restorer line trait. All other indirect effects are positive. All indirect effects are not significant. Jocković at al. (2015) in their research concluded the same.

Table 2. Analysis of direct and indirect effects of observed characters on seed yield in restorer lines

Character	Direct effect	Indirect effect:				Total
		Seed germination	1000 seed weight	Oil content	Protein content	
Seed germination	-0,485*	-	0,112	0,018	0,005	-0,321
1000 seed weight	-0,337	0,162	-	0,006	0,005	-0,164
Oil content	0,153	-0,150	-0,014	-	0,008	-0,003
Protein content	-0,065	0,035	0,026	-0,018	-	-0,022

Coefficient of determination R^2=0.211

CONCLUSION

Bringing these observed characters into optimal balance with seed yield is one of main principal for succsesfull sunflower breeding program. In this report, path coefficient analysis revealed that the greatest improvement in sunflower seed yield can be achieved through selection on seed germination and 1000 seed weight, because they have the highest direct effect on seed yield. Difference between observed parametrs is that effect of seed germination is negative while in 1000 seed weight is positive in sterile line trait and negative in restorer line trait.

Further research should be aimed at observation of the relationship between certain characters of seed quality, with the intention of obtaining high quality sunflower seed.

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EFFECT OF THE PLANT DENSITY AND FOLIAR FERTILIZATION ON THE YIELD FROM NEW BULGARIAN HUBRIDS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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ABSTRACT

During 2014–2015 a field experiment was conducted with three new sunflower hybrids (Veleka, Vokil and Sava) in the trial field of Dobrudzha Agricultural Institute. The aim was to determine the effect of the plant density and of a set of foliar fertilizers on the quantitative and qualitative indices of seed yield as a part of determining the elements forming the optimum agronomy practices for growing of the above hybrids. The variants of the experiment were the following: 1) check (untreated); 2) mineral fertilization at norm $N_{60}P_{120}K_{80}$ (active matter/ha); foliar fertilization with: 3) Root; 4) Siapton; 5. Lebosol B; 6) Lebosol Mg-S; 7) Lebosol Mn; 8) Yara Vita Brassitrel pro. The foliar treatment was done by sprinkling the leaf mass at stage 6-7th pair of leaves. Each hybrid was sown at four densities – 35 000, 45 000, 55 000 and 65000 plants/ha. The soil in the experimental field was leached chernozem (*Luvic phaeosem*) with 3.30% humus content classified as very suitable for sunflower growing. Based on the data obtained, it was found that the factor sowing norm had greater effect on the seed yield than foliar fertilization. This factor enhanced seed yield with 5 to 10 %, 1000 seed weight decreased with the higher sowing norm with 12 to 19 %, while oil content in seed did not change. The factor fertilization did not affect significantly the three followed indices. The reason for this result was the amount of rainfalls. During the first year they were abundant and during the second – scare; as a result from these deviations from the precipitation norm of the region the differences between the individual variants were leveled up.

Key words: sunflower, sowing norms, foliar fertilization, yield, oil content

INTRODUCTION

Investigations on the topic of this presentation are being permanently carried out in Bulgaria and abroad since sunflower is an important major oil seed crop in many agro ecological regions worldwide. New hybrids and promising lines of sunflower are being constantly introduced in practice, which have various peculiarities and growing requirements (Georgiev et al., 2006; Georgiev et al., 2013; Nenova et al., 2013).

Therefore constant studies on the agro technology of this crop are needed. Such studies would give an answer to the question what are the values of certain factors under which the tested hybrid can express to a maximum degree its biological potential. These particular factors are the parameters of the sowing norm (Amjed et al. 2011; Petcu et al. 2000; Sin & Partal, 2011; Yankov et al., 2009), the mineral macro and micro fertilization (Nankova and Tonev, 2004; Tonev, 2005,a; Tonev, 2005 b, Suzes, 2010), the use of bio stimulants (Ebrahimian et al., 2011; Milev, 2015), etc.

The topicality and significance of this problem consists in searching for the optimal combination of the agronomy practices related to the introduction of new sunflower hybrids developed at DAI – General Toshevo in production, with regard to both yield and the quality indices of the produce.

The aim of this investigation was to determine the effect of some main agronomy factors such as the plant density, the macro and micro fertilization and the use of bio stimulants on the quality and quantity of production from new Bulgarian oil seed sunflower hybrids.

MATERIAL AND METHODS

During 2014 – 2015, a field experiment was carried out with oil seed sunflower in the trial field of Dobrudzha Agricultural Institute – General Toshevo (DAI), Bulgaria. The experiment was designed according to the split plot method, in four replications of the variants, the size of the harvest plot being 12.6 m. The three hybrids were planted in the first-order plots, using 4 plant densities for each hybrid – 35 000, 45 000, 55 000 and 65 000 plants/ha. The following variants of treatment were positioned across the first-order plots: 1) check (untreated); 2) mineral soil fertilization with norm $N_{60}P_{120}K_{80}$, active matter per ha; foliar treatment with: 3) Root; 4) Siapton; 5) Lebosol B (boron); 6) Lebosol Mg-S (magnesium - sulfur); 7) Lebosol Mn (manganese); 8) Yara Vita Brassitrel pro (YVB). The foliar treatment was done by sprinkling the leaf mass at stage 3rd pair of leaves with the bio stimulant Root, and at stage 6th - 7th pair of leaves with the rest of the products. The applied doses were in accordance with the recommendations of the producers. Brief description of the tested products is given in Table 1.

Table 1. Characteristics of the tested products

Name	Type	Active substance	Action
Root	Bio stimulant for foliar application	Molecular complex similar to chlorophyll	Alters the energy balance in favor of yield. Accelerates rooting.
Siapton	Bio stimulant for foliar application	Natural hydrolyzed proteins	Accelerates the formation of amino acids and the uptake of nitrate nitrogen from soil.
Lebosol B	Foliar one-component fertilizer	11% B	Uniform flowering and maturation.
Lebosol MgS	Foliar combined fertilizer	24.1% MgO и 16.6% S	Higher plant vigor.
Lebososl Mn	Foliar one-component fertilizer	6% Mn	Enhances immunity
YVB (Yara Vita Brassitrel Pro)	Foliar combined fertilizer	6.9% amide nitrogen, MgO 11.6%, B 6%, Mn 7%, Mo 0.4%, CaO 8.9%	Higher yield and quality of production

Three new oil seed sunflower hybrids developed through interlinear hybridization were tested in the field experiment carried out. In the breeding field of DAI, these hybrids underwent three-year testing according to a scheme approved for this crop. The first hybrid **Veleka** is medium early, with vegetation period 120-123 days. Plants are medium high, 155 – 160 cm, with head diameter 18-22 cm, absolute weight of seeds 55 – 65 g, oil seed content 48 – 49 %, and the percent of kernel is within 72 – 76 %. The number of seeds per head is between 1060 and 1530, and the weight of seeds per plant is 61.5 – 89.3 g. The duration of flowering is 11-13 days. **Veleka** is shorter than the other Bulgarian hybrids distributed up to now. It gives stable yields in climatically unfavorable years. This hybrid exceeded the mean standard by seed and oil yield during the preliminary testing in the experimental fields of DAI. The exceeding by seed yield was within the range 12.7 – 21.1 %, and by oil yield – from 14.5 to 25.8 %. The maximum seed yield obtained from the new hybrid in the experimental fields was 4837 kg/ha and the oil yield was 2370 kg/ha, oil percent in seed reaching up to 49.0 %. Hybrid Veleka was acknowledged as clearly distinct from all other varieties, sufficiently uniform and stable with a technical testing report of the National Executive Agency of Variety Testing, Field Inspection and Seed Control of Bulgaria. Following three-year official testing, hybrid Veleka was registered also in Romania and was included in the European catalog of field and vegetable crop varieties.

The second hybrid **Vokil** is medium early, with vegetation period of 122 – 125 days, plant height 150 – 160 cm and head diameter 18 – 21 cm. Oil of seeds is of linoleic type, and its content is 49 – 51 %. Thousand seed weight is 53 – 58 g, number of seeds per head is 1180 – 1360, and their weight per plant is 81 – 91 cm. The percent of the kernel in the seed is 72 – 75 %. The duration of flowering is 11 – 13 days. During the three years of testing the hybrid exceeded the mean standard with 4.9 – 14.9 %, the maximum obtained seed yield being 4570 kg/ha, and the maximum oil yield – 2344 kg/ha. Oil content in seed reached up to 51.7 %.

Hybrid Vokil was officially registered in Romania in 2013 and was enlisted in the European catalog of field and vegetable crop varieties.

The last tested hybrid **Sava** is early. Its vegetation period is shorter in comparison to the other two hybrids with 10 to 12 days. The height of plants is 140 – 150 cm. Head diameter is 24 – 27 cm. The vegetation period is 109 – 112 days. Oil content in seeds is 49 – 50 %. It is resistant to downy mildew race 731 and to *Orobanche* races from A to F.

In 2012 hybrid Sava was presented for official testing within the structures of the Romanian varietal commission at 10 locations. During the three years of official testing the new hybrid exceeded the Romanian standard with averagely 2.2 % by the index seed yield. The mean seed yield per hectar for the three years of testing was 3273 кg/ha. Hybrid Sava was officially registered in Romania in 2015 and was enlisted in the European catalog of field and vegetable crop varieties under the name Sevar.

The hybrids were sown in mid-April, within the optimal dates for this agro-ecological region. Sowing was manual, and the number of plants per unit area was in accordance with the methodological requirements. All other elements of the agro technology of the hybrids in this experiment, which were not the aim of this investigation, were performed according to the traditional agronomy practices applied to sunflower production in the region (Klochkov et al., 1988).

The soil in the trial field was leached chernozem (*Luvic phaeozem*) with humus content 3.30 %, with neutral reaction, and can be classified as very suitable for growing of sunflower. The vegetation conditions for growth and development of sunflower in 2014 can be described as very favorable. The autumn-and-winter rainfalls of 323.5 mm exceeded their referential values and were a prerequisite for excellent moisture reserves in soil. The amount of vegetation rainfalls (370.5 mm) and their distribution during the respective growth stages were also entirely sufficient and suitable to meet the demands of the crop.

Highest vegetation rainfalls were registered in June - 192.5 mm, i.e. during the month when sunflower undergoes intensive vegetation growth. These rainfalls were accompanied by stormy winds and caused lodging of the plants to various degrees. Hybrid Veleka was affected most, and hybrid Sava – least. The degree of lodging was determined by the growth stage of the respective hybrids at the moment of this unfavorable occurrence. Lodging lead to formation of a non-uniform crop (deviations from the row, the height, instances of curved stems, etc.).

The vegetation conditions for growth and development of sunflower during the second year can be described as relatively unfavorable. The rainfalls at the beginning of the growth season were scarce, significantly below the mean monthly referential values (Table 2). The August rainfalls were too late and did not have significant economic effect on yield, especially on the earlier hybrid Sava.

Comparatively, the total amount of vegetation rainfalls during this growth season (158.9 mm) was 2.3 times lower than the rainfalls in 2014 (370.5 mm). The autumn-and-winter rainfalls, however, were abundant - 372.9 mm, considerably exceeding their referential values, and created excellent moisture reserves in soil.

Table 2. Vegetation and autumn-and-winter rainfalls during the investigated period, mm

Month	Years		Averaged for 2 years	Averaged for 60 years
	2014	2015		
April	29.6	46.3	37.9	49.1
May	78.2	12.9	45.5	50.6
June	192.5	31.3	111.9	65.4
July	50.9	27.2	39.5	49.2.
August	19.3	41.2	30.2	40.3
Amount for Apr-Aug	370.5	158.9	264.7	254.0
Autumn-and-winter rainfalls for Oct-Mar	323.5	372.9	348.2	294.0

With regard to air temperatures, the growth season of sunflower in 2014 was not interrupted by any disturbances. The growth season of 2015 occurred under recurrently high air temperatures exceeding the norm (above 32-35ºC). Such temperatures were registered during 25th – 30th July and 12th – 15th August. The combination of scarce rainfalls and extreme high temperatures caused severe soil drought during May – July. Under these meteorological conditions seed yield was formed mainly at the expense of the autumn-and-winter moisture reserves in soil.

RESULTS AND DISCUTION

The results presented in Table 3 show that the variants of treatment with the set of micro fertilizers, bio stimulants and mineral fertilization had zero effect on seed yield. The better and more vigorous vegetative growth observed during the growth season was not expressed on seed yield. What is more – the seed yield from the check variant was higher than the treated variants. This phenomenon can be explained by the greater lodging and the more severe stress which, however, the plants with better supply of nutrients suffered in these variants.

Table 3. Seed yield according to the major action of the factors for two years, kg/ha

Hybrid	Variant of treatment		Crop density		Year	
Veleka	Check	3363	35000	2930	2014	2711
	$N_{60}P_{120}K_{80}$	2996*	45000	3185*	2015	3307**
	Root	2911*	55000	3005 *NS*		
	Siapton	3000*	65000	2928 *NS*		
	Lebosol B	3000*				
	Lebososl Mg-S	2891**				
	YVB#	2897**				
	Lebososl Mn	3029*				
Vokil	Check	3465	35000	3250	2014	3398
	$N_{60}P_{120}K_{80}$	3344 *NS*	45000	3427 *NS*	2015	3393 *NS*
	Root	3274 *NS*	55000	3445*		
	Siapton	3496 *NS*	65000	3461*		
	Lebososl B	3482 *NS*				
	Lebososl Mg-S	3244NS				
	YVB	3497 *NS*				
	Lebososl Mn	3367 *NS*				
Sava	Check	3414	35000	3211	2014	3482
	$N_{60}P_{120}K_{80}$	3387 *NS*	45000	3490**	2015	3214*
	Root	3331 *NS*	55000	3382*		
	Siapton	3380 *NS*	65000	3289 *NS*		
	Lebososl B	3364 *NS*				
	Lebososl Mg-S	3283 *NS*				
	YVB	3392 *NS*				
	Lebososl Mn	3271 *NS*				

,,*** - Significance of differences at $p<0.05$, $p<0.01$, $p<0.001$ respectively;*
NS – not significant; # - Yara Vita Brassitrel

The factor sowing norm had significantly higher effect on the seed yield in comparison to the variants with fertilization. The variation from the lowest to highest yield caused by this factor by hybrids was the following: hybrid Sava – 279 kg/ha, hybrid Veleka – 257 kg/ha and hybrid Vokil – 211 kg/ha. Hybrids Veleka and Sava realized highest yield at crop density of 45000 plants/ha. In hybrid Vokil, the higher sowing norms gave higher seed yield than the check variant, without significant differences being observed between themselves.

The respective year conditions had more significant effect on the size of the seed yield from hybrids Veleka (a difference of 59 kg/ha) and Sava (a difference of 27 kg/ha), and did not have any effect on hybrid Vokil. In hybrid Veleka, the lodging of the crop in 2014 played a considerable role for this high variation in yield and lead to its logical decrease.

Hybrid Veleka realized highest 1000 seed weight in the variants with Lebosol Mg-S, Yara Vita Brasitrel and Lebososl Mn, respectively. The exceeding of the values of the index in these variants was from 3.2 to 5.4 g, respectively (Table 4).

In hybrid Vokil, only the treatment with Lebosol Mn significantly exceeded the check variant. The value of the index for the variants with $N_{60}P_{120}K_{80}$, Root, Siapton, Lebosol Mg-S and Lebosol B was even lower than the check variant with about 2.5 g.

Table 4. 1000 seed weight (g) according to the variants of the experiment averaged for two years,

Hybrid	Variant of treatment		Crop density		Year	
Veleka	Check variant	60.5	35000	69.0	2014	65.0
	$N_{60}P_{120}K_{80}$	59.1 *NS*	45000	62.8***	2015	58.0**
	Root	59.1 *NS*	55000	58.5***		
	Siapton	59.8 *NS*	65000	55.7***		
	Lebosol B	58.9 *NS*				
	Lebososl Mg-S	63.7*				
	YVB#	64.6*				
	Lebososl Mn	65.9**				
Vokil	Check variant	64.9	35000	58.0	2014	62.8
	$N_{60}P_{120}K_{80}$	62.5*	45000	55.8**	2015	64.3 *NS*
	Root	61.9*	55000	52.1***		
	Siapton	63.6 *NS*	65000	50.9***		
	Lebososl B	62.1*				
	Lebosol Mg-S	62.5*				
	YVB	64.6 *NS*				
	Lebosol Mn	66.6*				
Sava	Check variant	53.6	35000	58.0	2014	54.9
	$N_{60}P_{120}K_{80}$	53.1 *NS*	45000	55.8*	2015	53.2 *NS*
	Root	52.2 *NS*	55000	52.1***		
	Siapton	53.6 *NS*	65000	50.9***		
	Lebososl B	53.6 *NS*				
	Lebososl Mg-S	52.6 *NS*				
	YVB	55.7**				
	Lebsosl Mn	58.2***				

*,**,*** - *Significance of differences at p<0.05, p<0.01, p<0.001 respectively;*
NS – not significant; # - Yara Vita Brassitrel

Highest 1000 seed weight in the third hybrid Sava was registered for the variants Lebosol Mn and Yara Vita Brasitrel, the exceeding being with about 2-5 g.

The higher crop density gradually and definitely decreased 1000 seed weight, i.e. the correlation between them was inversely proportional.

The conditions of the respective year did not significantly change the value of 1000 seed weight of hybrids Vokil and Sava. In hybrid Veleka, 1000 seed weight was significantly higher during the first year of the experiment. The reason for this could be the thinning of the crop as a result from its lodging; at the expense of this, however, larger and more plums seeds were formed.

The results for the index oil content in seed are given in Table 5. The data clearly show that this index is a strong genetic peculiarity of the hybrid hardly affected by the factors of the trial. Variation was within extremely range even during the individual years and was not statistically significant.

Table 5. Oil content in seed averaged for two years, g

Hybrid	Variant of treatment		Crop density		Year	
Veleka	Check variant	51.50	35000	50.23	2014	50.98
	$N_{60}P_{120}K_{80}$	51.14 *NS*	45000	51.00 *NS*	2015	51.25 *NS*
	Root	51.04 *NS*	55000	51.42 *NS*		
	Siapton	50.89 *NS*	65000	51.30 *NS*		
	Lebososl B	51.35 *NS*				
	Lebososl Mg-S	51.18 *NS*				
	YVB#	51.02 *NS*				
	Lebososl Mn	51.74 *NS*				
Vokil	Check variant	52.59	35000	51.66	2014	52.35
	$N_{60}P_{120}K_{80}$	52.47 *NS*	45000	52.20 *NS*	2015	52.65 *NS*
	Root	52.01 *NS*	55000	52.87 *NS*		
	Siapton	52.22 *NS*	65000	52.68 *NS*		
	Lebososl B	52.58 *NS*				
	Lebosol Mg-S	52.75 *NS*				
	YVB	52.45 *NS*				
	Lebososl Mn	52.75 *NS*				
Sava	Check variant	50.53	35000	49.85	2014	50.38
	$N_{60}P_{120}K_{80}$	49.96 *NS*	45000	50.60 *NS*	2015	50.95 *NS*
	Root	50.83 *NS*	55000	50.57 *NS*		
	Siapton	49.94 *NS*	65000	50.50 *NS*		
	Lebososl B	49.90 *NS*				
	Lebososl Mg-S	50.40 *NS*				
	YVB	50.73 *NS*				
	Lebososl Mn					

*,**,*** - *Significance of differences at p<0.05, p<0.01, p<0.001 respectively;*
NS – not significant; # - Yara Vita Brassitrel

CONCLUSION

Based on the obtained data, it was found that the factor crop density of the plants had higher strength of effect on seed yield than the foliar fertilization. The first factor increased seed yield with 5 to 10 %, 1000 seed weight decreased with 12 to 19 % with the higher sowing norms, while oil percent in seed did not change. The factor fertilization did not have a significant effect on the three followed indices.

The significant deviation from the precipitation norm during the growth season of sunflower played a major role for the low effect of the investigated factors, fertilization in particular. During the first year the rainfalls were abundant, and during the second – scarce; as a result these deviations in both years of investigation neutralized the differences between the individual variants.

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EFFECT OF SOWING DATE ON HEAD DIAMETER IN SUNFLOWER

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ABSTRACT

Head diameter is very important trait in the sunflower seed yield structure. The size of head diameter influences the number of flowers and seeds per head which directly influence the seed yield per plant. In order to evaluate the effect of sowing date on head diameter, 3 sunflower hybrids, sown in 4 sowing dates during three growing seasons, were carried out. Head diameter was evaluated in the stage of flowering and physiological maturity. Head diameter at the stage of flowering was largely influenced by the year (Y) of investigation (46.6%), although other sources of variation (H-hybrid, SD-sowing date) showed also significance, except interaction H × SD. The largest head diameter is manifested in the hybrid Pobednik (11.9 cm) in the three-year average. In SD4 (20th of May) head diameter had the highest value (11.8 cm). In physiological maturity head diameter varied significantly depending on the sowing date (18.6%). Years, as well as hybrids had no significant influence on this trait. All interactions (Y × SD, H × SD, Y × H × SD), except year × hybrid (Y × H), were highly significant. Regarding sowing dates significantly higher mean value for head diameter can be noted in SD4, compared with earlier sowing dates in the three-year average. Values of head diameter, are doubled in the stage of physiological maturity in relation to the flowering stage. Coefficient of variation in the stage of physiological maturity was rather low (4,7%). The results of this study could be of importance in sunflower production.

Key Words : sunflower, sowing date, head diameter, flowering and physiological maturity

EFFICACY OF *TRICHODERMA* SPP. ISOLATES AGAINST *SCLEROTINIA SCLEROTIORUM* ON SUNFLOWER SEEDLINGS

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ABSTRACT

Trichoderma species are well known as effective antagonists to a variety of soil fungal pathogens. The aim of this research was to test the ability of *Trichoderma* spp. isolates, which previously indicated antagonistic activity (Tančić et al. 2012), to protect sunflower seedlings from *Sclerotinia sclerotiorum*. Ten *Trichoderma* spp. isolates obtained from different soil types and localities in Vojvodina province and one *S. sclerotiorum* isolate from sunflower grown at Rimski Šančevi (Serbia) were used in research. Biological efficacy was tested on 100 sunflower seeds treated with *Trichoderma* spp. suspensions ($1x10^6$) in two different treatments: T-30 (modified Mukhtar et al., 2012) and T-1.2 (Maslienko, 2005). *Trichoderma*-coated seeds were placed in four replicates on wet filter paper in Petri dishes. Next to each *Trichoderma*-coated seed the 5 mm^2 plug of *S. sclerotiorum* mycelia was placed, and incubated under the optimal laboratory conditions. Seeds treated with sterile distilled water with pathogen and without it were used as a positive and negative control, respectively. After seven days, biological efficacy of *Trichoderma* spp. isolates was assessed and calculated according to Liu et al. (2009). According to obtained results, biological efficacy of all tested *Trichoderma* isolates was statistically significant as compared to the positive control in both treatments. Good antagonism with over 50% of biological efficacy was registered in 8 isolates in T-30, and 3 isolates in treatment T-1.2. Three *Trichoderma* isolates which showed biological efficacy over 50% in both treatments can be considered as potential biocontrol agents which should be included in further more comprehensive research.

Key words: *Trichoderma*, *Sclerotinia sclerotiorum*, Antagonism, Sunflower

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important annual species grown in Serbia mostly for its edible oil. Areas grown under sunflower were around 170 000 hectares with the expected yield of 422 000 tones and sunflower oil production of 139 000 tones in economical year 2015/2016 (Chamber of Commerce and Industry of Serbia, 2016).

Farmers around the world are familiar with *S. sclerotiorum* (Lib.) de Bary as a threat to numerous crops such as sunflower, soybean, oilseed rape, edible dry bean, chickpea, peanut, dry pea, lentils and various vegetables as well. Occurrence of diseases caused by *S. sclerotiorum* on sunflower is influenced by genotype and weather conditions. Moist and cold weather conditions prevailing in temperate climate regions favours *S. sclerotiorum* development. In Serbia, weather conditions favoured economically important Sclerotinia development on sunflower head in 1999 and 2005 with diseased plants even over 60% (Maširević and Forgić, 2000; Maširević and Dedić, 2006). Diseases caused by this fungus can appear during the whole sunflower growing season, and yield loss depends on the sunflower development stage in which the disease occurs. Sunflower plants infected at the beginning of flowering stage can lose up to 98% of their potential yield, while plants infected eight weeks after flowering can lose not more than 12% of their potential yield (Maširević & Gulya 1992). The major control method for *Sclerotinia* diseases has been fungicide application in combination with host resistance.

Considering growing demand for organic food production, biocontrol of such cosmopolitan and devastating pathogen is a big challenge. The use of biofertilizers and biopesticides is an alternative for sustaining high eco-friendly production. Integrated control is facilitated by the fact that *Trichoderma* species are resistant to most chemical pesticides (Harman, 2011; FRAC, 2016). *Trichoderma* species have been known since 1930s (Weindling, 1932), but since 1990s their usage in commercial agriculture has been increased (Harman 2004, 2011). So far, *Trichoderma* species have been known as effective on nutrient utilization with high reproductive potential which allow them to survive under unfavourable conditions and makes them very competitive. Presence of great variety of lytic enzymes (cell-wall degrading enzymes) and secondary metabolites (gliotoxin, gliovirin, viridin, viridiol etc.) makes *Trichoderma* strongly aggressive to broad range of phytopathogenic fungi (Vinale et al., 2008). The main biocontrol mechanisms of *Trichoderma* species, when direct confrontation with pathogen occurs, are mycoparasitism and antibiosis (Howel, 2003). Another mechanism which is quite effective as well, but do not consider direct confrontation with the pathogen, is competition for soil nutrients and space. Additionally, *Trichoderma* species are known as well as plant growth promoter agents and promoters of plant defense mechanisms (Shoresh et al., 2010; Harman, 2011). *Trichoderma* colonizes roots and provides at least season-long benefits to plants, although it can be even for life because the best strains fully colonize roots as they grow (Harman 2000). So far it is recorded that *Trichoderma* species improve growth of lettuce, tomato, pepper, wheat, maize, soybean, chilli (Vinale et al., 2004; Tucci et al., 2011; Sukla et al., 2015; Maisuria and Patel, 2009; Asaduzzaman et al., 2010). Also, *Trichoderma* spp. is stimulating defense responses in its host plants and is known as one of the best induced systemic resistance (ISR) agents (Shoresh et al., 2010; Shoresh, 2005).

Trichoderma species are mainly soil fungi found in agricultural soils, native prairie, forests, salt marsh, desert soils of all climatic zones, but also in dead plant material, living roots of various plant species, seeds, lake water and air (Monte, 2001). World-wide distribution, fast growth and high spore production make those species easy to find and isolate. After all, one should bear in mind that not all *Trichoderma* strains are effective, most of them are not, and some may even be phytotoxic or pathogenic (Menzies, 1993), so strain selection is of crucial importance. Given that, the aim of this study was to test ability of native Serbian *Trichoderma* strains to protect sunflower seedlings in early stage from pathogen *S. sclerotiorum*.

MATERIAL AND METHODS

Plant and fungal material used: Fungal material was obtained from soil samples originated from different soil types and localities in Serbia, mainly from Vojvodina province. All *Trichoderma* spp. isolates were refined to single-spore according to Leslie and Summerell (2006). Ten isolates which previously indicated good antagonistic activity in dual culture test (Tančić et al., 2012) were selected for this research. Pathogen *S. sclerotiorum* was isolated from diseased sunflower plant at Rimski Šančevi.

Trichoderma isolates’ efficacy against *S. sclerotiorum* was tested on sunflower seeds of sterile parental line VL-A-8A.

Preparation of conidia suspension: A conidia suspensions of ten tested *Trichoderma* isolates were prepared from 7-days old isolates by flooding method. Such suspensions were filtered through cheesecloth, and conidial concentrations were adjusted to 10^6 conidia/ml by Neubauer's haemocytometer. Additionally, suspensions were amended according to Mukhtar et al. (2012) method.

Treatment T-1.2 considered that seeds were treated with 1.2 μl of *Trichoderma* suspension which was equally distributed per g of seeds and air dried on filter paper in Petri plates for 24 hours at room temperature (Маслиенко, 2005). Control was treated with 1.2 μl of sterile distilled water per g of seeds.

Treatment T-30 considered that seeds were dipped in seed-coating suspensions for 30 minutes and air dried on filter paper in Petri plates for 24 hours at room temperature, while sterile distilled water was used as a control.

Biological efficacy test: was done on 100 sunflower seeds treated with *Trichoderma* suspensions of different intensities (T-1.2 and T-30). Treated seeds were germinated in four replicates on double wet filter paper. Next to each sunflower seed, the 5 mm^2 plug of potato dextrose agar (PDA) with 7-day old micelia of *S. sclerotiorum,* was placed. Seeds treated with sterile distilled water without presence of pathogen *S. sclerotiorum* plugs were used as negative control, while seeds treated with sterile distilled water with presence of *S. sclerotiorum* plugs were used as positive control. Seeds were germinated in growth chamber with 12h photoperiod at 25±1ºC. After seven days diseased seedlings and seeds were counted, and biological efficacy of the *Trichoderma* isolate was calculated according to formula (Liu et al. 2009):

$$C\ (\%) = 100 * (a - b) / a$$

where C is biological efficacy in %, a – number of diseased seeds and seedlings in positive control, and b – number of diseased seeds and seedlings in treatment.

Beside biological efficacy, germination (G) was calculated as well on 7th day of the experiment.

Statistical analyses: All obtained data were analyzed in Statistica 12 using Duncan's test (percentages were previously transformed in ArcSin√%).

RESULTS AND DISCUSSION

Formation of rhizosphere microflora occurs usually in first three days after germination, and its progress in the deeper soil layers follows root growing and stimulates plant exometabolites at the same time (Асатурова, 2009). This is very important in biocontrol especially because young seedlings are often infected by pathogens in early stage of their development. Due to above mentioned, biological efficacy was estimated in the first days of sunflower germination and expressed as a percentage of protected seeds and seedlings comparing positive control (seeds without *Trichoderma* treatment grown in presence of pathogen *S. sclerotiorum*).

Germination was calculated on 7th day of incubation. Lower germination rates were registered in treatments with lower biological efficacy. Biological efficacy of all tested isolates was statistically significant as compared to the positive control in both treatments. According to obtained results, biological efficacy of tested *Trichoderma* isolates varied from 36 – 68% and 23.8 – 60.6% for treatments T-30 and T-1.2 respectively (Table 1). Excellent antagonism with over 50% of biological efficacy was registered in 8 isolates in T-30, and 3 isolates in treatment T-1.2 (bold values in Table 1). Three *Trichoderma* isolates – K150, K173 and K174 showed biological efficacy over 50% in both treatments. These are promising results considering that some authors with bacterial antagonist reached biological efficacy against *Fusarium* spp. on sunflower seedlings from 0-36% (Асатурова, 2009), while biological efficacy of fungal and bacterial antagonist against *S. sclerotiorum* on sunflower stem under the field conditions was much higher - 54.5-100% (Фирсов et al., 2009). Besides on sunflower, the antagonistic activity of *Trichoderma* spp. against *S. sclerotiorum* was proven on other crops as well. Thus, the application of *T. harzianum* as alignate capsules increased the survival of soybean plants more than 100% and 40% in greenhouse and in the field, respectively (Menendez and Godeas, 1998). Isolates of *T. harzianum* also protected over 80% of tomato, squash and eggplant seedlings inoculated with *S. sclerotiorum* in the greenhouse experiments (Abdullah et al., 2008). Further, *T. virens* significantly reduces the percentage of viable sclerotia and number of apothecia produced (Huang and Erickson, 2008) which can be used for bioregulation of pathogen density in soil.

Table 1. Biological efficacy of two different treatments with *Trichoderma* spp. isolates against *S. sclerotiorum* on sunflower seedlings

	T-30		T-1.2	
Isolate No	C (%)	G (%)	C (%)	G (%)
K114	**50.0^{ab}**	86^{ab}	26.2^{bc}	78^{a}
K132	36.0^{b}	74^{a}	45.2^{a}	84^{ab}
K150	**58.0^{ac}**	94^{ab}	**58.3^{a}**	80^{ab}
K160	**50.0^{ab}**	90^{ab}	40.5^{abc}	77^{a}
K173	**56.0^{ac}**	76^{a}	**54.8^{a}**	85^{ab}
K174	**58.0^{ac}**	86^{ab}	**60.6^{a}**	85^{ab}
K175	**68.0^{c}**	74^{a}	23.8^{b}	91^{b}
K176	**59.5^{a}**	88^{ab}	48.0^{ab}	87^{ab}
K178	40.0^{b}	90^{ab}	42.9^{ac}	80^{ab}
K179	**53.6^{a}**	98^{b}	44.0^{ab}	87^{ab}
- Control	100^{d}	88^{ab}	100^{d}	96^{ab}
+ Control	0.00^{e}	80^{ab}	0.00^{e}	82^{ab}

Legend: Values in the columns followed by the same letters are not significantly different ($p<0.05$) by Duncan’s test; Values are average of four replicates;

Beside *S. sclerotiorum*, it has been proven that *Trichoderma* spp. are aggressive to broad range of phytopathogenic fungi – *Rhizoctonia, Fusarium, Alternaria, Ustilago, Venturia, Colletotrichum, Pythium, Phytophthora, Thielaviopsis, Sclerotium cepivorum, Sclerotinia minor* etc. (Vinale et al., 2008; Thomas et al., 2004; McLean et al., 2012).

All mentioned above is leading to a conclusion that those perspective isolates from our research could also be good antagonists for some other important sunflower pathogens which should be tested in some further research.

CONCLUSION

Three out of ten tested *Trichoderma* isolates originating from Serbia expressed excellent ability to protect sunflower seedlings from pathogen *S. sclerotiorum* in both treatments. Those isolates can be considered as potential biocontrol agents and should be included in further, more comprehensive, research.

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EFFECT OF BIOSTIMULATORS ON SEED QUALITY, YIELD AND OIL CONTENT IN SUNFLOWER

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ABSTRACT

The effect of five biostimulators on seed quality, yield and oil content in sunflower was tested in this study. Seed was treated with biostimulators Amalgerol, Slavol, Иммуноцитофит,ТАБ, Raykat Start and НИКФАН, ж, as well as with fungicide Apron XL 350 ES and insecticide Cruiser 350 FS with added polymer Sepiret. Seed treatment with particular biostimulators had significant effect on the germination energy and germination. This effect was especially visible in the second trial year, when seeds lost their germination due to a long storage period. Treatments with pure Slavol and НИКФАН, ж showed the most significant positive effect. Positive effect was completely reduced when fungicide and insecticide were used with biostimulators. The largest average seed yield was achieved in treatment with НИКФАН,ж+insecticide and fungicide (4467 kg/ha), while the highest average oil content was achieved in treatment with pure НИКФАН,ж (53.34%). However, the effect of all treatments on seed yield and oil content was weak.

Key words: Sunflower, Biostimulators, Germination Energy, Germination, Seed Yield, Oil Content

INTRODUCTION

The most important target of sunflower production is high seed yield and high oil yield. In order to achieve this, it is necessary to grow high-yielding hybrids using optimal cultivation practices. Apart from these standard measures, various biostimulators are more often used via seed treatment or foliar treatment, with various degrees of success. Biostimulators are substances that can enhance the immunity of cultivated crops, benefit their metabolism (Kolomaznik et al., 2012), and decrease the effects of stress. The type of the biostimulator, its application, genotype and environmental conditions all affect its performance.

Using different foliar biostimulators based on 2-(1-Naphthyl) acetic acid, naphthalene derivatives, etc., Tahsin and Kolev (2005) found significant increase of sunflower seed yield with treatment in the flowering phase, but not with treatment in the budding phase; additionally there was no significant effect on the oil content. Beltrano et al. (1994) used gibberellic acid and benzyladenine and recorded yield increase of 25% through the increase of 1000-seed weight and pollination in the middle part of the sunflower head. Using various biostimulators on different oil crops, Ghosh et al. (1991) reached yield increase of 10-40%, but it was inconsistent throughout the trial years. Foliar application of amino acids had positive effect on the head diameter and pollination in sunflower in drought conditions (Kheybari et al., 2013). With foliar application of Fertileader Gold (patented extract of sea algae with addition of nitrogen, boron and molybdenum), Glijin et al. (2013) found significant increase in plant height and head diameter. By treating the seed with BION (active matter BTH), Buschmann and Sauerborn (2002) achieved induced resistance of sunflower to broomrape infection.

Jakienė and Liakas (2013) treated the soil with Azofit and Amalgerol and recorded significant increase in sugar beet root yield (7.26-9.67%), sugar content and sugar yield. Boteva (2014) found that fertilization with bioproducts Biofa and Amalgerol on background Biosol resulted in increased number of fruits in pepper – on average 3.1 fruits per plant. The increase of pepper yield was recorded from 6.2% (background Lumbrikal) to 16.9% (background Biosol+Amalgerol). The foliar products Amalgerol+Cereal mix, Foliar extra and KTS were the most effective for wheat grain yield, and the increase of yield compared to untreated control was 39.3%, 38.1% and 36.2%, respectively (Kostadinova et al., 2015). Šimunić et al. (2011) reported that foliar application of Amalgerol caused increased sunflower oil yield per hectare by 7.26% and soybean grain yield by 2.56%. On the other hand, under the conditions of extremely high temperatures during the growing season and severe soil drought in the region of Dobrudzha, Milev and Todorova (2014) found that foliar application of Almagerol on soybean did not have a significant positive effect neither on seed yield nor on 1000-seed weight. Treatment of growth stimulator Amalgerol premium with herbicides Goal, Raft, Wing, Pledge and Modown as tank mixtures increased the selectivity of these herbicides (Delchev, 2013).

The seed of Nadine F1 lettuce, treated with Slavol before sowing, sprung up two days earlier than the seed that was not treated at all (Kaliđerović and Mirecki, 2013). Treating sunflower seed with Slavol (indole-3-acetic acid) and Bioplant Flora (mixture of humic and fulvic acids, amino acids, macro and micro elements) Miladinov et al. (2014a) recorded increased length of sprout root (but not sprout shoot) in individual sunflower genotypes, but also found negative effects in certain treatments. Miladinov et al. (2014b) applied the same products while testing germination energy and germination, and found positive effect in certain treatments, higher on filter paper than on sterile sand.

Чухланцев (2010) reported that sunflower seed treatment with Vermikulen ŽK (3 l/t) + Иммуноцитофит, ТАБ (0.5 g/t) VDB (0.2 l/t) provided biological efficiency in the management of root white rot and fusariosis. Treatment of sunflower seed with a mixture of Иммуноцитофит and several other formulations increased yield, 1000-seed weight and number of seeds per head in sunflower (Высоцкая, 2013), as well as assimilating leaf area by 8.9-9.1% and seed yield by 320-360 kg/ha (Фирсов et al., 2010). Иммуноцитофит stimulated the mass germination of the sunflower seeds and increased their germination ability. The yield obtained from such plants (treated seeds + threefold treatment during the vegetation: in bud formation phase + two fold treatments every 15 days with addition of 0.5% Kristalon 18, 18, 18) was on average higher by 23.54% than control (Masheva et al., 2012).

Maize seed was treated with НИКФАН and germination increased by 20-40%, fresh weight yield increased by 22-32%, quality of fresh weight also increased (Маркелова et al., 2011). Петров and Шершнев (2007) found that maize seed treated with Agat – 25K and НИКФАН had better plant development and shorter growing season (by 7-8 days) and significant increase in seed yield.

Савенкова (2011) found that treatment of *Galega officinalis* seed with Raykat Start enhanced germination and root growth. Агафонов and Шабалдас (2013) reported increased yield of soybean seed treated with Raykat Start and several other products. However, this was not in agreement with Гракова (2011).

The aim of this study was to assess the effects of treating sunflower seed with biostimulators Amalgerol, Slavol, Иммуноцитофит, ТАБ, Raykat Start and НИКФАН, ж on seed yield, oil content and seed quality parameters.

MATERIAL AND METHODS

The trial was set up as split-plot design at the experimental field Rimski šančevi of the Institute of Field and Vegetable Crops in Novi Sad, Serbia in 2012 and 2013. The seed of sunflower hybrid Baća produced in 2011 was used in the trial and regular cultivation practices were performed.

The seed was treated with the systemic insecticide Cruiser 350 FS (1 l per 100 kg seed) and fungicide Apron XL 350–EC (300 ml per 100 kg seed), with addition of polymer and colorant Sepiret (300 ml per 100 kg seed), according to the regular sunflower seed processing procedure at the Institute of Field and Vegetable Crops. Additionally, the seed was treated with biostimulators in doses recommended by the manufacturers: Amalgerol at a concentration of 2%, Slavol at a concentration of 25%, Иммуноцитофит,ТАБ - one tablet in 10-15 ml of water per 5 g seed, Raykat Start - 0.5 l per 1000 kg seed, НИКФАН,ж- 0.6 l in 10 l of water per 1000 kg seed.

Amalgerol is an organic stimulator and soil enhancer. It contains essential oils, plant extracts and plant oils, marine algae extracts and mineral oil distillates. Slavol is a liquid microbiological fertilizer and growth stimulator certified for organic and traditional agricultural crop production. This product contains no chemical additives and has beneficial effect on the crops, soil and the environment. Иммуноцитофит, ТАБ is a plant growth regulator with active matter arachidonic acid ethyl ester. Raykat Start is a special fertilizer for the initial plant growth, used as seed / tuber dressing (free amino acids 4%, polysaccharides 15%, cytokine 0.05%, nitrogen (N) a single 4%, phosphorus pentoxide (P_2O_5) water-soluble 8%, potassium (K_2O) soluble in water 3%, iron (Fe) chelate EDDHA 0.1%, zinc (Zn) chelate of EDTA - 0.02%, boron (B) water-soluble 0.03%). НИКФАН, ж is an environmentally-friendly fertilizer, a product of microbiological synthesis mushroom-producing properties with strong stimulator for plant growth and development.

Oil content in clean seed was determined by nuclear magnetic resonance (NMR) method, according to Granlund and Zimmerman (1975). Sunflower seed yield was calculated to t/ha and corrected to 11% moisture. Laboratory analyses were performed in 2012 and 2013 at the Laboratory for Seed Testing of the Institute of Field and Vegetable Crops according to randomized block design in four repetitions, and the tested parameters were determined by standard laboratory methods. The data were processed in GENSTAT, and two-factorial analysis of variance was used for assessing results.

RESULTS AND DISCUSSION

The treatment of sunflower seed with the tested biostimulators did not show significant effect on the oil content in seed (Table 1). The highest oil content on average for both trial years was found in seed treated with pure НИКФАН, ж (53.34%), and the lowest in seed treated with the combination of Raykat Start with Apron and Cruiser (51.78%). Between these two treatments the differences were significant, but not highly significant, and in individual years there were no significant differences among the treatments (Table 2). No significant differences were found between the control and the treatments. In 2013 there was a higher average oil content than in 2012, but the differences were not significant.

Sunflower seed treatment with the tested biostimulators did not significantly affect the seed yield (Table 3). The highest seed yield was found in seed treated with НИКФАН, ж + Apron and Cruiser (4467 kg/ha), and the lowest in seed treated with Slavol + Apron and Cruiser (3846 kg/ha). The differences between these two treatments were significant, but not highly significant (Table 4). There were no significant differences in relation to the control, and there were no significant differences among all treatments in individual trial years. The highest average seed yield was achieved in 2013 (4431 kg/ha), and the lowest in 2012 (3853 kg/ha), there were no significant differences between the trial years.

Table 1. ANOVA for oil content in hybrid Baća seed

Source of variation	df	SS	MS	F	P
Year of study (Y)	1	74.64	74.64	6.71	0.122^{ns}
Error Y	2	22.25	11.13	10.14	-
Treatment (T)	15	18.56	1.24	1.13	0.353^{ns}
Y x T	15	7.60	0.51	0.46	0.950^{ns}
Error T	60	65.84	1.10	-	-
Total	93	188.89	-	-	-

**significant at 1% level; *significant at 5% level; ^{ns}not significant

Table 2. Effect of year and biostimulators on oil content (%) in hybrid Baća seed

Treatments (T)	Trial year (Y)		Mean (T)
	2012	2013	
Control	53.64	51.64	52.64
Amalgerol	53.18	50.98	52.08
Amalgerol+Apron XL 350 ES	54.35	52.08	53.21
Amalgerol+Apron XL 350 ES+Cruiser 350 FS	54.50	52.11	53.30
Slavol	53.09	51.80	52.45
Slavol+Apron XL 350 ES	54.00	51.28	52.64
Slavol+Apron XL 350 ES+Cruiser 350 FS	53.61	51.63	52.62
Иммуноцитофит,ТАБ	53.70	51.72	52.71
Иммуноцитофит,ТАБ+Apron XL 350 ES	54.09	52.04	53.06
Иммуноцитофит,ТАБ+Apron XL 350 ES+Cruiser 350 FS	53.55	51.38	52.46
Raykat Start	53.27	52.17	52.72
Raykat Start+Apron XL 350 ES	53.90	52.68	53.29
Raykat Start+Apron XL 350 ES+Cruiser 350 FS	52.30	51.26	51.78
НИКФАН,ж	53.66	53.02	53.34
НИКФАН,ж+Apron XL 350 ES	53.62	51.83	52.72
НИКФАН,ж+Apron XL 350 ES+Cruiser 350 FS	52.92	51.57	52.25
Mean (Y)	53.59	51.82	

	Y	T	Y x T
$LSD_{0.05}$	2.93	1.21	2.35
$LSD_{0.01}$	6.76	1.61	3.30

Both seed treatment and trial year showed highly significant effect on the germination energy of sunflower seed (Table 5). The highest average of germination energy was found in seed treated with pure Slavol (90.62%), and the lowest in seed treated with the combination Amalgerol + Apron and Cruiser (80.12%). The differences between these two treatments were highly significant and the treatment with Slavol gave significantly higher germination energy than the control (Table 6). In 2012 there was highly significantly higher average of germination energy (91.89%) than in 2013 (78.48%). In 2012 no treatment showed significantly higher germination energy than the control, but there were several combinations with highly significant differences. Namely, highly significantly higher germination energy was found in seed treated with НИКФАН, ж + Apron than in Raykat Start + Apron and Cruiser. In 2013 the differences among treatments were much higher – treatments with only Slavol and НИКФАН, ж were highly significantly higher or significantly higher than the control, but there were also significant reductions in some treatments, mostly in Amalgerol + Apron and Cruiser. These results imply that seed treatment with biostimulators showed more effect on the seed with lower average of germination energy, as was the case in 2013. It was discovered that in treatments with certain biostimulators which showed positive effect, the positive effect was lacking in combinations of biostimulator with fungicide and insecticide. Since seed treatment with fungicides (and insecticides as well) is a mandatory measure in seed processing, the practical possibility of biostimulator application is questionable.

Table 3. ANOVA for seed yield of hybrid Baća

Source of variation	**df**	**SS**	**MS**	**F**	**P**
Year of study (Y)	1	8015126	8015126	5.21	0.150^{ns}
Error Y	2	3076814	1538407	7.92	-
Treatment (T)	15	3328390	221893	1.14	0.341^{ns}
Y x T	15	1022172	68145	0.35	0.986^{ns}
Error T	60	11649289	194155	-	-
Total	93	39227240	-	-	-

**significant at 1% level; *significant at 5% level; ^{ns}not significant

Table 4. Effect of year and biotimulators on seed yield (kg/ha) of hybrid Baća

Treatments (T)	Trial year (Y)		Mean
	2012	2013	(T)
Control	3817	4317	4067
Amalgerol	3817	4692	4255
Amalgerol+Apron XL 350 ES	3994	4725	4360
Amalgerol+Apron XL 350 ES+Cruiser 350 FS	4053	4279	4166
Slavol	3661	4237	3949
Slavol+Apron XL 350 ES	3918	4139	4028
Slavol+Apron XL 350 ES+Cruiser 350 FS	3718	3975	3846
Иммуноцитофит,ТАБ	4013	4585	4299
Иммуноцитофит,ТАБ+Apron XL 350 ES	3764	4630	4197
Иммуноцитофит,ТАБ+Apron XL 350 ES+Cruiser 350 FS	3530	4221	3875
Raykat Start	3868	4554	4211
Raykat Start+Apron XL 350 ES	3901	4740	4320
Raykat Start+Apron XL 350 ES+Cruiser 350 FS	4081	4518	4299
НИКФАН,ж	3826	4319	4072
НИКФАН,ж+Apron XL 350 ES	3531	4186	3858
НИКФАН,ж+Apron XL 350 ES+Cruiser 350 FS	4156	4778	4467
Mean (Y)	3853	4431	

	Y	T	Y x T
$LSD_{0.05}$	1089	509	918
$LSD_{0.01}$	2513	677	1270

Seed treatment and trial year showed highly significant effect on the seed germination (Table 7). The highest mean seed germination was achieved in seed treated with pure Slavol

(91.12%), and the lowest in seed treated with Amalgerol + Apron and Cruiser (81.12%). The difference was highly significant and the treatment with Slavol showed significantly higher germination than the control (Table 8). In 2012 mean seed germination (93.03%) was highly significantly higher than in 2013 (79.80%). In individual years, the trends were similar to the germination energy, i.e. the treatment was more effective in a year with lower mean germination. In 2012 no treatment showed significant difference in relation to the control, but there were highly significant differences among individual treatments. In 2013 the treatments with Slavol and НИКФАН, ж showed highly significant increase in seed germination than the control. In 2013 the treatment with pure biostimulators showed better results than the treatments with added fungicides and insecticides, while in 2012 this was not the case.

Table 5. ANOVA for the germination energy of hybrid Baća seed

Source of variation	df	SS	MS	F	P
Year of study (Y)	1	5751.28	5751.28	446.68	<.001**
Error Y	15	1016.50	67.77	5.26	<.001**
Treatment (T)	15	675.72	45.05	3.50	<.001**
Y x T	93	1197.44	12.88	-	-
Total	124	8855.50	-	-	-

**significant at 1% level; *significant at 5% level; nsnot significant

Table 6. Effect of year and biostimulators on the germination energy (%) of hybrid Baća seed

Treatments (T)	Trial year (Y)		Mean
	2012	2013	(T)
Control	93.75	80.00	86.88
Amalgerol	90.75	79.25	85.00
Amalgerol+Apron XL 350 ES	94.25	79.25	86.75
Amalgerol+Apron XL 350 ES+Cruiser 350 FS	90.75	69.50	80.12
Slavol	92.75	88.50	90.62
Slavol+Apron XL 350 ES	90.25	73.25	81.75
Slavol+Apron XL 350 ES+Cruiser 350 FS	90.00	74.25	82.12
Иммуноцитофит,ТАБ	91.75	85.00	88.38
Иммуноцитофит,ТАБ+Apron XL 350 ES	91.50	78.50	85.00
Иммуноцитофит,ТАБ+Apron XL 350 ES+Cruiser 350 FS	94.00	76.50	85.25
Raykat Start	91.75	78.50	85.12
Raykat Start+Apron XL 350 ES	92.25	77.25	84.75
Raykat Start+Apron XL 350 ES+Cruiser 350 FS	88.50	76.75	82.62
НИКФАН,ж	91.50	86.75	89.12
НИКФАН,ж+Apron XL 350 ES	95.50	79.00	87.25
НИКФАН,ж+Apron XL 350 ES+Cruiser 350 FS	91.00	73.50	82.25
Mean (Y)	91.89	78.48	

	Y	T	Y x T
$LSD_{0.05}$	1.26	3.56	5.04
$LSD_{0.01}$	1.67	4.72	6.67

It is evident that the sunflower seed treatment with the tested biostimulators did not generally result in a significant increase of oil content in seed and seed yield, which is contrary to the results on sunflower reported by Šimunić et al. (2011), Высоцкая (2013), Фирсов et al. (2010), on maize by Маркелова et al. (2011), and on soybean by Агафонов and Шабалдас (2013). Lack of biostimulator effect on soybean yield was reported by Milev and Todorova (2014). There was a certain effect in individual treatments, but it was difficult to deduce any regularity which could justify commercially viable recommendations for general use.

Table 7. ANOVA for seed germination of hybrid Baća

Source of variation	df	SS	MS	F	P
Year of study (Y)	1	5604.76	5604.76	504.45	<.001**
Error Y	15	784.18	52.28	4.71	<.001**
Treatment (T)	15	702.37	46.82	4.21	<.001**
Y x T	93	1033.29	11.11	-	-
Total	124	8269.05	-	-	-

**significant at 1% level; *significant at 5% level; ^ns^not significant

None the less, the seed quality parameters showed different results. The effect of the treatment was much higher, especially in years with low mean values of germination and germination energy. The best effect was achieved with Slavol and НИКФАН, ж. The positive effects of individual biostimulators on the sunflower seed quality parameters were previously reported by Miladinov et al. (2014b), Masheva et al. (2012), and on other crops by Маркелова et al. (2011) and Савенкова (2011). The problem is that the combination of biostimulators with fungicides or fungicides and insecticides did not show any positive effects as pure biostimulators did, which greatly impedes the practical use of biostimulators.

Table8. Effect of year and biostimulators on seed germination (%) of hybrid Baća

Treatments (T)	Trial year (Y)		Mean
	2012	2013	(T)
Control	94.00	81.00	87.50
Amalgerol	92.00	79.50	85.75
Amalgerol+Apron XL 350 ES	95.25	79.50	87.38
Amalgerol+Apron XL 350 ES+Cruiser 350 FS	91.50	70.75	81.12
Slavol	93.75	88.50	91.12
Slavol+Apron XL 350 ES	90.75	74.25	82.50
Slavol+Apron XL 350 ES+Cruiser 350 FS	91.50	76.75	84.12
Иммуноцитофит,ТАБ	92.75	85.25	89.00
Иммуноцитофит,ТАБ+Apron XL 350 ES	93.50	79.00	86.25
Иммуноцитофит,ТАБ+Apron XL 350 ES+Cruiser 350 FS	97.50	78.00	87.75
Raykat Start	93.00	79.25	86.12
Raykat Start+Apron XL 350 ES	93.75	78.50	86.12
Raykat Start+Apron XL 350 ES+Cruiser 350 FS	89.25	82.50	85.88
НИКФАН,ж	92.00	87.50	89.75
НИКФАН,ж+Apron XL 350 ES	96.00	79.25	87.62
НИКФАН,ж+Apron XL 350 ES+Cruiser 350 FS	92.00	77.25	84.62
Mean (Y)	93.03	79.80	

	Y	T	Y x T
$LSD_{0.05}$	1.17	3.31	4.68
$LSD_{0.01}$	1.55	4.38	6.20

In the current situation of slow increase of genetic yield and quality potential in new cultivars of many crops and the level of cultivation practices that cannot easily be revolutionized nor quickly improved, various biostimulators are more often being used. The results show that the positive effects were not as spectacular as marketed or reported in different studies. Individual biostimulators certainly hold their place in the improvement of individual crops cultivation, so investments into biostimulators application must be economically viable, which is only possible through detailed and objective studies in different agricultural environments using different genotypes.

CONCLUSIONS

Sunflower seed treatment with the tested biostimulators did not show significant effect on oil content in seed nor the seed yield. The highest oil content on average for both trial years was found in seed treated with pure НИКФАН, ж (53.34%), and the lowest in seed treated with Raykat Start in combination with Apron and Cruiser (51.78%). Between these two treatments the differences were significant, but not highly significant, and in individual years there were no differences between the treatments. The highest seed yield was found in seed treated with НИКФАН, ж + Apron and Cruiser (4467 kg/ha), and the lowest in seed treated with Slavol + Apron and Cruiser (3846 kg/ha). The differences between these two treatments were significant, but not highly significant.

Sunflower seed treatment with the tested biostimulators showed highly significant effect on the seed quality parameters. The highest mean first count was found in seed treated with pure Slavol (90.62%), and the lowest in seed treated with Amalgerol + Apron and Cruiser (80.12%). The differences between these two treatments were highly significant, and the treatment with Slavol showed significantly higher germination energy than the control. The highest mean seed germination was found in the seed treated only with Slavol (91.12%), and the lowest in seed treated with Amalgerol + Apron and Cruiser (81.12%). The difference was highly significant and treatment with Slavol showed significantly higher germination than the control.

The conclusion is that the tested biostimulators could be more applicable in seed production than in commercial (mercantile) production. Practical application of individual biostimulators for enhancement of seed quality parameters is restricted by the fact that the positive effects drastically drop when biostimulators are combined with fungicides and insecticides, which should further be studied. This indicates that biostimulators can be used more successfully in organic production.

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INSECT MONITORING IN SUNFLOWER CROPS (HELIANTHUS ANNUUS) IN NORTHERN GREECE (2010-2015)

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ABSTRACT

Twenty-eight insect species were recorded in sunflower crops in Northern Greece, during the 2010-2015 period. The recorded species were classified into three categories: a) pests, b) beneficial and c) insects that were merely observed in sunflower fields. In the first category, the recorded insect species in sunflower crops were green peach aphids (*Myzus persicae*, Hem.: Aphididae), thrips (Thys.: Thripidae), ground beetle grubs (Col.: Scarabaeidae), meadow froghoppers (*Philaenus spumarius,* Hem.: Aphrophoridae), common meadow bugs (*Lygus pratensis,* Hem.: Miridae), click beetle larvae (*Agriotes* spp., Col.: Elateridae), grasshoppers (Orth.: Acrididae), cutworms (*Agrotis* spp.), long horn beetle larvae (*Agapanthia cynarae*, Col.: Cerambycidae), sugarbeet weevils (*Bothynoderes punctiventris*, Col.: Curculionidae), leafhoppers (Hem.: Cicadellidae), whiteflies (*Bemisia tabaci,* Hem.: Aleyrodidae), vine chafer beetles (*Anomala vitis,* Col.: Scarabaeidae), flea beetles (*Chaetocnema tibialis,* Col.: Chrysomelidae), bordered straw larvae (*Heliothis peltigera,* Lep.: Noctuidae), black bean aphids (*Aphis fabae,* Hem.: Aphididae), two-spotted spider mites (*Tetranychus urticae,* Tetranychidae) and nematodes (*Meloidogyne hispanica,* Tylenchida). In the beneficial insects category, ladybirds (*Coccinella septempunctata,* Col.: Coccinellidae), damsel bugs (*Nabis* spp., Hem.: Nabidae) and lacewings (*Chrysoperla carnea,* Neur.: Chrysopidae) were recorded. In the third category, sloe bugs (*Dolycoris baccarum, Hem.: Pentatomidae*), red shield bugs (*Carpocoris mediterraneus,* Hem.: Pentatomidae), lucerne bugs (*Adelphocoris lineolatus*, Hem.: Miridae), clearwing flies (*Terellia* spp., Dip.: Tephritidae), green stink bugs (*Nezara viridula*,Hem.: Pentatomidae), the harmless pollen-feeding beetles (Col.: Oedemeridae) and painted-lady adults (*Vanessa cardui,* Lep.: Nymphalidae) were recorded.

Key Words : sunflower

INFLUENCE OF SEED SIZE GRADE ON SUNFLOWER PLANT HIGH

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ABSTRACT

The seed size is one of the seed quality components which affect the performance of the crop. In order to equalize the quality, the seeds are processed and packed by grade where seeds are separate by size and specific weight. The objective of this study was to examine the effect of seed processing and grading on sunflower plant height at bud stage. The field experiment was carried out during the growing seasons of 2010 and 2011, with six seed grade of hybrid Sremac at the experimental fields of Institute of Field and Vegetable Crops at Rimski šančevi and Zrenjanin Agricultural Advisory Services. Data were analyzed using three-way ANOVA for a split-split-plot design. Based on obtained results it can be concluded that the effect of all three observed factors - locality, growing seasons and seed grade on sunflower plant height at bud stage was statistically highly significant as well as interaction year x locality, while other interactions did not show statistical significance. Also, significant differences were observed between bigger and smaller grades, where the plant height proportionally decreased with seed size.

Key words: Plant Height, Seed Size, Sunflower

INTRODUCTION

Seed quality is a collection of properties that are considered to have a significant impact on the seed value which is used for sowing (FAO, 1999). The seed size is one of the seed quality components which affect the performance of the crop, and therefore on the yield (Singh et al., 2010; Adebisi et al., 2013).

In the sunflower seed production the most important is to get a high quality seed as a final product. The quality, and therefore the seed size, primarily is determined by growing conditions and it is necessary to cultivate crop in optimal plant density, the more fertile soils, with timely and quality execution of all other agro-technical measures (Crnobarac, 1992). On the other hand, seed quality depends not only on field conditions and cultural practices applied but also on seed processing (Miklič et al., 2012). During processing, unwanted ingredients are removed from the natural seeds by applying various technological processes, based on differences in the seed characteristics (Prole et al., 2011).

Commercially seed are rarely uniform in size, and in one lot can be found the seeds of different sizes and different quality (Komba et al., 2007). The goal of seed processing is to prepare seed material in form and condition suitable for sowing, by separation seeds by size

(Štatkić et al., 2007). Pucarić (1992) considered it necessary make seed calibration because it affects the uniform germination, emergence and early growth of plants, and therefore provides a higher yield. Similar attitudes present Pucarić and Ujević (1986) and conclude that the corn seed calibration can accomplish 15% higher yields compared to commonly seed processing. Calibration, i.e. equalizing of seed by size and weight, affect seed quality, but also visual appearance on the increasingly demanding market and provides uniform sowing. Global standards do not prescribe calibration parameters, and calibration of sunflower seeds is done by experience (Prole et al., 2011).

Processing can have various and very large impact on seed quality in different sunflower genotypes, and it is necessary to know the specific characteristics of each genotype, especially in the case of seeds with lower quality (Miklič et al., 2012).

The objective of this study was to examine the effect of seed processing and grading on sunflower plant height at bud stage.

MATERIAL AND METHODS

The research was carried out on seed of hybrids Sremac, conventional oil hybrid created in the Institute of Field and Vegetable Crops from Novi Sad. The seed is produced within the seed production by applying agro-technical measures required by the technology of sunflower hybrid seed production.

Natural seed was pre-cleaned, and after processing separated into six grades. First, seed was graded with a *Cimbria Heid* type *ZS 500* cylinder grader, with the screens set to make two grades, small seeds of 2.8 -3.5 mm and large seeds of 3.5-5.0 mm. After that, both grades were run through a *Cimbria Heid* type *GA 200* gravity table to separate seeds by specific weight. 1000-seed weight was determined for each grade (Table 1).

Table 1. Seed grade of hybrid Sremac

Seed grade	Diameter (mm)	1000-seed weight (g)
I	3.0 – 5.0	66.4
II	3.0 – 5.0	71.8
III	3.0 – 5.0	57.1
IV	3.0 – 5.0	54.1
V	2.8 – 3.0	50.5
VI	2.8 – 3.0	47.7

After processing seed was chemically treated with Cimbria *Heid* type *CC 50* centrifugal duster with fungicide *Apron XL 350 EC* (300 ml per 100 kg seed) and insecticide *Cruiser 350 FS* (1 l per 100 kg seed), with addition of polymer Sepiret (500 ml per 100 kg seed), that allows a better adhesion of pesticides for seed. Seed processing and treatment, as well as sample preparation was conducted in the Oil Crops Department of Institute of Field and Vegetable Crops in Novi Sad.

The field experiment was carried out during the growing seasons of 2010 and 2011, at the experimental fields of Institute of Field and Vegetable Crops at Rimski šančevi and Zrenjanin Agricultural Advisory Services according to the *split-plot* model design with three replications.

Plant height was measured by a graduated stick, and parameter values are expressed in cm. The measurement was carried out in the bud stage (R2), according to Schneiter and Miller (1981).

Statistical analysis of data was performed by analysis of variance (ANOVA) of the tri-factorial trial using the statistical package *STATISTIKA 10.0* for *split-split-plot* design model. Table of analysis of variance shows the probability of significance of differences by F-test, and based on the participation in the treatment sum of squares, percentage ratio of each factor was calculated in the total variability. LSD values at 1% and 5% were computed to compare differences between treatments of the observed factor.

RESULTS AND DISCUSSION

The results of ANOVA showed that the interaction year x locality had the greatest influence on plant height in bud stage, with a participation of 65% in the total variation of these properties. Also, a highly significant influence had all the examined individual factors although their participation was a smaller percentage, at seed grade only 7% (Table 2).

Table 2. ANOVA for hybrid Sremac plant height at bud stage

Source of variation	df	SS	% in SS	MS	F	P
Y x L x Rep.	8	1291.00	-	161.38	3.72	0.002**
Year (Y)	1	3500.06	13	3500.06	80.79	<.001**
Locality (L)	1	3253.56	12	3253.56	75.10	<.001**
Seed grade (G)	5	1997.17	7	399.43	9.22	<.001**
Y x L	1	17734.72	65	17734.72	409.34	<.001**
Y x G	5	331.78	1	66.36	1.53	0.202ns
L x G	5	304.28	1	60.86	1.40	0.243ns
Y x L x G	5	184.44	1	36.89	0.85	0.522ns
Error	40	1733.00	-	43.33	-	-
Total	71	30330.00	100	-	-	-

**significant at the 1% level of probability; *significant at 5% level of probability; ns not significant

On average, highly significantly higher plant height was measured in 2010 (130.31 cm), and at the locality Rimski šančevi (130.06 cm). The reason for these results we can see on the interaction year x location, where is in the locality of Zrenjanin in 2011 the highly significantly lowest plant height was measured (93.94 cm). Also, highly significantly lower height had plants at Rimski šančevi in 2010 in relation to Zrenjanin in 2010 and Rimski šančevi in 2011, where no statistically significant difference was found (Figure 1).

Looking at the seed grades, we can see that the plant height, on average, decreased proportionally the seed size (Figure 2). Therefore, the largest plant height was measured in I grade, and the lowest in VI, and this difference was highly significant. Plant height of I grade was significantly higher compared to other tested grades, except in relation to II grade, where the difference was not statistically significant. Also, significant differences were observed between II grade and other tested grades, among which no statistically significant difference was found. Almost identical results can be noted for the first order interactions - year x seed grade and location x seed grade, for both investigation years and both localities.

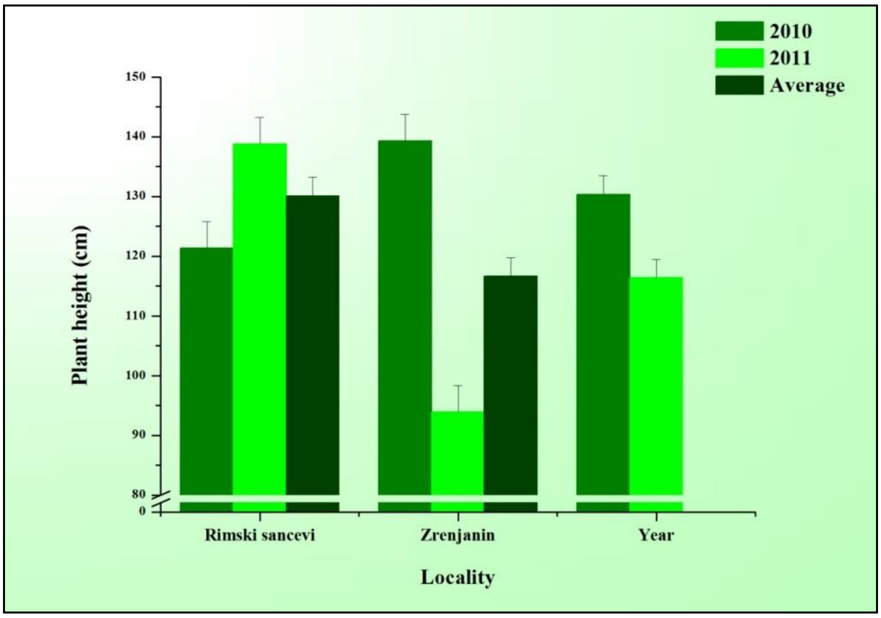

Figure 1. The effect of locality and production year on hybrid Sremac plant height at bud stage

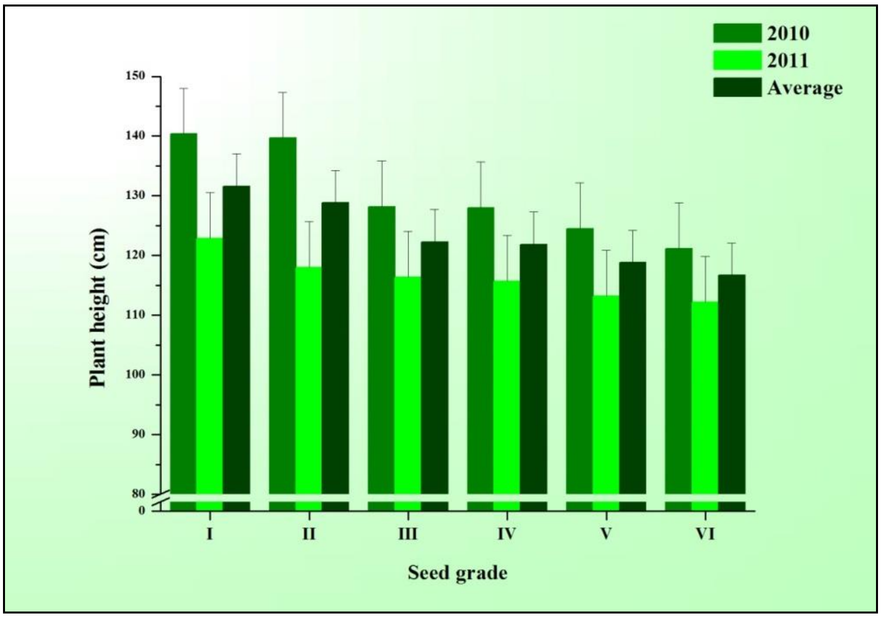

Figure 2. The effect of seed grade and production year on hybrid Sremac plant height at bud stage

Plant height mostly depends on genotype (Velasco et al., 2003; Mijić et al, 2005) and cropping practices and especially soil moisture content (Human et al., 1990; Iqbal et al., 2013) and growing spaces (Hall et al., 2010; Sposaro et al., 2010). Results from our research are in compliance with previous statement, plant height is significantly dependent on locality and year of trial. For hybrid Sremac year and locality had similar part in total variation, with difference of 1%. The third factor, seed grade, had significantly influenced plant height although it had only 7% in total variation. Rogers and Lomman (1988) obtained similar results. Usage of seed smaller size resulted in delay of the initial plant growth and development in comparison with plants grown using larger seed. In this research plant height was negatively correlated to seed size.

Results from other researchers are confirming that seed size influence yield and plant development. In the research of Haskins and Gorz (1975) plants of same variety but growing using large seed were much stronger. They confirm statement made by Kaufmann (1958) that plants from large seed were stronger and pointed that seed size as source of variation. Fenner (1983) proved that seedlings develop from large seed easily penetrates deeper in soil, which helps early plant growth.

Mishra et al. (2008) research gave conclusion that usage of seed larger in size is much better considering field emergence well as plant performance then use of middle size seed. Same authors recommended avoidance of use of seed small in size. Explanation for these results, according to Jevtić (1981), is that large seed have larger endosperm, higher auxin content which positively influence development of young seedlings root and enhance plant growth.

CONCLUSION

Based on obtained results it can be concluded that the effect of all three observed factors - locality, growing seasons and seed grade on sunflower plant height at bud stage was statistically highly significant as well as interaction year x locality, while other interactions did not show statistical significance. Also, significant differences were observed between bigger and smaller grades, where the plant height proportionally decreased with seed size.

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AGRONOMIC PERFORMANCE OF SUNFLOWER CULTIVARS IN CAMPO NOVO DO PARECIS - MT, BRAZIL

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ABSTRACT

Sunflower seeds are a promising future crop in Brazil, especially as a catch crop in soy bean production. Sunflower seeds are processed mainly for their oil leaving press cakes or meals as by-products. Sunflower is an annual cycle plant of rapid growth, less needs of water and resistance to high and low temperatures comparing to most common explored oil plants in Brazil. Sunflower is cultivated in Brazil mainly in the winter season in the central west regions of Brazil. This study aimed to evaluate the agronomic characteristics of different genotypes of sunflower sown as a second crop in the year 2014. The work was implemented in the experimental field of the Instituto Federal de Educação Ciência e Tecnologia de Mato Grosso - Campus Campo Novo do Parecis - Brazil. The experimental design was a randomized block design with 16 treatments (16 genotypes) and four replications. The experimental plots consisted of four rows 6.5 m long with row spacing of 0.45 m, containing area of 11.7 m², totaling an area of 748 m². A population of 45,000 plants per hectare is used. The genotypes performance were evaluated according to following parameters: plant height (PH; cm), date to the early flowering (DEF), days until physiological maturity (DPM), stem curvature (SC), capitulum size (CS; cm), number of broken plants (NBP), harvest index (HI), achenes productivity (PR; kg ha^{-1}) and mass of thousand achenes (MTA, g). All variables showed significant differences ($p<0.05$) in the analysis of variance, especially the SYN 045 (PH and SC), ADV 5504 (DEF and DPM), PARAISO 20 (CS), AGUARÁ 06 (NBP) and AGUARÁ 04 (HI). For the mass of a thousand achenes, genotypes that stood out were BRS 323, MG 360 and M734 while the most productive were the genotypes MG 360, AGUARÁ 06, MG 305, AGUARÁ 04, CF 101, SYN 045, GNZ NEON, HELIO 251 and SYN 3950HO.

Keywords: Brazilian savannah, *Helianthus annuus* L., oilseed, genotypes performance, sunflower meal.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an annual cycle plant and its characteristics rapid growth, straight stem, sub woody and little branched at the apex, with characteristics of resistance to drought, cold and heat, more than most cultivated species of economic interest in Brazil. Sunflower fractions like presscake and hulls can be used for various purposes such as the for the production of food ingredients, animal feed and high quality oil as well. Furthermore, sunflower can be used as ornamental plant and to feed birds (Leite et al., 2005).

The cultivated sunflower area in Brazil in the harverst year of 2013/2014 was 145,700 hectares, totalizing 244,100 tons. The national average yield in the mentioned period was 1,599 kg ha^{-1}. In the state of Mato Grosso, sunflower planted area represented 87.2% compared to the total planted area (126,200 hectares) and with the highest production (202,300 tons) with an average yield of 1,611 kg ha^{-1}. The Region of Campo Novo do Parecis is Brazil´s largest sunflower producer, with a planted area of over 100,000 hectares (CONAB, 2014).

Among the various technologies developed for sunflower production, the proper choice of cultivar and the planting season, which has high grain yield is important to ensure the success of culture as one of the production system components (Porto et al., 2007). In the region of Campo Novo do Parecis, the sunflower is cultivated as second crop from February / March, due to the occurrence of rainfall conditions (500-700 mm evenly distributed throughout its cycle) and appropriate temperatures (20 at 28 °C) for its cultivation (Castro and Farias, 2005). Despite being the main growing region in the country, little information is available on adaptation and other agronomic characteristics of genotypes that facilitate the cultivation, reducing risk and increasing profitability.

In this sense, this study aimed to evaluate the agronomic characteristics of different genotypes of sunflower as a second crop in the region of Campo Novo do Parecis – MT. In the frame of this study, results will be used to identify best performance materials and a Sunflower meal for human consumption will be developed in collaboration with german researchers

MATERIAL AND METHODS

The work was carried out at the experimental fields and facilities of the Instituto Federal de Educação Ciência e Tecnologia de Mato Grosso - Campo Novo do Parecis in second-crop system in succession to soybeans in the agricultural year 2013/2014. The soil, according to the American System of Soil Classification (USDA, 1960) is the Typic Tropudox. The initial characterization of fertility, for the first layer of 0-0.20 m, presented the following values: pH ($CaCl_2$) = 5,7; MO = 26 g dm^{-3}; P (resina) = 5,9 mg dm^{-3}; K, Ca, Mg e H+Al = 1,5; 32; 11 e 40 $mmol_c$ dm^{-3}, respectively; with V = 54,8%.

Average temperatures occurred during the experimental period were: 30.3; 23.2 and 18,9 °C for maximum temperature, medium and minimum, respectively, and 570 mm rainfall, meeting the water demands required by sunflower between 500 and 700 mm distributed along its growing cycle (Castro and Farias, 2005).

The experimental design was a randomized complete block design with 16 treatments (genotypes) and four replications, as follows: ADV 5504, AGUARÁ 04, AGUARÁ 06, BRS 323, BRS G42, CF 101, GNZ NEON, HELIO 250, HELIO 251, HLA 2012, M734, MG 305, MG 360, PARAISO 20, SYN 045 and SYN 3950HO. The experimental plots consisted of 4 rows with 6.5 m long, with row spacing of 0.45 m, containing area of 11.7 m² (1.8 x 6.5 m). Only the two 5 meters central rows of each genotype were considered for data collection. The plotted area comprises 4.5 m².

The plot of the rows, was done on March 7, 2014, and the previous application of fertilizers was carried out with the aid of a sowing machine and was distributed at a depth of 0.10 m, 45 kg ha^{-1} Potassium Chloride + 267 kg ha^{-1} NPK 10-30-20, totalizing: 26.7 kg ha^{-1} N; 80 kg ha^{-1} P_2O_5; 80 kg ha^{-1} K_2O, according to the results of soil analysis and recommendation (EMBRAPA, 2004). Further, beside the row fertilization at 0.04 m deep, three seeds were placed in each hole, each 0.495 m, by manual planter.

The desiccation and the application of boron was performed on March 07, using trawl trailed sprayer with an application volume of 150 L ha^{-1} using glyphosate (648 g a.i. L^{-1}) at a dosage of 2 L ha^{-1} + Prometryn dosage 2 L ha^{-1} + mineral oil (0.5 L ha^{-1}) + boric acid dosage of 3 kg ha^{-1} (600 g ha^{-1} Boron). Thinning was done 10 days after emergence (DAE) with a scissor, leaving only one plant per hole, reaching a population of 45,000 plants ha^{-1}.

The following coverage fertilizations were made: 1) 32 DAE with a dosage of 50 kg ha^{-1} N (urea); 2) foliar application of boron, with knapsack sprayer at 35 DAE using a dosage of 3 kg ha^{-1} (600 g ha^{-1} Boron), and 43 DAE with a dosage of 11 kg ha^{-1} (1.1 kg ha^{-1} of Boron). The source of Boron used was boric acid 150 L ha^{-1} according to the requirement of sunflower of 2 kg ha^{-1} B, Control of weed, pests and diseases have been carried out according to the recommendations of EMBRAPA (2004). To avoid birds attacks, the plotted sections of the central rows were protected (stage R6) by using polypropylene based bags (30 x 30 cm) and fixed with clips.

The following agronomic characteristics were evaluated: plant height (**PH**; cm), collected in ten plotted plants from the soil base to the apex of the plant, in $R_{5.5}$; date of the early flowering (**DEF**), when 50% of the plants showed yellow petals R_4; days to physiological maturity (**DPM**), when 90% of plotted plants showed color between yellow and brown; stem curvature (**SC**), visual assessment using the rating scale Castiglioni et al. (1997); capitulum size (**CS**; cm) collected in the diameter of the ten capitulums demarcated plants, R_9; number of broken plants (**NBP**), counting on the two central lines of 5 meters; harvest index (**HI**), determined by dividing the mass of achenes by the mass of capitulums collected from ten demarcated plants.

The achenes productivity (**PR**; kg ha^{-1}) was defined based on two central 5 meters rows, this being corrected for moisture condition of 11% (wet basis) by obtaining a reading of the moisture value of achenes, and calculated according to the Equation 1, proposed by Dalchiavon et al. (2011):

$$PR = P.[(100\text{-}Uob) / (100 - Ud)] \quad \text{Eq. (1)}$$

where: PR represented the corrected mass of achenes (kg ha^{-1}); **P** represented the field of mass (uncorrected) of achenes (kg ha^{-1}); **Uob** represented the moisture observed for each plot (%) and **Ud** representing the desired moisture as standard (11%). Mass thousand achenes (**MMA**; g) was obtained by counting and weighing samples collected from ten marked plants.

The harvest of the capitulums was performed manually in the two 5 meter central rows in R_9 with pruning shears aid. Later the capitulum inflorescence were natural dryied, cleaned and weighed. The datas collected were submitted to analysis of variance followed by the average test Scott-Knott, both 5% probability, with the help of statistical program SISVAR (Ferreira, 2011).

RESULTS AND DISCUSSION

All variables showed significant differences ($p < 0.05$) in the analysis of variance (Table 1). For plant height, the genotype with the highest average was the SYN 045 (198.5 cm), and the lowest average were BRS G42, MG 360, CF 101, ADV 5504, HELIO 250 and BRS 323, with values between 142.1 and 157.4 cm (Table 2). Nobre et al. (2012), carried out tests with different genotypes in the North of Minas Gerais (Brazil) and reported averages of 170.0 and 200.0 cm, respectively, for genotypes CF 101 and M734. The smallest plant height facilitates the cultivation and reduces the loss in mechanical harvesting.

Table 1. ABSTRACT of the analysis of variance for the sunflower productivitiy parameters

Variables[1]	F[2]	CV (%)[3]	GA[4]
PH (cm)	27.4*	3.6	167.7
DEF	489.0*	0.4	57.6
DPM	15103.9*	0.1	101.4
SC	8.6*	7.0	4.7
CS (cm)	8.2*	6.8	15.4
NBP	8.4*	27.4	8.6
HI	2.2*	11.2	0.64
PR (kg ha^{-1})	6.4*	12.4	1846.9
MTA (g)	9.5*	9.2	54.1

[1] PH = plant height, DEF = date to the early flowering, DPM = days to physiological maturity, SC = stem curvature, CS = capitulum size, NBP = number of broken plants, HI = harvest index, PR = achenes productivity and MTA = mass thousand achenes; [2] * significant at 5%; [3] CV = Coefficient of variation; [4] GA = General average.

For the early flowering, the HELIO 250 and HELIO 251 were the earliest, starting flowering to 53 days after emergence (DAE), as shown in Table 2. The genotype that flourished later was the GNZ NEON, at 63 DAE, followed SYN 045, 61 DAE. According to Castro and Farias (2005), high temperature and dry weather accelerate flowering.

With regard to the days to physiological maturity, the earliest genotypes were ADV 5504 and BRS 323, both with 92 DAE (Table 2). The AGUARÁ 06, GNZ NEON and MG 305 had longer cycle (112 DAE). In the work of Backes et al. (2008), in Southern Brazil, it was observed 105 days between emergence and maturation for the M734 genotype while in the present study that moment was reached at 97 DAE (M734), confirming the influence of environmental question in the growth stages of culture. Because it is grown in second harvest in Campo Novo do Parecis, early sunflower genotypes as ADV 5504 and BRS 323 are desirable to facilitate the adjustment of sowing time within the production system of the region.

As for stem curvature, the genotypes AGUARÁ 04, AGUARÁ 06 and HLA 2012 had the lowest average (Table 2). According to Santos et al. (2011), stem larger curvature may be influenced by the wind speed, contributing to increase bedding and break of plants. The more affected genotypes were PARAISO 20, ADV 5504, BRS G42, CF 101, GNZ NEON, HELIO 250, HELIO 251, M734, MG 305, SYN 045 and BRS 323.

Regarding the capitulum size, genotypes AGUARÁ 06 (18.3 cm) and PARAISO 20 (18.5 cm) have shown the highest average. Balbinot et al. (2009), when studying performance of sunflower genotypes in the northeast of Santa Catarina, Brazil, has reached higher averages of 15.4 (AGUARÁ 04) and 18.4 cm (M734). The capitulum size can be considered an indicator for assessing the development and productivity of plants, although extreme conditions of stress can cause low productivity of achenes.

Table 2. Mean values for plant height (PH), the date for early flowering (DEF), days to physiological maturity (DPM), stem curvature (SC), capitulum size (CS) and number of broken plants (NBP) different sunflower genotypes

Genotypes	PH (cm)	DEI	DPF	SC	CS (cm)	NBP
ADV 5504	153.6 e	56 h	92 l	4.8 a	13.7 d	11.3 a
AGUARÁ 04	170.4 c	57 g	98 f	4.0 c	15.4 c	6.3 b
AGUARÁ 06	184.6 b	60 c	112 a	3.8 c	18.3 a	1.3 c
BRS 323	157.4 e	55 i	92 l	5.5 a	14.7 c	6.5 b
BRS G42	142.1 e	56 h	95 h	5.0 a	13.3 d	13.5 a
CF 101	153.3 e	56 h	94 i	5.0 a	15.1 c	10.5 a
GNZ NEON	172.5 c	63 a	112 a	5.0 a	14.6 c	2.7 c
HELIO 250	155.5 e	53 j	93 j	5.0 a	13.7 d	7.3 b
HELIO 251	163.2 d	53 j	100 e	5.0 a	16.2 b	8.5 b
HLA 2012	185.9 b	60 c	110 c	4.0 c	15.2 c	8.5 b
M734	169.8 c	59 d	97 g	5.0 a	15.5 c	9.8 a
MG 305	165.0 d	58 f	112 a	5.0 a	15.4 c	12.0 a
MG 360	148.1 e	57 g	100 e	4.5 b	16.1 b	11.3 a
PARAISO 20	188.0 b	58 e	111 b	4.7 a	18.5 a	8.3 b
SYN 045	198.5 a	61 b	104 d	5.0 a	14.3 d	7.8 b
SYN 3950HO	175.3 c	59 d	100 e	4.3 b	16.9 b	13.0 a

Different letters differ by Scott-Knott test at 5% probability.

The lowest rates of broken plants were observed for genotype AGUARÁ 06, in average 1.3 broken plants per plot(Table 2) or 2,888 plants ha^{-1} and GNZ NEON, with 2.7 broken plants per plot (6,000 plants ha^{-1}). Genotypes with the highest averages were SYN 3950HO, MG 360, MG 305, M734, CF 101, BRS G42 and ADV 5504, with values ranging between 9.8 and 13.5, ie, 21,777 and 28,889 broken plants ha^{-1}. Higher results for M734 of 33,750 plant ha^{-1} were mentioned by Backes et al. (2008) as well as lower value for the AGUARÁ 04, with an average 10,000 broken plants ha^{-1} on tests carried out in Southern Brazil.

For the harvest index, the higher the value, the higher the mass of the trade capitulum. This parameter is considered important for the processing industry, as the achenes are needed. Thus, the genotypes MG 305, SYN 045, ADV 5504, BRS 323, CF 101, PARAISO 20 and AGUARÁ 04 showed higher harvest index (Table 3), which were 0.67; 0.67; 0.67, 0.68; 0.69; 0.69 and 0.74, respectively, reaching statistical indexes equal to each other. The lowest rate observed was 0.54 (HLA 2012), indicating that 46% of the total mass of the capitulum does not have commercial value.

In respect to the achenes productivity (Table 3), the best performance genotypes were the SYN 3950HO (2,205.5 kg ha^{-1}) and HELIO 251 (2,204.1 kg ha^{-1}), but did not differ statistically from GNZ NEON, SYN 045, CF 101, AGUARÁ 04, MG 305, AGUARÁ 06 and MG 360, who had productivity averages between 1,836.8 and 2,132.5 kg ha^{-1}. It is also important to highlight, that lower productivities were observed for HLA 2012 and BRS G42 genotypes, with an average of 40% lower than the most productive genotypes. Vogt et al. (2010) worked with sunflower crop tests sown in November in Northern Santa Catarina, Brazil and reported higher productivities for AGUARÁ 04 (1,916.0 kg ha^{-1}) and M734 (1,962.0 kg ha^{-1}) and lower average for HELIO 250 (1,450.0 kg ha^{-1}).

Table 3. Mean values for harvest index (HI), achenes productivity (PR) and mass of thousand achenes (MTA) from different sunflower genotypes

Genotypes	HI	PR (kg ha^{-1})	MTA (g)
ADV 5504	0.67 a	1,446.9 c	46.4 c
AGUARÁ 04	0.74 a	2,084.1 a	47.9 c
AGUARÁ 06	0.61 b	1,859.5 a	46.0 c
BRS 323	0.68 a	1,782.0 b	63.3 a
BRS G42	0.61 b	1,425.9 c	60.3 b
CF 101	0.69 a	2,104.4 a	50.3 c
GNZ NEON	0.62 b	2,132.5 a	51.6 c
HELIO 250	0.61 b	1,694.7 b	45.7 c
HELIO 251	0.63 b	2,204.1 a	45.5 c
HLA 2012	0.54 b	1,313.0 c	50.3 c
M734	0.58 b	1,673.7 b	68.5 a
MG 305	0.67 a	1,993.8 a	55.7 b
MG 360	0.56 b	1,836.8 a	64.3 a
PARAISO 20	0.69 a	1,685.3 b	47.9 c
SYN 045	0.67 a	2,108.5 a	59.7 b
SYN 3950HO	0.64 b	2,205.5 a	60.7 b

Different letters differ by Scott-Knott test at 5% probability.

In respect to the mass of thousand achenes, the highest averages were represented by genotypes M734, MG 360 and BRS 323, whose values ranged from 63.3 (BRS 323) and 68.6 g (M734) (Table 3). MTA is the sunflower crop main component of production along with characteristic number of seeds for each capitulum, having a direct relationship with the achenes productivity. In this study, the genotype with highest MTA (MG 360) was also the most productive when these variables (PR and MTA) were analyzed by statistical grouping to which they belong.

CONCLUSIONS

The mass of thousand achenes for the higher performance genotypes are between 63.3 and 68.5 g, represented by BRS 323, MG 360 and M734. The most productive genotypes are MG 360, AGUARÁ 06, MG 305, AGUARÁ 04, CF 101, SYN 045, GNZ NEON, HELIO 251 and SYN 3950HO, whose values are between 1,836.8 and 2,205.5 kg ha^{-1}.

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OR MASTER APP, THE UNIC SMARTPHONE APPLICATION TO FIGHT AGAINST *OROBANCHE CUMANA*

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ABSTRACT

Euralis Semences, one of the European leader sunflower seeds company in Europe, has developed an innovative smartphone application allowing the farmers to fight against Orobanche Cumana, a very dangerous parasite of the sunflower crop, affecting more than 60% of the European surfaces. Launched under the name OR MASTER App, this new application is based on a cross expertise of field observation and broomrape samples analysis. First of all we evaluated the broomrape risk level for each local administrative unit (NUTS 3) in the 8 main sunflower countries: Russia, Ukraine, Turkey, Romania, Bulgaria, Spain, France, Hungary and summarized the data collected in a risk scale (0= no risk to 4= high risk). According to the field information (crop rotation, previous variety and observation) entered by the farmer in OR MASTER app, the software calculates the risk level at farmer level by pooling the regional database and the local conditions of the farmer field. In this way, OR MASTER app suggests to the farmers a list of varieties well adapted with this risk level and helps them protecting themselves against the parasite by a fully personalized solution. The user can choose among different strategies using genetically OR resistant hybrids, Clearfield varieties, or combination of both technologies inside the same hybrids in order to get the maximum protection. In any case, the application will advise a tailor made strategy fitting with the OR pressure and with the farm needs.

Key Words : Orobanche Cumana, smartphone, Euralis Semences, Broomrape, OR MASTER, sunflower

PICTOR® – A BROAD-SPECTRUM FUNGICIDE FOR SUNFLOWER

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ABSTRACT

During the growing season, a number of fungal diseases attack sunflower plants. For the effective control of yield-devastating diseases, BASF SE developed a fungicide with a broad spectrum of efficacy, PICTOR®. PICTOR® is formulated as a suspension concentrate. It combines two highly active fungicidal substances, 200 gai/l Boscalid and 200 gai/l Dimoxystrobin with different modes of action. Boscalid is a pyridine carboxamide and inhibits the enzyme succinate dehydrogenase (SDH), also known as complex II in the mitochondrial electron transport chain (Kulka and von Schmeling 1995). Dimoxystrobin belongs to the QoI group of fungicides and inhibits the mitochondrial respiration, resulting from a blockage of the electron transport from ubihydroquinone to cytochrome c. Since 2006, BASF is running trial series to proof efficacy on the major diseases of sunflower as well as the beneficial effects on sunflower yield. Applied preventatively PICTOR® is very effective against *Phoma macdonaldii*, *Botrytis cinerea*, *Alternaria helianthi*, *Sclerotinia sclerotiorum* and *Diaporthe helianthi*. Even in years when disease occurrence was low due to unfavorable weather conditions for the fungi, yield increases have been observed following the application of PICTOR®. The yield benefits cannot be explained by disease control only. A vitalizing effect on the crop was visible across trials. The effect can be explained amongst others factors by an inhibition of ethylene synthesis, resulting in a delayed senescence and an improved stress tolerance. PICTOR® is currently registered and sold in all sunflower growing countries, all over Europe. The recommended dose rate is up to 0,5 l/ha. During the vegetation, PICTOR® can be applied up to 2 times from 8-leaf stage to the end of flowering.

Key Words : Boscalid – Dimoxystrobin – fungal disease – fungicide – PICTOR® – sunflower

PATHOGENICITY AND MOLECULAR CHARACTERIZATION OF AN INTERNATIONAL COLLECTION OF VERTICILLIUM DAHLIAE, PATHOGEN OF SUNFLOWER

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ABSTRACT

Verticillium wilt, caused by the soilborne fungus *Verticillium dahliae*, is one of the most important diseases in the world, causing high economic losses in crops such as artichoke, olive tree, cotton, sunflower, potato, tomato, etc. Since the disease is genetically controlled, knowing the virulence and genetic diversity of the pathogen are key factors to increase the effectiveness of control measures. Both have been the objectives of this study. An international collection of seven *V. dahliae* isolates from sunflower was pathogenically characterized in an experiment under greenhouse conditions. Eight sunflower genotypes were inoculated with the fungal isolates and their virulence was determined for eight weeks. The molecular characterization of 13 isolates of *V. dahliae* from sunflower and from olive tree was carried out using molecular markers generated by five microsatellite primers. Concerning the study of virulence, significant differences of disease were found for isolates, genotypes, and most interestingly, for their interaction. Our results show that, although all the isolates caused different symptoms severity in the plants, certain genotypes of sunflower were less susceptible to the disease than others. In addition, the new race of *V. dahliae* recently reported in Spain was also identified in France and in Rumania. On the other hand, molecular differences between isolates of *V. dahliae* were related to the host (sunflower or olive tree) and, within those from sunflower, to geographical origin, as reported for other pathogens of this crop.

Key Words : disease control, genetic resistance, leaf mottle, SSR, verticillium wilt

SOCIO-ECONOMIC IMPACTS OF NEW SUNFLOWER IDEOTYPES

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ABSTRACT

The study of barriers to adoption and diffusion of innovation is highly relevant when considering the agricultural sector. Even if innovative practices are technically feasible and socially beneficial - in the sense that they improve the collective welfare by reducing the use of inputs (including water) - actors may not implement them. Moreover, these inputs seem more important when they come from Nature, due to the high intensity of the relationships between agriculture, agricultural practices, and the environment. In this context, understanding the adaptation of the various agro chains agents, from farmers to industry, facing this innovation is an important issue. The SUNRISE project *(SUNflower Resources to Improve yield Stability in a changing Environment)* is an 8 years project supported by the French National Research Agency and gathering 16 public and private French partners of sunflower sector since 2012. As part of this project, societal impacts of new sunflower ideotypes are analyzed at different relevant scales (national or European...). Main objectives of this study are (i) Microeconomic farm-focused analysis of competitiveness and acceptability of new sunflower hybrids and (ii) Mesoeconomic analysis of impacts and diffusion conditions of the innovation within industrial chains and territories. To carry this study, analyses are performed at farm level, as individual unit of adoption of new practices, and at agro-chains level, in order to identify coordination aspects which can enhance competitiveness and conditions of acceptance of new hybrids. Quantitative and qualitative methods are mobilized to meet the objectives identified: field surveys and interviews, scenario-building method with multi-criteria analysis, bioeconomic modelling and econometrics of individual data, including contracts. This study will allow to measure socio-economic impact of newly developed sunflower ideotypes and to better adapt this innovation to agricultural sector, with a view to improve environmental sustainability.

Key Words : SUNRISE, New ideotypes, Social sciences, Economic sciences

SUNFLOWER YIELD RESPONSE TO CROP DENSITY UNDER CLIMATIC UNCERTAINTY: COUPLING AN EXPERIMENTAL AND A SIMULATION APPROACH.

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ABSTRACT

Crop establishment is a critical step for optimal agronomic and economic crop performances. In sunflower, average emergence rate stands between 70-85% in France, with a tendency to decrease because of increasing bird predation. Consequently, farmers have to sow again the crop in about 8% of the situations. But obtaining a successful plant stand depends not only on the crop emergence rate but also on the initial sowing density. Currently, the practical recommendation for sowing density is between 65-70k seeds per ha (target of 50-60k plants/ha) which should be increased (70-75k seeds/ha) in case of minimum tillage, because of lower crop emergence risk. Ideally sowing density should also be adapted to expected soil water resources, pathogen pressure in the growing area, and cultivar. Our study aims to refine the current sowing recommendations from *Terres Innovia* by providing site-specific decisions based on climate, soil, and cultivar. We used field experiments (multi-environment trials) to assess yield and oil concentration response to plant density, soil type, and cultivar in French growing conditions. We then extended this dataset with numerical experiments (simulations from *SUNFLO* crop model) to evaluate how climatic uncertainty and crop management were impacting or not current sowing recommendations. Datasets were analyzed with linear and quantile regressions both globally and for subsets of the studied population of crops. We found that crop yield variance was mainly explained by farm location (soil and soil x climate interactions), with a weak average impact of plant density (<= 5%); the hierarchy of factors was similar with field or simulated dataset. When refining practical recommendations to account for available soil water content (AWC), adjustment of plant density had a greater impact on crop performance. In deep (AWC > 200 mm) and intermediate (100mm < AWC < 200mm) soils, optimal density range was around 50-60k plants/ha, with important yield loss (10-30%) below this level in deep soils and above it for intermediate soils. In shallow soils (AWC < 100 mm), sparse plant stands were more adequate, given low water available for growth. From the exploration of unexperienced climatic conditions with simulation, we concluded that sowing density recommendations should be adapted to climatic conditions, to better account for soil x climate interactions. Finally, our method coupling field and simulation experiments contributed to adapt more efficiently the crop water demand (through plant population) to available soil water ressources, hence refining the scope of technical support.

Key Words : crop density, simulation, crop model, yield, sunflower

FERTILIZATION OF SUNFLOWER, ACCORDING TO DATA FROM FOUR-CROP ROTATION LONG-TERM EXPERIMENT

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ABSTRACT

The sunflower is the most important oil crop in Serbia. It can be grown on poor soils more successfully than other crops, and usually on rich soils the effect of fertilizers is low. Optimal fertilising, beside supplying plant with required nutrients in the amounts and at the times they are most needed, also should simultaneously sustain nutrient level in soil and maximizes the economic benefits of nutrients while minimizing any environmental impact. For such multi purpose approach the most appropriate are data from long term experiment (LTE). The research was carried out on LTE, established in 1966 on chernozem soil type at Institute of filed and vegetable crops in Novi Sad. It is four crop rotation (sugar beet, corn, sunflower and wheat) trial with 20 variants of different rates and quantities of single, double and triple NPK fertilizers (F). During near 50 years each plot was fertilized with same fertilizer and now there are plots with very different fertility. This paper presents the results of three year (Y) (2013-2015) for three domestic sunflower hybrids (H) (Ns–oskar, Ns–fantazija and NS-orfej). All factors(Y, F, H) and their interaction had highly significant influence on seed yield. Partitioning in total of sum squares off all treatments for yield were the highest for year (59%), while for F and H were 23% and 1%, respectively. Partitioning for oil content were the highest for hybrids (40%), for F is 29% and the lowest only 13% for Y. In three-year average the lowest seed yield and the highest oil content were in 2014, while the highest yield and the lowest oil content had hybrid Ns-orfej. Optimal seed yield reach with triple nutrients, with amounts of 50-100 $kgha^{-1}$ of each. Oil content regularly decreases for about 1% with each increasing of nitrogen for 50 $kgha^{-1}$, considering triple nutrients combinations.

Key words: Sunflower, Fertilization, LTE, Seed yield, Oil content

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oilseed crop which ranks fourth next only to soybean, groundnut and rapeseed as a source of edible oil of premier quality in the world (Malligawad et al, 2004) and for Serbia is the most important oil crop in. Sunflower could be successfully grown in a great range of climatic conditions and soils. It could also play an important role in the cultivation of the new reclaimed lands, which are suffering drought, high temperatures and salinity effects (Keshta et al, 2008) In Serbia it can be grown on poor soils more successfully than other crops since it uses less available water and nutritients from deep soil layers. It also responds positively to residual nitrogen from previous crop (Crnobarac et al, 2002). That is the reason why the effect of fertilization on good soils for sunflower is low. Among the different nutrients required, N and P are the primary limiting nutrients under most environments where it is being cultivated. Further, it is also reported that sunflower has high N and moderate P requirements (Malligawad et al, 2004). Nitrogen deficiency reduces the leaf production, individual leaf area and total leaf area resulting in a reduced area for light interception for photosynthesis. Also, up to 75% of leaf nitrogen is found in the chloroplasts so in conditions of the nitrogen limitation, are often lower rates of photosynthesis and consequently sunflower yield decreasing (Cechin et al, 2004). At the same time it is necessary to bear in mind that it is more sensitive to diseases, which especially develop with increasing N in nutrition. N also decreases oil content, but like in other crops it is the most important for seed yield. Beyond monitoring of input costs and reduction of pollution risks due to N excess it is also necessary to increase net income avoiding yield losses due to N excess and N deficiency, as well as improving the oil content of the seeds.(Reau et al, 2004). Phosphorus and potassium are also very important for disease and drought resistance, oil content and positive interaction which increase nitrogen effect.

METHODS

The data of sunflower seed yield and oil content are from long term experiment with a four crop rotation (sugar beet, corn, sunflower and wheat) which was established on chernozem soil type in 1966. There are 20 treatments with different rates and quantities of single, double and triple NPK fertilizers (F). The amounts of NPK are in kg per hectare of N, P_2O_5 and K_2O (Fig. 2 and 3). During near 50 years each plot was fertilized with same fertilizer and now there are plots with very different nutritient content. This paper presents the results of this practice on three new NS sunflower hybrids (H) (Ns–oskar, Ns–fantazija and NS-orfej) in the period 2013-2015 (Y). Data were analyzed by ANOVA using Mstatc method 19 (two factorial randomized complete block design combined over years) and graphically presented in Origin. For data interpretation, beside F-test and LSD- test, we used partitioning of each experimental factor in the total of sum squares off all treatments.

RESULTS

According to F-test of ANOVA all factors (Y, F, H) and their interaction had highly significant influence on seed yield and oil content. Partitioning in total of sum squares off all treatments for seed yield were the highest for year (59%), while for F and H were 23% and 1%, respectively. Partitioning for oil content were the highest for hybrids (40%), for F is 29% and the lowest only 13% was for Y (Table 1). It means that the highest influence on seed yield had year and hybrids on oil content, while influence of fertilizers for both traits were almost similar. The highest interaction for seed yield was Y*F (8%) and for oil content Y*H (10%).

On the three year average significantly the highest seed yield had hybrid NS-orfej (3.80 tha^{-1}), mainly due to relatively high yield in 2014. Between other two hybrids there were no significant differences. (Fig.1). On average for all hybrids in 2014 was extremely low seed yield caused by diseases. Differences in oil content between all hybrids were significant and the highest had NS-oskar and the lower NS-orfej. This relation was similar in almost all year.

On average for three years and hybrids, nitrogen alone or in combination with P and K significantly increased seed yield, but it simultaneously decreased oil content related to control, alone P and K and double PK treatments. (Colons in Fig. 2 and 3). P and K alone or in combination had significantly higher seed yield and lower oil content only in regard to control. The effect of NK treatment was slightly better than NP for both traits.

Triple NPK combination with the lowest amount of 50 kg ha^{-1} of each nutrient had significantly higher oil content than treatments with nitrogen alone or in combination with P and K, but there is no significant differences between them in seed yield. It is proof that balanced triple combination of NPK is better then any single or double combinations.

Table 1. Probability of F –test and partitioning of experimental factor in the total treatments of sum off squares

Source of variation	Seed yield		Oil content	
	F probabability.	Partitioning	F probabobability	Partitioning
Year	<,001	59%	<,001	13%
Fertilisers	<,001	23%	<,001	29%
Year * Fertilisers	<,001	8%	<,001	4%
Hybrids	<,001	1%	<,001	40%
Year * Hybrids	<,001	2%	<,001	10%
Fertilisers * Hybrids	<,001	2%	<,001	2%
Year * Fertilisers * Hybrids	<,001	4%	<,001	3%

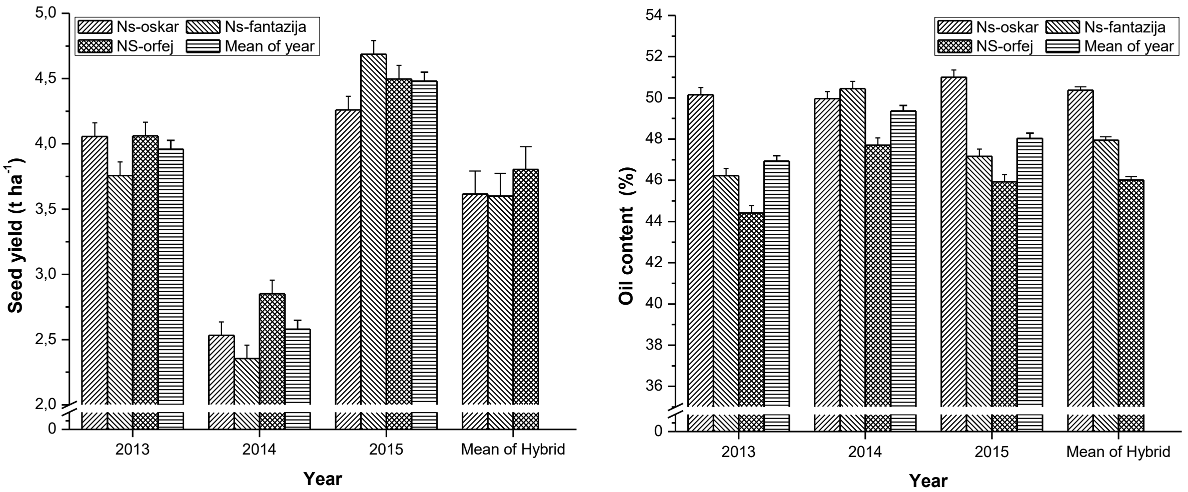

Figure 1. Seed yield and oil content, average values per year, hybrids and their interaction

Among triple NPK combinations the lowest combination with 50 kg ha^{-1} of each nutrient had significantly the highest oil content but also the lowest seed yield. Next three triple combination had similar oil content which were significantly higher then all other triple treatments. Also, after the same triple combinations, in all other triple treatments there were no significantly higher seed yields. Regarding seed yield and oil content simultaneously in average for three year and three sunflower hybrids in our environmental condition the best is balanced nutrition, with triple NPK combinations in amount between 50-100 kg ha^{-1} of each nutrient.

Considering triple nutrients combinations in average for three hybrids, oil content regularly decreases for about 1% with each increasing of nitrogen for 50 kgha^{-1} (Fig. 3)

Differences in oil content between hybrids were similar in all fertilizers treatments, the highest had NS-oskar and the lowest NS-orfej (Fig 3). Contrary, hybrid NS-orfej had especially higher seed yield in treatments without N and in triple combination with highest amount of 100-150 kg ha-1 of each nutrient (Fig. 2).

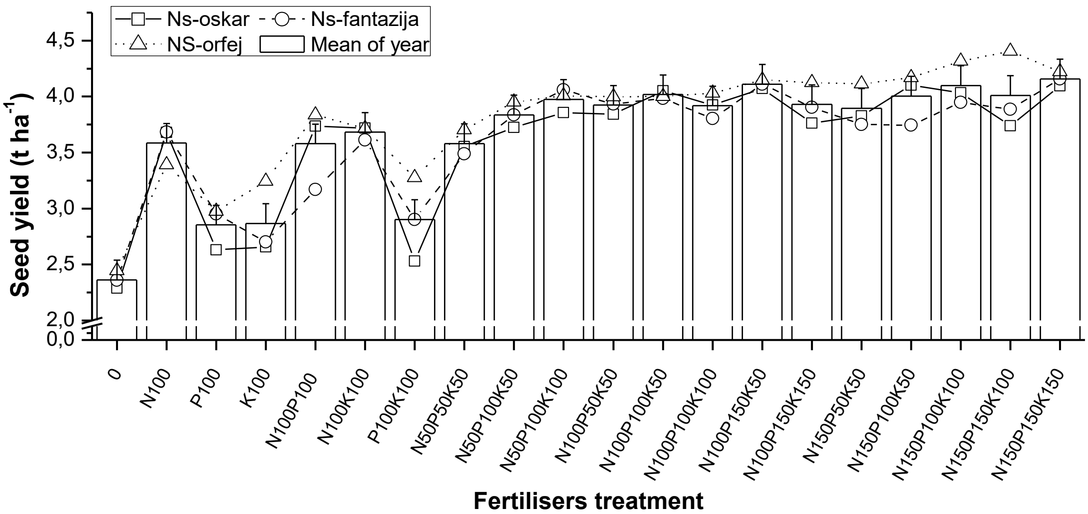

Figure 2. The effect of NPK fertilizers and hybrids on sunflower seed yield (average of 3 year)

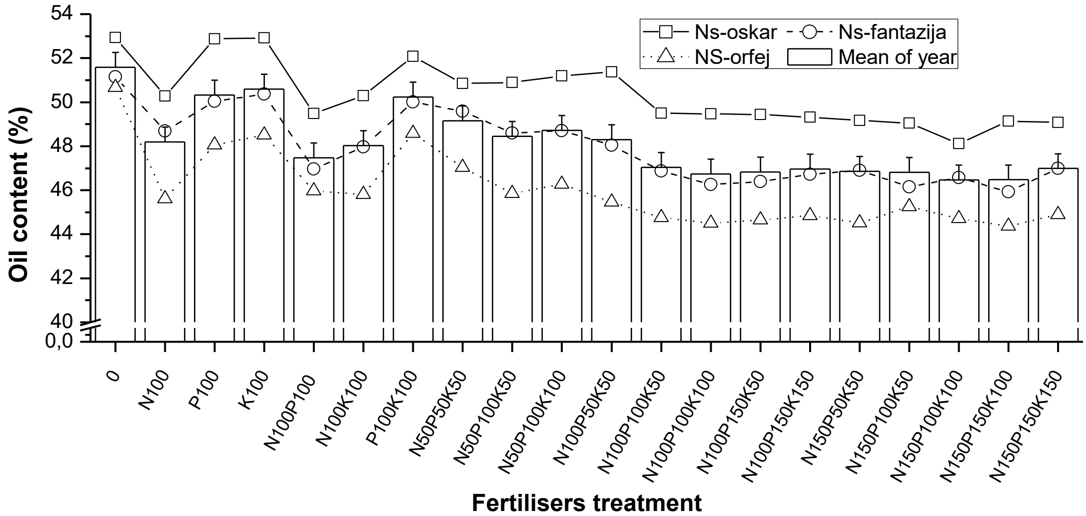

Figure 3. The effect of NPK fertilizers and hybrids on sunflower oil content (average of 3 year)

CONCLUSION

Based on obtained results it can be concluded that regarding seed yield and oil content simultaneously in environmental condition of Serbia the best is balanced nutrition, with triple NPK combinations in amount between 50-100 kg ha-1 of each nutrient.

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RELATIONSHIP BETWEEN SEED YIELD AND SOME QUALITATIVE TRAITS *OF* SUNFLOWER (*HELIANTHUS ANNUUS* L.) UNDER DIFFERENT IRRIGATION REGIMES AND FERTILIZER TREATMENTS

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ABSTRACT

In order to investigate the relationships between yield and qualitative traits by correlation of sunflower in response to biofertilizers under different irrigation regimes. This study was arranged in split plot laid out in RCB design with three replications at the Kermanshah province, Iran, during 2006-2007. Three levels of irrigation regimes (irrigation at 85% field capacity, irrigation at 70% field capacity, and irrigation at 55% field capacity) set as main plot and six levels of fertilization (control, recommended N, *Azotobacter* & *Azospirillum* (AA), AA+100% recommended N , AA+75% recommended N, and AA+50% recommended N) set as subplot. The results showed that there were positive and significant correlations among seed yield and oil content and protein content. There were negative and significant correlation among seed yield and saturated fatty acids (palmitic acid and stearic acid); whereas there were positive and significant correlation among seed yield and unsaturated fatty acids (oleic acid and linolenic acid). There were negative correlation among seed yield and osmolytes content (proline and soluble carbohydrates).

Keywords: Biofertilizers, Correlation, Irrigation, Qualitative Trait, Seed Yield, Sunflower.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oil-producing plants in the world because its oil exhibits a fatty acid composition that is favorable for human consumption (Jalilian *et al.,* 2012). Oil quality and yield are both dependent upon the genotype of the plant and its interaction with the environment. Irrigation (Blum, 1997) and fertilizer (Reddy *et al.,* 2003) among the various factors responsible for increasing the yield and quality of crops, are the most important. Environmental stresses restricted the growth and development, of plants. Water deficit stress is one of the most serious stresses that affect crop productivity (Boyer, 1982). The absorption of nitrogen fertilizer is heavily impacted by water deficit. Nitrogen (N) is an essential mineral nutrient for plants, which increases total biomass production and yield. In the context of plant nutrition, nitrogen deficiency is the most important limit to sunflower production, as is true for most other crops (Blamey *et al.,* 1997). Biofertilizers are products that contain living cells of different types of microorganisms, which stimulate plant growth (Vessey, 2003). Because of the high N requirement of sunflowers, application of biofertilizer can decrease potential groundwater pollution, facilitating the adoption of eco-friendly agronomic techniques (Jalilian *et al.,* 2012). Plant breeders commonly prefer yield components that indirectly increase yield. Indirect selection of yield components such as 1000-seed weight, plant height, and head diameter can increase grain yield. Therefore, it is important to know the relationships among yield traits in sunflower to get higher yields. Although relationships between seed yield and other traits were investigated in many studies using correlation, path analysis, combining ability, and similar statistical techniques (Kaya and Atakifli, 2003; Dusanic *et al.,* 2004; Hladni *et al.,* 2006), no research using correlation analysis for relationships between seed yield and quality traits in sunflower.

Due to the global economic importance of the sunflower and the limited knowledge available regarding the effects of combining biofertilizer and different levels of N fertilizer on sunflower characteristics under water stress conditions, this research was performed to determine the relationship between seed yield and some quality traits of sunflower under water deficit condition.

MATERIALS AND METHODS

Field experiments were conducted at the Eslam Abad-Gharb Agricultural Research Station (34° 8´ N and 46° 26´ E) with an altitude of 1346 m, Kermanshah province, Iran during the 2006 and 2007 growing seasons (May to September). The clay loam soil texture was determined. The field capacity and permanent wilting point, were 34 and 16.2%, respectively. The fertility status of the soil was classified as low in available and high in available and K. Nitrogen was applied as urea. Half the dose of recommended N (124 kg ha^{-1}) was applied at sowing time, and the remaining N was topdressed at the 5-6 leaf stage.

Three strains of bacteria, including Azospirillum lipoferum, Azospirillum brasilense, and Azotobacter chroccoccum were used in this study for seed inoculation of sunflowers. Nature BioTechnology Co. (NBICO), Iran, supplied these bacteria. Seed inoculation involved placement of the seeds in bacterial suspensions at 109 CFU ml-1 for 30 min before planting (Ozturk et al., 2003).

The experimental design was a randomized complete block (RCB) design with a split-plot arrangement of treatments in three replicates. The treatments were three levels of irrigation regimes [irrigation at 85% field capacity (I1), irrigation at 70% field capacity (I2) and irrigation at 55% field capacity (I3) in the main plot] and six types of fertilization [control (C), nitrogen recommended (N), Azotobacter and Azospirillum (AA), AA+100%N recommended (AA100), AA+75%N recommended (AA75) and AA+50% N recommended (AA50) in subplots].

Inoculated seeds were hand-sown on 4m×2.6 m plots (5 rows) on 12 May 2006 and 13 May 2007, respectively. Seeds of the sunflower (H. annuus L., cv. Azargol) were sown at 3 cm depth in the middle of rows, with 0.6 m between rows and 0.30 m between seed groups. This yielded a population density of about 5.7 plants m-2. Before planting, the soil surface of the cultivated area was thoroughly irrigated using a solid-set movable sprinkler system. At the 3-4 leaf stage, plants were selected for uniformity and thinned out to the recommended plant density. Weed control was performed manually without any chemical additive. All plants were irrigated equally by sprinkler, until the 8-leaf growth stage (V8) (Aliary *et al.*, 2000). A sample comprising 50 g clean seeds from each plot was isolated for measuring oil and protein content. Oil and protein content were determined using an Inframatic 8620 near-infrared spectrometer (Ludwiga et al., 2006). The fatty acid composition of the sunflower seed oils was determined according to Metcalf et al., (1966) by using a UNICAM 4600 gas chromatograph. Levels of palmitic (C16:0), stearic (C18:0), oleic (C18:1), and linoleic (C18:2) acids were determined using a computing integrator. Statistical analysis was carried out using the SAS software package (SAS Institute, 1997) and MSTAT-C. Differences among the treatments were evaluated with the least significant difference (LSD) method. $P<0.05$ was accepted as statistically significant.

RESULTS AND DISCUSSION

Among the sunflower traits seed yield, oil content, protein and fatty acids are particularly important. Therefore, the correlation of these traits with other traits studied. In correlation results, sunflower seed yield had negative and significant relationship with saturated fatty acids (palmitic and stearic acid) and osmolytes (proline and soluble carbohydrates). Also the results showed that seed yield had significant positive correlation with oil content and protein, unsaturated fatty acids (oleic and linoleic acid), quantum yield of photosynthesis (Fv/Fm) and chlorophyll a and b (Table 1.).

Palmitic and stearic acids has negative correlation with oil content (Table 1). Among the unsaturated fatty acids (oleic and linoleic acid) only oleic acid was positively correlated with protein content (Table 1.). Proline and soluble carbohydrates correlation with sunflower oil content was negative and significant. Proline was a significant negative correlation with seed yield in sunflower. In fact, sunflower plants in response to drought stress increased proline and soluble carbohydrates in the leaves, which was consistent with the reduced yield. In other words sunflower plants in such condition to deal with stress through yield reduction to cost a lot of that with the results correspond (Fredeen *et al.*, 1991).

Table1. Sunflower seed yield and seed quality correlation affected by different irrigation regimes and fertilizer treatments

	1	2	3	4	5	6	7	8	9	10	11	12
1-seed yield	1											
2-oil content	0.6**	1										
3-protein content	0.39**	-0.16	1									
4-Palmetic acid	-0.74**	-0.82**	0.19	1								
5-stearic acid	-0.79**	-0.78	-0.11	0.84**	1							
6-Oleic acid	0.92**	0.59**	0.3*	-0.77**	-0.74**	1						
7-Linoleic acid	0.85**.	0.77**	0.1	-0.88**	-0.84**	0.82**	1					
8-Fv/Fm	0.83**	0.65**	-0.06	-0.86**	-0.73**	0.85**	0.87**	1				
9-Proline	-0.3*	-0.53**	0.69*	0.71**	0.36**	-0.37**	-0.48**	-0.69**	1			
10-Chl a	0.84**	0.7**	0.1	-0.89**	-0.81**	0.84**	0.9**	0.83**	-0.51**	1		
11-Chl b	0.77**	*0.69***	0.06	-0.81**	-0.76**	0.8**	0.84**	0.8**	-0.5**	0.82**	1	
12-Soluble Carbohydrate	-0.16	*-0.33*	0.67**	0.5**	0.17	-0.20	-0.3*	-0.54**	0.92**	-0.32*	-0.33*	1

*and **, Significant at 0.05 and 0.01 probability level, respectively.

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LONG TERM CHANGES IN GERMINATION AND VIGOUR OF SUNFLOWER HYBRID SEEDS HARVESTED AFTER CHEMICAL DESICCATION WITH PARAQUAT

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ABSTRACT

Anticipated harvest reduces the risk of losses caused by exposure to weather, pathogens and birds in sunflower seed production. Chemical desiccation with paraquat could affect physiological quality of hybrid seed during a long-term storage. This study was aimed to analyze the effect of chemical desiccation on the germination and vigour of low and high-oleic sunflower hybrid seeds, during long-term storage. Tree female parental lines where desiccated at 30% seed moisture content by means of: (i) spraying with paraquat (2 L ha-1) or (ii) mechanical cut. Control plants remained in the field until seeds reached 10% moisture content. After dried, seeds of the three treatments were stored under room (25 °C, 30 – 80 % RH) or cold chamber (10 °C, 60 % RH) conditions during 1, 5, 9, 13 and 19 months. Germination (pre-chilling, pericarp + seed coat excision), vigour (electrical conductivity without pericarp), oil and oleic acid content (by NMR) were analysed. Chemical desiccation advanced the harvest condition by one month. The seeds of low oleic hybrids showed high levels of germination (>85%) and vigour (<70 mS.m-1.g-1) across all the storage period, discarding desiccant toxic effects. The high-oleic hybrid had low germination (< 85%) and vigour (85-110mS.m-1.g-1) during all storage period. Cold chamber kept higher levels of vigour during 5-13 months, mainly in chemically desiccated seeds. Changes in seed quality were not associated with oil content or composition. Plant chemical desiccation with paraquat at 30% seed moisture did not affect the sunflower hybrid seed quality during 19 months storage.

Key Words : seed storage; oleic; electrical conductivity; physiological quality

VARIABILITY OF THE LIFE CYCLE ASSESSMENT RESULTS OF SUNFLOWER ACCORDING TO DIFFERENT AGRICULTURAL PRACTICES

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ABSTRACT

Animals' feeding contribute very significantly to the overall environmental impact of animal products (meat, milk). The French project ECOALIM aims to improve the environmental impacts of husbandries by optimizing their feed. This project defines the environmental impacts of the production of raw materials for animal feeding and optimizes the formulation of feed compounds with environmental constraints in order to improve environmental footprint of animal products. The project covers different farming systems and production areas in France and is based on Life Cycle Assessment (LCA). The ECOALIM database provides life cycle inventories and environmental impacts of feed ingredients utilized in France. It contains 150 values of which 58 national average feed ingredients (cereals, oilseeds crops, pulses and processed products like meals, etc), 27 variants (crops with improved cultural practices) and 10 foreign feed ingredients. The results obtained for French sunflower crops are discussed here. Several results were calculated: national average data representative of the country, and results with different crop managements based on case studies. The LCA methodology was applied, considering environmental burdens at the rotation system scale. Focus was made on four impact indicators (Energy demand, GHG emissions, Acidification, Eutrophication), while identifying the most contributing steps during crops life cycle. The main contributor to selected environmental impacts were field emissions. The assessment of practices such as organic fertilization, the introduction of intermediate crops or the introduction of legumes in the rotation showed some improvements on environmental impacts.

Key Words : LCA, environmental impact, sunflower, emission models, agricultural practices

STUDIES OF SOME HYBRID SUNFLOWER(HELIANTHUS ANNUUS L.) CULTIVARS FOR THEIR YIELD AND YIELD COMPONENTS IN THRACE AREA

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ABSTRACT

This research was carried out to determine yield and yield components for 6 different sunflower varieties (Tunca, NK Califa, P4223, DKF2525, C70165 and Sanbro) in Kırklareli (Lüleburgaz) ve Tekirdağ (Malkara) ecological conditions during years of 2008- 2009. In this research, characteristics such as plant height, stem circumference, head diameter, thousand grain weight and yield per hectare were investigated. The highest grain yields were obtained from variety Tunca (237.2 kg / da) and DKF2525 (224.7 kg / da) by an average of two years of research.

Key Words : sunflower, plant height, thousand grain weight, seed yield

TOWARDS DEVELOPMENT OF SUNFLOWER IN WEST AFRICA: BURKINA FASO AND MALI

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ABSTRACT

For several years, with the support of the French sector of vegetable oils and proteins, a development project on sunflower crop has emerged in West Africa, supported by FAO This program was born of the desire shared Burkinabe farmers, members of the local Unions farmers and French farmers, members of the Federation of Oilseed Producers (FOP) to test the culture, set up the technics, evaluated the potential and develop a sunflower industry (oil and cake). The emergence of such industries is indeed a strategic lever of agricultural and economic development for countries heavily dependent on imports of oil and strong deficit in plant proteins. The program aims to increase domestic oil supply and oil cakes, diversify income sources of family farming and improve the performance and sustainability of farming systems. Technical expertise benefits of support of Terres Inovia and project coordination is ensured by Agropol. After several years of experimentation, it appears possible to realize an analysis of the strengths and weaknesses of the project but also opportunities and risks.

• Strength : An important agricultural development potential for this crop and strong motivation of the actors (professional, institutional organizations and also the private sector).

• Weaknesses: Technical practices are not enough mastered by producers and lead to little motivating incomes; soils are compacted (lake of equipment's, most of the soil preparation is done by hand) and the root system (pivot) is not deep enough. Random climatology like water stress, lack of sustainable support structures for the production and marketing; the strong dependence of seed imported (hybrids) at a high cost; the lack of a sustainable mechanism for pre-financing of the crop year.

• Opportunities: a high demand for edible oil (mainly due to the quality, versus cotton oil or imported oils) and cake for animal feed; a strong national political will.

• Threats: unfair competition from uncontrolled imports; soil fertility problems and an emerging parasitic context (Alternaria helianthii).

Key words : Sunflower, limiting factors, Africa

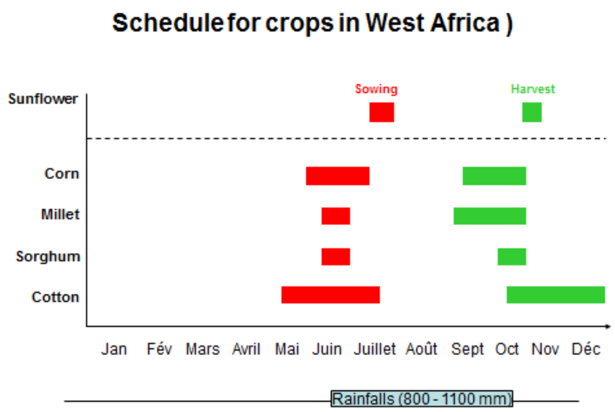
INTRODUCTION

In West Africa, most of the oil came from cotton (local production). Nevertheless, the quality of this oil is bad. According to the climatic windows during the rainy season, we identified some opportunity to grow sunflower during the rainy season. The interest of this crop is not only for the oil (sunflower oils is available on the market, coming from South Africa or from Turkey). The meal is also very well appreciated to feeds cattle's, especially during the dry season.

The sowing date needs to be adjusted as soon as the first rains are well established. This for at least two reasons:

- The soil needs to be wet enough to be plough (by hand or animal traction)
- To prevent from water stress at germination stage

The graph bellows show the best opportunity for the cycle of sunflower. Due to the high level of temperature and the heat units, the growing cycle take place is less than 100 days. The crops yield are subjected to a strong variation mainly due to the water stress, to the poor quality of the soils and a lots of problems with the root growth due to a bad soil preparation and a high level of compaction.



A progress is nevertheless obtained, and the yield ranks from 0.5 t/ha to 2t/ha, improving each year. The economic threshold is around 1 t/ha.

	2011	2012	2013	2014	2015
Average Yield (kg/ha)	267	489	545	450	620
% of farmers that succeeded with more than 1000 kg/ha	3,1	6,1	8,9	8.1	10.2
Average yield > 1000 kg/ha	1267	1222	1305	1150	1300
Records yield (kg/ha)	1884	1860	1904	1900	1920

Following the project for 5 years now, a SWOT analysis could be done.

1. **Strength :**
   - An opportunity of diversification sought by farmers and compared to cotton (crops – often GMO, that required a lot of labor, still pesticide interventions, and delay in the payment ...).

- A crop adapted to the work schedules, especially with the food crops (corn, millet ...)
- An crop “simple”, compare to cotton
- An oil meeting more and more a consumer audience aware of his qualities.
- New opportunities for honey
- The ability to have access to meal for animal feed, the capital in the areas of short rainy season.
- Small mechanization projects (seed driller, harvest)
- A new crop promoted today by the authorities and a well-structured project
- News interests for some breeders (local or international)

2. Weaknesses :

- Yields leveled are too often around 1 t / ha, sometimes less, which does not match the viable economic threshold for crop. The establishment of the crop is often there, but the end of the growing cycle and takes place under high water stress. Seed abortions on capitulates are detected and seed filling defects.
- Logistics for routing inputs remains a critical issue in the absence of reliable local circuits. This needs to be improve (seeds distribution, nitrogen availability, seed collected at harvest)
- It now offers an alternative to genetic seed: continue work on improving populations of Peredovik and / or development of local production of hybrids.
- Soil quality and soil tillage undoubtedly remains one of the major obstacles
- Although culture is considered less restrictive than cotton, some improvements in mechanization are expected by producers
- A sunflower fertilizer at the same price as the cotton fertilizer (that includes subsidies) would undoubtedly an important leverage effect on the development of culture and profitability.
- Structuring the project in islands of production must remain the rule (this could also be classified as "assets" since today is the case ......)
- The industrial tool is undoubtedly an obstacle to date to the success of the project :
- Local initiatives should be well identified and keep under control.

3. Opportunities :

- There is a real desire to diversify among both authorities and producers: the main target is undoubtedly growing cotton (working time, soil depletion, GMO and pesticide use). This is undeniably a "window" favorable for growing sunflower in the heading of diversification opportunities.
- The project is emphasized by the local authorities (Ministry of Agriculture, Research / INERA, ...).
- The project led by AGROPOL for 4 years is now recognized as credible and locally, the work on the project is appreciated by all actors.

- The evidence of the potential of crop in the context of Burkina Faso and Mali, despite the identification of limiting factors well identified, is now established : 1.5 t/ha could be the average goal.
- Since the beginning of this project, there is a mobilization and support of all stakeholders of the French oilseed around this project.

4. **Threats :**

- The disease risk is not excluded : Alternaria Helianthii, bacterial disorder.
- Potential for lines versus hybrids (due to the cost of hybrids seeds, the returns could be a weak point).
- Up to day, bird damages remains fairly anecdotal (at sowing time as at harvest)
- The curvature of the flower head, triggered by an acceleration of the development phase (appearance of the flower head and flowering) when growth is not yet completed can induce a strong curvature of the stem under the head that could affect translocations during seed filling.

CONCLUSIONS

The potential for sunflower crops during rainy season is real in West Africa. The uses of the oil and of the meal are very well adopted by the local consumers. For sunflower oil, the price of local production could easily compete with the price of imported oil. The valorization of meal is also very good. The crushing stage needs to be securing (size and efficiency of the equipment, seed collections from the field farmers ...). An improvement in the genetic material is also expected, mainly from lines through a local selection program to produced material adapted to the local conditions.

MICROMYCETES ASSOCIATED WITH SUNFLOWER SEEDS DURING STORAGE PERIOD

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ABSTRACT

Sunflower seeds can become contaminated with fungi which attack the plants at different stages of development and subsequently during harvesting and storage. An important role for the production of healthy crops is being played by quality seeds. Although the initial seed quality and storage environment are mandatory to prolong the shelf-life of seeds, the invasion of fungal pathogens causes various abnormalities like damaged seeds, undersized, rotted seeds and reduced in germinability. Fungal organisms play a significant role in infection, altering quality and longevity of seeds during the storage. The sunflower seeds losses recorded during storage period on worldwide scale according to FAO estimations are 10-15% of total production. In developing countries, due to reduced possibilities of implementing appropriate technologies, the reported damages during storage period may increase up to 30%. The paper work presents a study regarding the occurrence and development of specific storage micromycetes of sunflower achenes, collected from a deposit in Prahova County, Romania. Analysis performed on four sunflower hybrids' seeds, regarding the fungal load, revealed the occurrence of several pathogenic and saprophytic fungi belonging to the following genera: *Aspegillus*, *Fusarium*, *Alternaria*, *Stemphylium*, *Trichoderma*, *Cladosporium*, *Rhizopus*, *Mucor*, *Pencillium*, and *Sclerotinia*. All studied hybrids were contaminated with species of *Alternaria* and *Stemphylium*, the highest incidence noticed was for NK Adagio hybrid with 56 % of *Alternaria* spp. Placing on the market safe food and feed products is first and foremost a question of good management practices at each stage of the feed and food chain from primary production to final.

Key words: sunflower, micoflora, *Alternaria* spp., stored products

INTRODUCTION

Sunflower (*Helianthus annuus*) is one of the most cultivated oilseed crops worldwide. In 2015, Romania ranked first in the European Union both in terms of area and sunflower production, with a total harvest of 1.75 million tones obtained from one million hectares (www.paginadeagricultura.ro/). Compared to 2014, sunflower production decreased in 2015 by 19.7% due to the yield per hectare which fell by 19.6%.

Storage of sunflower seeds may last for various periods of time, when this product is kept for subsequent planting, oil processing or use in confectionery industry. A series of environmental factors, when improperly managed, could make sunflower seed storage questionable, particularly when long-term keeping is foreseen. Among the microbes that interact with the seeds during their storage, fungi play a dominant role in decreasing quality and longevity of the seeds (Mardare et al., 2015, Cristea et al., 2004, Cristea et al., 2009, Mardare, 2014) Fungi cause various abnormalities like damaged seeds, undersized, rotted seeds and reduced in germinability. Fungal organisms play a significant role in infection, altering quality and longevity of seeds during the storage. In order to develop the list of storage fungi of sunflower, sunflower seeds were screened to study the incidence of fungi which gave the occurrence of *Alternaria alternata, Aspergillus flavus, A. niger, Curvularia lunata, Fusarium moniliforme, Penicillium citrinum, Macrophomina phaseolina* and *Rhizopus nigricans* with sunflower seeds (Afzal R., et al., 2010). Same types of fungi including species of *Cladosporium* and *Drechslera* have been reported from sunflower seeds. (Kakde R. B. et al., 2012). *Absidia corymbifera, Alternaria alternata, Aspergillus flavus, A. niger, A. terreus, Chaetomium bostrychodes, C. globosum, Emericella nidulans, Fusarium pallidoroseum, F. solani, Macrophomina phaseolina, Penicillium spp., Rhizoctonia solani* and *Rhizopus stolonifer* were predominantly isolated from sunflower (Nahar, S. et al., 2005).

Sunflower seed storage needs particular care, due to its high fat content, easily cracking shell, exposing the kernel to various alterations, such as germination loss, colonization of fungi and attacks by insects and mites. Seed moisture content is critical mainly if long-term storage is intended. Proper management of equilibrium between relative air humidity and seed moisture is an essential element, dictating need for seed drying at storage start and frequent aeration during storage (Beratlief, 1997). During the stockpile, a series of fungi appear on the seeds' surface, which generally not produce damages to the crop, whereas at the moment of tilling, they disappear due to the inauspicious soil conditions. However, certain situations have been encountered when the storage funguses have had a major influence while keeping the seeds in deposits. It can ultimately get to the germination diminution, so much that it can drop under the limit allowed by the law (specifically for seeding), and, in this case, the lot is entirely compromised and the loss is total. Also, the storage fungi negatively influenced seeds in process of field germination, leading to weakling plants, more susceptible to diseases (Zala et al., 2010).

MATERIALS AND METHODS

The research aimed to identify the spectrum of pathogens present on sunflower achenes, in order to determine the yield's health status after being harvest and recommend an effective treatment.

The biological material consisted in samples of sunflower seeds, naturally infected with pathogens and collected from a storage unit Prahova County, in South-Eastern part of Romania. The achenes belonged to four sunflower cultivars, two Romanian hybrids (Performer and Favorit) and two international ones (NK Adagio and NK Meldimi), adapted to growing conditions in this part of the country.

In order to study the micoflora, sunflower contaminating fungi were isolated using Ulster method (Hulea A., 1969) and identified with optical microscope, after 12 days of growth. Using the Ulster method there can be identified the majority of seed pathogens, regardless the species and type of seed. In separate Petri dishes of 10 mm diameter, were placed 15 wheat seeds on growth solid media (water-agar, 20 g/l, autoclaved 20' at 121 ºC), with space between the achenes in order to allow the development of fungi or bacteria. The water agar media was preferred due to its low nutrients composition which allows the fungi growth, but not its abundant sporulation. This is an important step in order to be able to isolate each fungus from the Petri dish multitude of pathogens. The dishes were kept at room temperature (22-24 ºC) and 12h/12h light conditions. After 7 days there were performed macroscopic observations regarding the mycelia growth in Petri dishes, followed by optical microscope determinations, using a Zeiss Primo Star microscope. For further isolation and purification of each fungus was used the Potato-Dextrose-Agar medium (Hulea A., 1969). The determination of sunflower seeds' germination was performed on filter paper.

Figure 1. Sunflower seeds inoculated on water-agar medium, incubated for 7 days

RESULTS AND DISCUSSIONS

Microscopic examinations revealed a spectrum of fungi belonging to *Ascomycetes* and *Deuteromycetes* classes.(Gheorghies et al, 2001, Kieffer et al., 2000, Varga et al., 2009).

The data in table 1 presents the pathogen species detected on sunflower achenes belonging to *Alternaria* spp., *Penicillium* spp., *Stemphylium* spp., *Rhizopus* spp., *Aspergillus* spp., *Fusarium* spp., *Mucor* spp., *Sclerotinia* spp., *Trichoderma* spp., and *Cladosporium* spp.

Table 1. Micoflora detected on sunflower achenes

The pathogenic agent	***Hybrid***			
	PERFORMER	FAVORIT	NK ADAGIO	NK MELDIMI
Alternaria spp.	+	+	+	+
Stemphylium spp.	+	+	+	+
Penicillium spp.	+	+	-	+
Rhizopus spp.	+	+	+	+
Aspergillus spp.	+	+	+	-
Fusarium spp.	-	-	-	+
Sclerotinia sclerotiorum	-	+	-	-
Mucor spp.	+	+	+	+
Trichoderma spp.	-	+	-	-
Cladosporium spp.	+	+	+	+

From our studies, it was found that pathogens *Alternaria* spp., *Stemphylium* spp., *Rhizopus* spp., *Mucor* spp. and *Cladosporium* spp. have populated the achenes of all studied sunflower hybrids. The fungi belonging to *Penicillium* were present on the following achenes hybrids: Performer, Favorit, NK Meldimi. Species of *Fusarium* were isolated from NK Meldimi hybrid achenes. *Aspergillus* spp. has populated seeds from Performer, Favorit and NK Adagio cultivars. Species of *Trichoderma* and *Sclerotinia* were observed on achenes from Favorit hybrid.

In figures 2 - 7 are presented microscopical observations captured with the Zeiss Primo Star microscope.

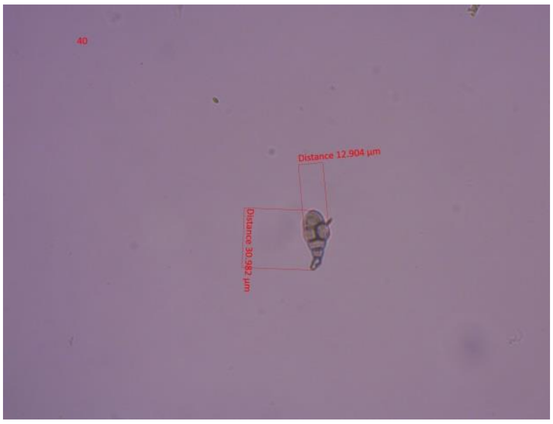

Figure 2. *Alternaria* sp. conidia

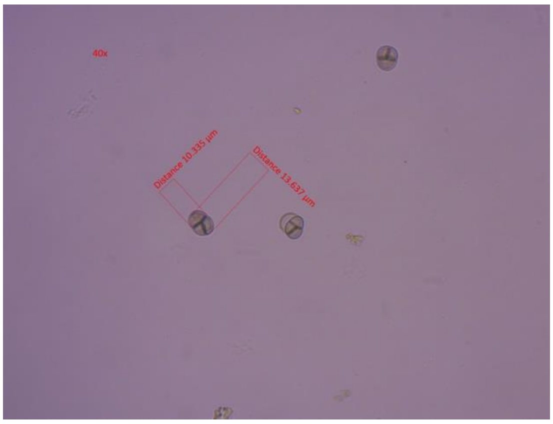

Figure 3. *Stemphylium* sp. conidia

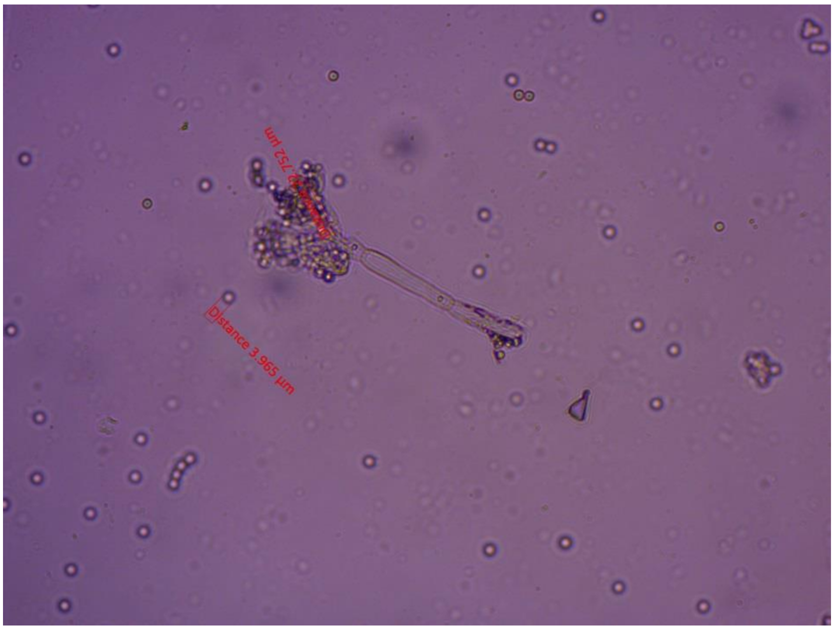

Figure 4. *Penicillium* sp. conidiophore and conidia

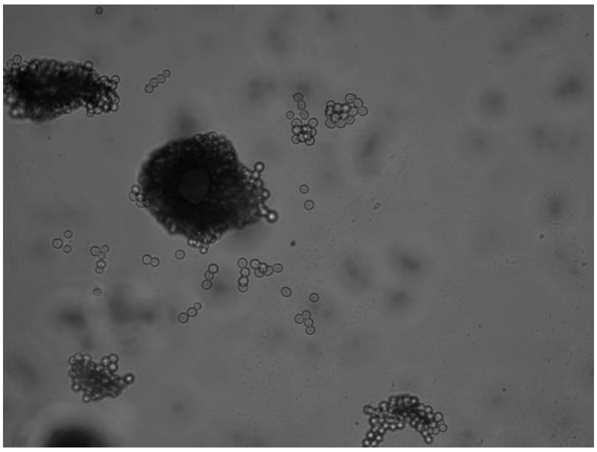

Figure 5. *Aspergillus* sp. conidias

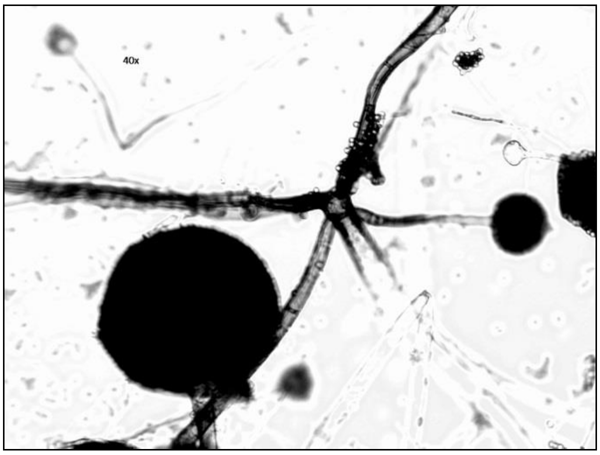

Figure 6. *Rhizopus* sp. sporangium

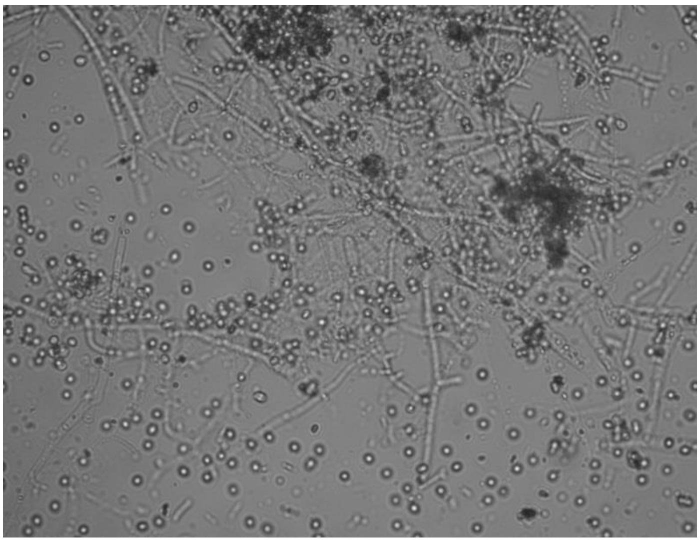

Figure 7. *Trichoderma* sp. fructifications

The incidence' rate of detected micoflora is presented in table 2. *Alternaria* spp. were present on sunflower achenes from all four hybrids, with highest values of frequency from all identified pathogens, respectively 56% for NK Adagio, 47% for NK Meldimi, 35% for Performer and 31% for Favorit hybrid.

The pathogens from *Stemphylium* spp. presented the highest values of incidence for Performer hybrid with 33% and Favorit hybrid with 30%. The other two hybrids presented 19% incidence for NK Adagio and 18% incidence for NK Meldimi.

Penicillium spp. were present in highest rate on sunflower achenes from NK Meldimi hybrid in 14%, 10% for Favorit hybrid and only 7% for Performer hybrid.

Species from *Mucor* and *Rhizopus* were detected on sunflower achenes belonging to all four hybrids, with relatively close incidence values. *Mucor* spp. was present in 3% on Performer and Favorit hybrids achenes, in 5% NK Adagio achenes and 6% the highest value for Favorit hybrid. *Rhizopus* spp. had the highest incidence value for Favorit hybrid, followed by Perfomer hybrid with 8% incidence, NK Adagio with 7% incidence and NK Meldimi with 4% incidence.

Fusarium sp. was detected with a low incidence of 5% only for NK Meldimi hybrid; Also *Trichoderma* sp. and *Sclerotina sclerotiorum* were present in 3% respectively 2% on sunflower achenes from Favorit hybrid.

Cladosporium spp. were detected with low incidence values on all sunflower hybrids achenes.

Table. 2 The micoflora's incidence detected on sunflower achenes

Fungi (*observations after 9 days*)	***Pathogens' incidence on hybrid (%)***			
	PERFORMER	FAVORIT	NK ADAGIO	NK MELDIMI
Alternaria spp.	35	31	56	47
Stemphylium spp.	33	30	19	18
Penicillium spp.	7	10	0	14
Rhizopus spp.	8	10	7	4
Aspergillus spp.	3	2	3	0
Fusarium spp.	0	0	0	5
Sclerotinia sclerotiorum	0	2	0	0
Mucor spp.	3	6	5	3
Trichoderma spp.	0	3	0	0
Cladosporium spp.	4	3	3	4
Other pathogens	7	3	7	5

Table 3. Micoflora's influence on sunflower germination

Hybrid	**Germination (%)**	
	After 4 days	After 7 days
Performer	80	90
Favorit	85	95
NK Adagio	85	100
NK Meldimi	80	95

From our experiments, as it is shown in table 3, it was observed that after 7 days sunflower seeds germination was not affected for NK Adagio hybrid also was 95% for Favorit and NK Meldimi. The lowest seed germination rate was recorded for Performer hybrid seeds, respectively 90%.

CONCLUSIONS

The micoflora detected on the sunflower achenes was numerous, with pathogens belonging to *Alternaria*, *Penicillium*, *Stemphylium*, *Rhizopus*, *Aspergillus*, *Fusarium*, *Mucor*, *Sclerotinia*, *Trichoderma* and *Cladosporium* genera.

Alternaria spp. and *Stehphylium* spp. were the pathogens with the highest incidence rate on all analyzed hybrids.

Pathogen association did not affect the germination rate of seeds from the analyzed hybrids, except for Performer hybrid that presented the lowest germination rate of 90%.

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PROJECTION OF SUNFLOWER AND SUNFLOWER OIL PRODUCTION AND FOREIGN TRADE

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ABSTRACT

Turkey has a big potential for sunflower seed production, considering climate and soil charectristics. Although sunflower seed is the first in the sowing area and production of oilseeds in Turkey, its production is not enough to meet the need of sunflower oil. The production gap in sunflower oil that is the first in the vegetable oils consumpted in Turkey is met by importation because of lacking of raw material. 65% of sunflower raw oil supply is met by seed and total raw oil importation. Therefore, the oilseed crop whose production firstly should be increased is sunflower seed to meet the gap of vegetable oil, considering the consumption pay of it. In this context, making long term projections is important to present the state of the production and trade of sunflower seed and oil with regard to production planning and developing policies for the future. The aim of this study is to project the production and foreign trade, presenting the current situation of sunflower seed production in Turkey. For this aim, times series analysis method will be carried out using the data of Turkish Statistical Institute (TSI) in the study.

Key Words : Sunflower Seed, Sunflower Oil, Time Series Analysis

SUNEO: TECHNOLOGY FOR YIELD PROTECTION

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ABSTRACT

Nowadays it is not enough for seed companies to focusing only on breeding new varieties with good resistance for broomrape. The broomrape races evoluate rapidly with increasing aggressiveness, gaining surface across Europe. In this context it is necessary to be revolutionary if we want to win against this parasite. The main pillars of development durable solution:

Breeding for resistance: Finding new genetic resources is a key priority of Limagrain. Besides running field screening in the highly infected areas, it is reinforced with fundamentally different approach, by using high throughput screening platform Oroscreen ®. The platform serves our breeding since 2012 and allows promising progress in exploring genetic diversities of resistance against *Orobanche*.

Monitoring: Drawing the map of distribution of *Orobanche* races based on systematic collections of broomrape along with analysing the risk of drought across Europe is enabling us to create customer specific recommendation.

Integrating herbicide technology: Post- emergence herbicide can control the spread broomrape in new areas and to reduce the damage in infected areas. Limagrain is the first to coupling the newest herbicide tolerance with most powerful genetic resistance. This double security is giving full protection during the vegetation period from early to late attack. The new formulation of the herbicide is permitting to reduce also the residue in the soil and to give flexible protection in dry areas.

Limagrain Europe launched SUNEO® brand in 2013. This concept integrates LG 's best sunflower genetics issue from Soltis breeding program, an innovative screening platform for Orobanche resistance and the Clearfield® system

Key Words : broomrape resistance, herbicide tolerance, broomrape monitoring

RESULTS REGARDING BIOMASS YIELD AT SUNFLOWER UNDER DIFFERENT TECHNOLOGICAL CONDITIONS

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ABSTRACT

Crop biomass is an important source of renewable energy and it is used by the mankind from the ancient times. It was used mainly for producing heat, but recently it is also of interest as source of bioethanol, biodiesel, biogas, and even electricity. Nowadays, we are more and more interested in so called energy crops, including here the crops used for producing biomass. The specific crop technology for these energy crops is of great importance for producing biomass in an efficient way. Sunflower is one of the energy crops which are of interest for its above-ground biomass that could be used as substrate for producing biogas. Considering these matters, the aim of the present paper is to present the biomass yield obtained at an assortment of five sunflower hybrids under different preceding crop conditions (triticale with harrowing as soil tillage, maize with harrowing as soil tillage, and maize with ploughing as soil tillage) and row spacing conditions (70 cm, 50 cm, and twin-rows of 70/40 cm). For accomplishing this aim, a field experiment was performed in 2015 which was located in South Romania, respectively in the specific conditions from Moara Domneasca Experimental Farm belonging to the University of Agronomic Sciences and Veterinary Medicine of Bucharest. Determinations of fresh and dry biomass were performed in the early dough - dough plant growth stage. For biomass purposes, the grower has to choose a sunflower hybrid with a high potential to produce biomass among other characteristic, but also he has to use a proper crop technology within which the preceding crop and row spacing are important elements.

Key words: Sunflower, Biomass, Yield, Preceding crop, Row spacing

INTRODUCTION

Biomass could be defined as a form of energy storage whose major peculiarity is that to be renewable. Starting from this idea, the biomass that was used by humankind as source of energy since ancient times has become of great importance in the present context of global warming and searching for alternative ways of energy.

Biomass crops can take many forms and can be converted to a number of different products (Alexopoulou and Kretschmer, 2011). Concerning the use of crop biomass for energy purposes, this is of interest either as crop residues or as energy crops especially grown to accomplish this purpose.

Among the energy crops, sunflower could be used as a source of lignocelluloses biomass (Ziebell et al., 2013; Ion et al., 2014), which could be used as substrate for biogas production. In this respect, sunflower offers an advantage as its oil produces a higher methane content in biogas than other biogas crops (Hahn and Ganssmann, 2008). Also, sunflower is of interest because it could be characterized as being a crop tolerating the drought and succeeding under limited input conditions (Ion et al., 2015), and having the capacity to supply important yields of above-ground dry biomass, usually of 10-15 tons.ha^{-1}, reaching even 20 tons.ha^{-1} (Stefan et al., 2008).

But, one of the important conditions to produce biomass in an efficient way is to use the most appropriate cultivation techniques (Balodis et al., 2011; Basa et al., 2014; Beg et al., 2007; Ion et al., 2014). There are several technological measures with great impact on the biomass production. Thus, apart from choosing the most appropriate sunflower hybrid according to the growing and technological conditions, one can consider the preceding crop and the row spacing.

Energy crops for biogas production need to be grown in sustainable crop rotations (Amon et al., 2007; Hahn and Ganssmann, 2008). Sunflower is one of the energy crops which could be included into the crop rotations in view to assure its sustainability.

Diepenbrock et al. (2001) found in 1996 and 1998 that the above-ground biomass increased significantly with increasing row spacing, but in 1997, however, the differences between the row spacing were small. Sunflower can be manipulated over a wide range of plant populations and row spacing without seriously affecting yield (Vijayalakshmi et al., 1975). Nevertheless, the experimental results show that different planting patterns sometimes produced higher yield, but not always (Zarea et al., 2005). Also, lodging increased with wider row spacing (Holt and Zentner, 1985). All these findings reveal the fact that there are several implications of row spacing but not always the results are very clear, which means that this subject needs further investigations.

The aim of the present paper is to present the biomass yield obtained at an assortment of five sunflower hybrids under different preceding crops (triticale with harrowing as soil tillage, maize with harrowing as soil tillage, and maize with ploughing as soil tillage) and row spacing conditions (70 cm, 50 cm, and twin-rows of 70/40 cm).

MATERIALS AND METHODS

Researches were performed in a field experiment in the year 2015, which was located in South Romania, respectively in the specific conditions from Moara Domneasca Experimental Farm (44^{o}29’ N latitude and 26^{o}15’ E longitude) belonging to the University of Agronomic Sciences and Veterinary Medicine of Bucharest.

The specific soil for Moara Domneasca area is reddish preluvosoil, which is characterized by a humus content of 2.2-2.8%, clay loam texture, and pH of 6.2-6.6. Taking into account the growing period of sunflower in this area (April-August), this period is characterized by the multiannual average temperature of 18.5^{o}C and by the multiannual average rainfall of 313.2 mm. In the year 2015, the growing period of sunflower in the studying area was characterized by the average temperature of 19.2^{o}C and the sum of rainfall of 237 mm. This means that the year 2015 can be characterized as being warmer and drier than normal years.

Five sunflower hybrids were studied, respectively: Favorit, Performer, LG56.62, P64LE19, and Pro 144. Each hybrid was studied under three preceding crop conditions (triticale with harrowing as soil tillage, maize with harrowing as soil tillage, and maize with ploughing as soil tillage) and under three row spacing (70 cm, 50 cm, and twin-rows of 70/40 cm). The total area of the field experiment was of 1,640 m^{2}.

Soil tillage consisted in ploughing performed on 10th of November 2014, one harrowing work performed on 14th of April 2015, and seedbed preparation performed on 21st of April 2015 with a cultivator. The sowing was performed manually on 22nd of April 2015 and the plant density was of 70,000 plants.ha^{-1} for all the 45 experimental variants. The fertilization was performed with 80 kg.ha^{-1} of nitrogen and 40 kg.ha^{-1} of phosphorus. The weed control was performed by the help of herbicide (Dual Gold 960 EC based on the active substance S-metolaclor 960 g/l) applied at a dose of 1.2 l.ha^{-1} one day after sowing (on 23rd of April, 2015). The herbicide weed control was completed by one manual hoeing performed on 26th of May 2015.

Determinations of fresh and dry biomass were performed in the early dough - dough plant growth stage, respectively in the growth stage when the sunflower biomass is of importance to be used as substrate for biogas production. For each experimental variant the sunflower plants from one square meter were cut at soil level and were weighed immediately for determining the fresh biomass yield (as above-ground biomass). One sunflower plant for each variant was taken into the laboratory and dried in the oven at 80°C for 24 hours in view to be determined the dry biomass yield. The biomass to which we are referring in this paper represents the above-ground biomass.

RESULTS AND DISCUSSIONS

Among the three studied preceding crops, the highest biomass yields as average values were obtained when sunflower followed after maize with ploughing as soil tillage, respectively 33.46 tons.ha^{-1} of fresh biomass and 8.72 tons.ha^{-1} of dry biomass (Figure 1). When the preceding crop was maize but with harrowing as soil tillage (without ploughing) the biomass yield decreased compared to the variant with ploughing as soil tillage, but the decrease was less important for fresh biomass (33.24 tons.ha^{-1}) and more important for dry biomass (8.28 tons.ha^{-1}). The smallest biomass yields were obtained after triticale with harrowing as soil tillage, respectively 32.12 tons.ha^{-1} of fresh biomass and 7.91 tons.ha^{-1} of dry biomass.

Despite the fact that maize as preceding crop with ploughing as soil tillage determined the largest variation of fresh biomass yields, the dry biomass yields registered less variations and the highest values (Figure 1).

Regarding the biomass yields obtained at different row spacing conditions, the average values of the biomass yields were not significant different (Figure 2). The differences among the average values were more visible for fresh biomass than for dry biomass. It is interesting to point out that narrow rows determined higher yields of fresh biomass compared to row spacing of 70 cm, but with larger variations of the values. Concerning the dry biomass, the yields registered the highest values at wider rows, respectively at row spacing of 70 cm (8.36 tons.ha^{-1}). Taking into account the fact that the results were obtained in a year characterized as being warmer and drier than normal years for the studying area, these results are confirming partly the previous results we have obtained in the area where the field experiment was performed, respectively when growing conditions are less favourable, the yields of fresh and dry biomass tend to be higher at narrow rows (Ion et al., 2014; Ion et al., 2015).

Despite the fact that the row spacing of 70 cm determined the smallest average value for the fresh biomass (32.44 tons.ha^{-1}), however it determined the highest value for the dry biomass (8.36 tons.ha^{-1}). Also, despite the fact that the row spacing of 70 cm determined the smallest variation for the fresh biomass yield, it determined the largest variations for the dry biomass yield (Figure 2).

It is interesting to underline that the dry biomass obtained at row spacing of 50 cm (8.28 tons.ha^{-1}), which is quite closed to that obtained at row spacing of 70 cm (8.36 tons.ha^{-1}), it registered the smallest variations and the highest minimum values, this being quite stable, (Figure 2).

The twin-rows of 70/40 cm determined the highest average value for the fresh biomass yield (33.53 tons.ha^{-1}) but, however the smallest average value for the dry biomass yield (8.25 tons.ha^{-1}).

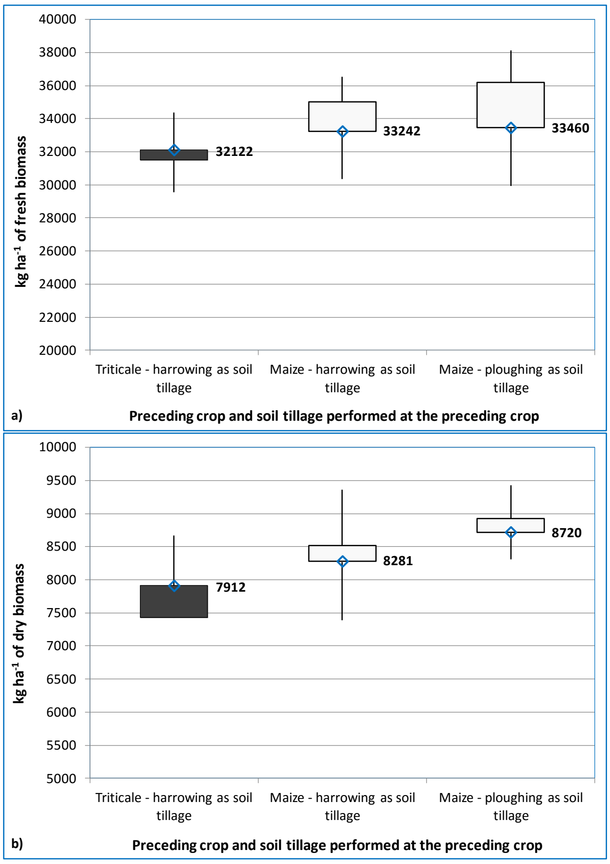

Figure 1. The fresh (a) and dry (b) biomass yields obtained at sunflower after different preceding crop conditions (Moara Domnească location, 2015)

As it was expected, there are important variations regarding the fresh and dry biomass yields according to hybrid, function of the hybrid characteristics (Figure 3). This is confirming the idea that the hybrid has to be chosen also according to the crop destination, respectively for biomass purposes has to be chosen a hybrid with a high potential to produce biomass among other characteristic.

In the year 2015, which was affected by drought, and for the studied conditions, the average dry biomass yields were less than 10 tons.ha^{-1}, while in the same area but under better climatic condition the average dry biomass yields were between 13 and 18 tons.ha^{-1} (Ion et al., 2014; Ion et al., 2015).

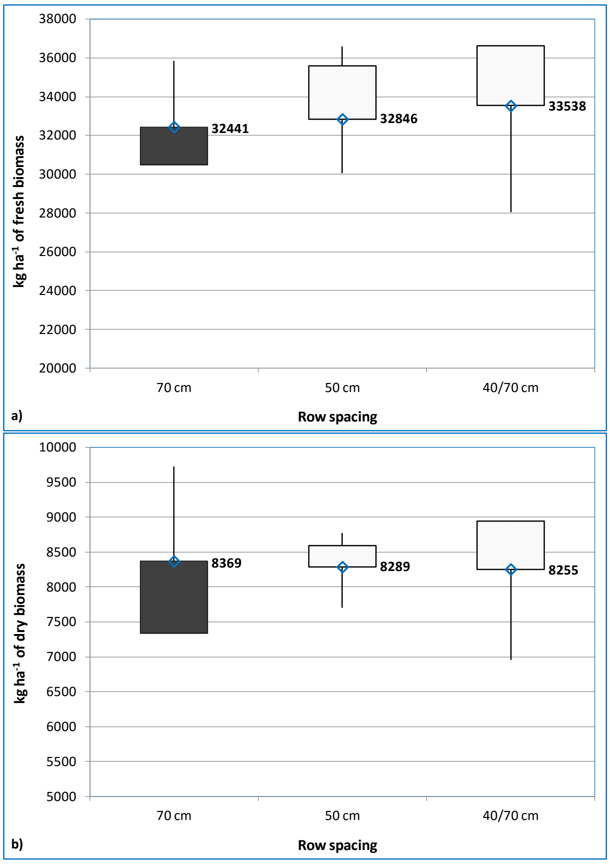

Figure 2. The fresh (a) and dry (b) biomass yields obtained at sunflower at different row spacing conditions (Moara Domnească location, 2015)

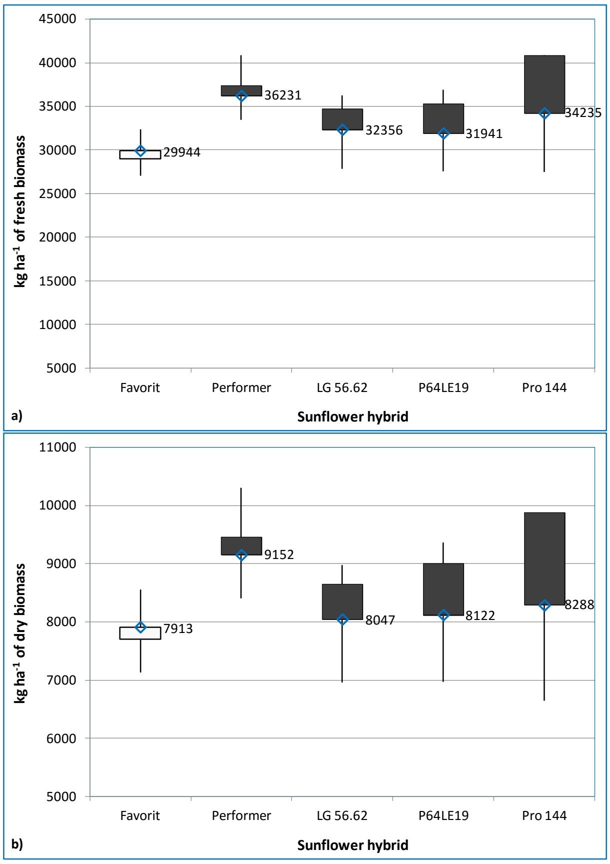

Figure 3. The fresh (a) and dry (b) biomass yields obtained at different sunflower hybrids (Moara Domnească location, 2015)

CONCLUSIONS

For biomass purposes, the grower has to choose a sunflower hybrid with a high potential to produce biomass among other characteristic, but also he has to use a proper crop technology. Thus, for producing biomass at sunflower crop and for the studied conditions, in a year affected by drought, maize was a better preceding crop compared to triticale, especially when maize had the ploughing as soil tillage. The different row spacing conditions determined dry biomass yields quite closed, but with a larger variation at 70 cm between rows and a smaller variation at 50 cm between rows.

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RESULTS REGARDING THE CORRELATION OF THE GRAIN YIELD WITH THE YIELD OF ABOVE-GROUND BIOMASS AT SUNFLOWER CROP

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ABSTRACT

Climatic and soil conditions, and the crop technology influence the correlation of the grain yield with the yield of above-ground biomass at sunflower crop. The aim of the paper is to present the results we have obtained at different hybrids of sunflower studied in the specific conditions of South Romania under different environmental and technological conditions regarding the correlation of the grain yield with the yield of above-ground biomass. The grain yields were expressed as yields at 9% moisture content of the grains, while the yields of above-ground biomass were expressed as yields of dry matter. Researches were performed in field experiments in 2013 and 2014 in two locations from South Romania (Fundulea from Calarasi County and Moara Domneasca from Ilfov County). In both experimental years, four sunflower hybrids were studied (Pro 111, Pro 953, LG 56.62 and P64LE19) at three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and three plant densities (50,000, 60,000, and 70,000 plants.ha^{-1}). Under the climatic conditions of 2013 and 2014 and in the two locations from South Romania with different soil conditions (chernozem and reddish preluvosoil), the grain yield did not correlated very well with the yield of above-ground biomass, whatever was the row spacing and plant density. However, there are some differences according to row spacing and plant density. Generally, the grain yields correlated negatively with the yield of above-ground biomass, except the situations registered at narrow rows under less favorable climatic conditions, especially when these were associated with less favorable soil conditions.

Key words: Sunflower, Correlation, Yield, Grains, Biomass

INTRODUCTION

Yield is the most economic character in almost all of the crops (Yasin and Singh, 2010). The yield is determined by the so called yield components. In sunflower, yield is determined by the proportions of the various components (Fetri et al., 2013). Sunflower seed yield, like other crops, is dependent of yield components which have interrelation among them and affect the seed yield directly or indirectly (Gjorgjieva et al., 2015).

Plant growth, plant biomass and plant yield are conditioned by different factors (Basa et al., 2014). The yield of achenes and the yield components of the head are specific to each sunflower hybrid, but they are influenced by the different growing factors, such as environmental factors (e.g. soil and climatic conditions) and technological factors (e.g. row spacing and plant population) (Ion et al., 2015). Under optimal conditions it is expected that grain yield correlates positively, at least to some point with the biological yield, respectively the yield of above-ground dry biomass (Basa et al., 2015). Climatic and soil conditions, and the crop technology influence the correlation of the grain yield with the yield of above-ground biomass at sunflower crop.

The aim of the present paper is to present the results we have obtained at different hybrids of sunflower studied in the specific conditions of South Romania under different environmental and technological conditions regarding the correlation of the grain yield with the yield of above-ground biomass.

MATERIALS AND METHODS

Researches were performed in field experiments in the years 2013 and 2014, in two locations from South Romania, respectively Fundulea (Calarasi County) and Moara Domneasca (Ilfov County). These two locations represented different soil and climatic conditions. In both experimental years (2013 and 2014), researches were performed in field experiments with four sunflower hybrids, respectively: Pro 111, Pro 953, LG 56.62, and P64LE19.

The soil from Fundulea area is chernozem (cambic chernozem soil). At Fundulea area and for the growing period of sunflower, respectively period April-August, the average temperature was 20.1°C in 2013 and 18.9°C in 2014, while the multiannual average value for the same period is 18.6°C. The sum of rainfall for the same period was 381.1 mm in 2013 and 399.0 mm in 2014, while the multiannual average value is 327.9 mm.

The soil from Moara Domneasca area is reddish preluvosoil. At Moara Domneasca area and for the growing period of sunflower, respectively period April-August, the average temperature was 20.5°C in 2013 and 18.8°C in 2014, while the multiannual average value for the same period is 18.5°C. The sum of rainfall for the same period was 115 mm in 2013 and 408 mm in 2014, while the multiannual average value is 313.2 mm.

At Fundulea area, the rainfall was higher than the multiannual average value, the year 2014 being more humid than the year 2013. At Moara Domneasca area, the rainfall in 2013 was much less than multiannual average value, this year being characterised as a drought one, while 2014 was a humid one with more rainfall than multiannual average value.

Each sunflower hybrid was studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm), and three plant densities (50,000, 60,000, and 70,000 plants.ha^{-1}).

In each location and from each variant, the sunflower plants from one square meter were cut at soil level and were weighed immediately in view to be determined the yield of fresh above-ground biomass. The seeds of sunflower heads were collected and weighed in view to be determined the yield of grains. It was determined the moisture content of the sunflower seeds to let us calculate the yield of grains in kg.ha^{-1} at moisture content of 9%. One sunflower plant for each variant was taken into the laboratory, where it was determined the dry biomass by oven drying at 80°C for 24 hours, as to be determined the yield of dry above-ground biomass. In both experimental years, the determinations were performed at fully ripe stage. The yield of dry biomass was calculated in kg.ha^{-1} and represents the yield of above-ground biomass.

RESULTS AND DISCUSSIONS

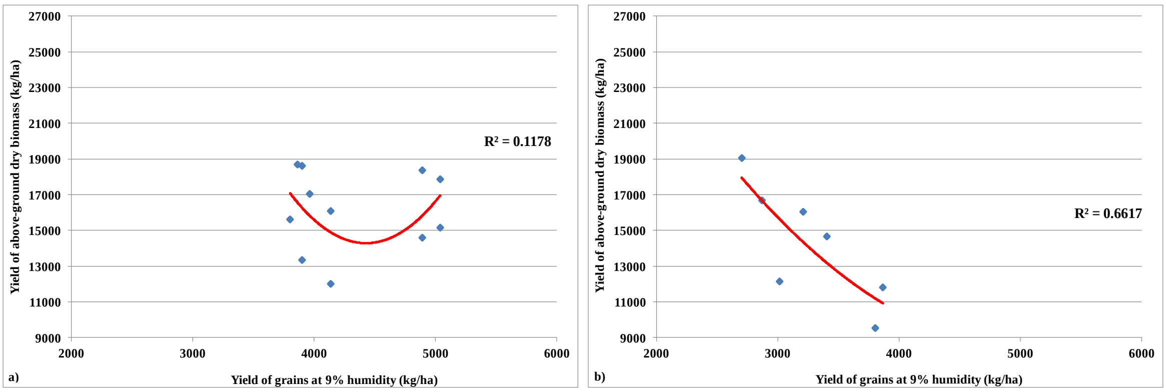
Under the climatic conditions of 2013 and 2014 and in the two locations from South Romania with different soil conditions (chernozem and reddish preluvosoil), the grain yields of the four sunflower hybrids, as average values, did not correlated very well with the yields of above-ground biomass, regardless of distance between rows and plant density (Figures 1-6). However, there are some differences according to row spacing and plant density.

At row spacing of 75 cm, the grain yields correlated negatively with the yield of above-ground biomass in both experimental years and both soil conditions (Figure 1).

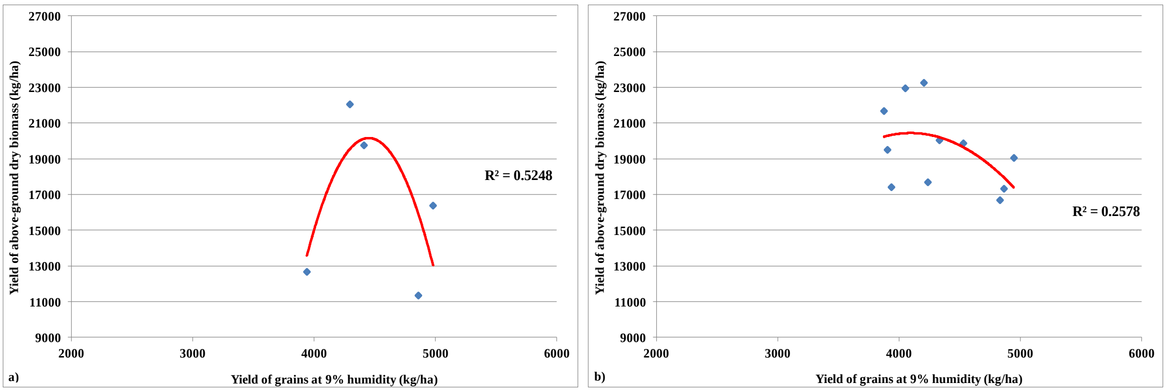
At row spacing of 50 cm, the grain yields correlated positively with the yields of above-ground biomass in the year 2013 under both soil conditions, but especially on reddish preluvosoil which was associated with less favorable climatic conditions, especially drought. In the year 2014, characterized by better climatic conditions for the two soil conditions, the grain yields correlated negatively with the yields of above-ground biomass (Figure 2). These findings can be explain by the fact that under less favorable growing conditions, the sunflower plants produce more grains once the above-ground biomass increase. But, under favorable growing conditions, the sunflower plants react by producing more vegetative biomass than reproductive one, respectively despite the fact that the above-ground biomass increases the weight of seeds decrease. This means that at row spacing of 50 cm and under favorable growing conditions the harvest index decrease.

At twin-rows of 75/45 cm, as in the case of row spacing of 50 cm, the grain yields correlated positively with the yields of above-ground biomass in the year 2013 under both soil conditions, but especially on reddish preluvosoil, which was associated with drought. Also as in the case of row spacing of 50 cm, in the year 2014, respectively under better climatic conditions, the grain yields correlated slightly negatively with the yields of above-ground biomass, especially on reddish preluvosoil (Figure 3).

Generally, at different plant densities, the grain yields correlated negatively with the yields of above-ground biomass (Figures 4-6), except the situation registered at plant density of 50,000 plants.ha^{-1} and reddish preluvosoil (Figure 4) and the situation registered at plant density of 60,000 plants.ha^{-1} and chernozem (Figure 5).

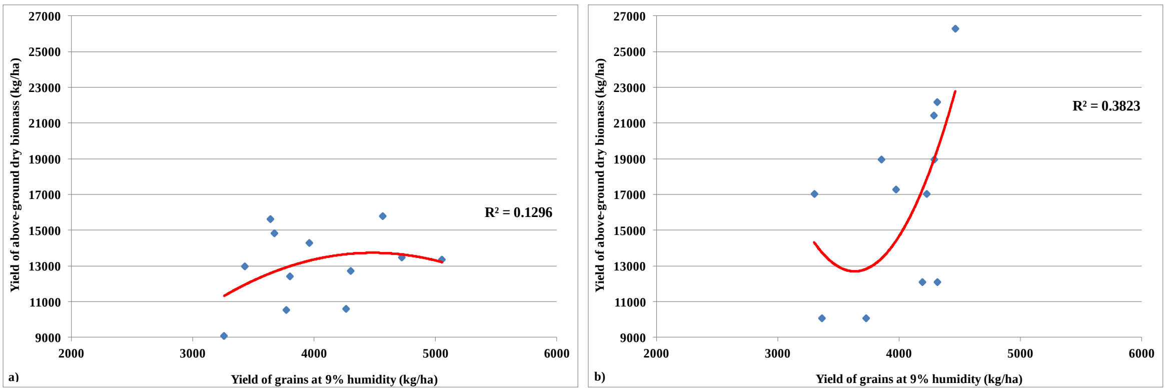


Climatic conditions of 2013 (a- chernozem soil; b- reddish preluvosoil)

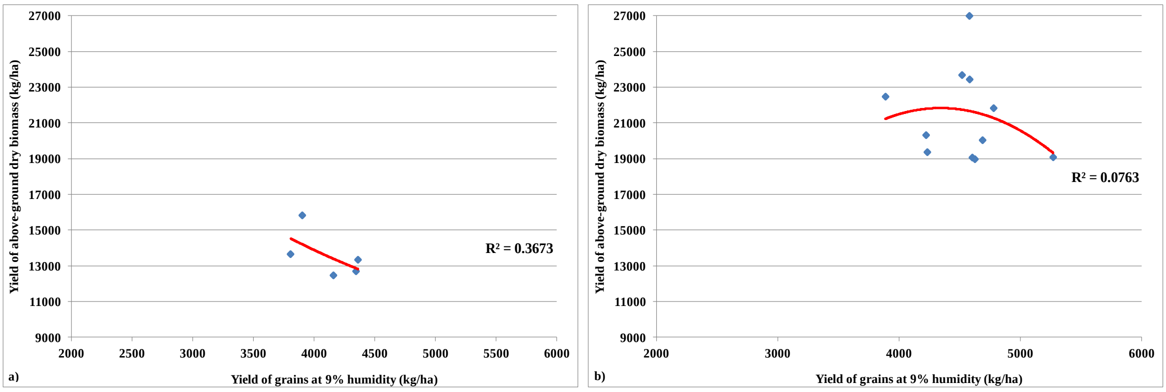


Climatic conditions of 2014 (a- chernozem soil; b- reddish preluvosoil)

Figure 1. Correlations of the yield of grains with the yield of above-ground dry biomass at sunflower at row spacing of 75 cm and under different climatic and soil conditions

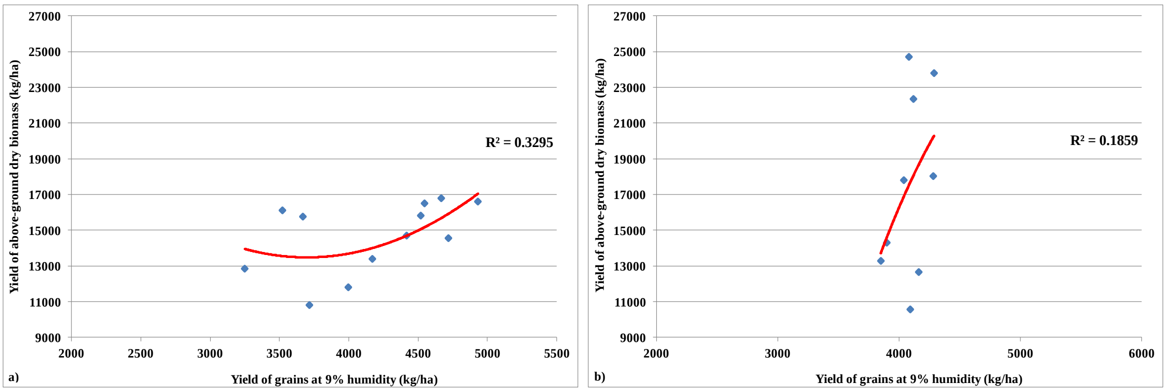


Climatic conditions of 2013 (a- chernozem soil; b- reddish preluvosoil)

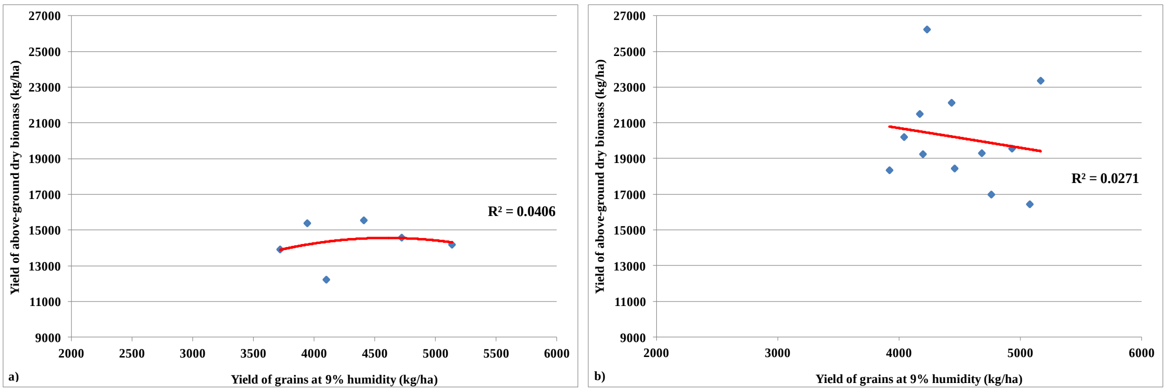


Climatic conditions of 2014 (a- chernozem soil; b- reddish preluvosoil)

Figure 2. Correlations of the yield of grains with the yield of above-ground dry biomass at sunflower at row spacing of 50 cm and under different climatic and soil conditions

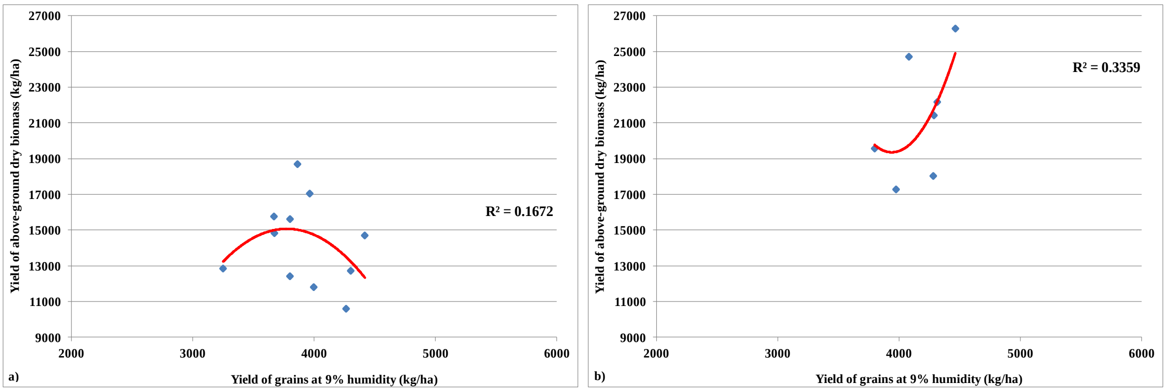


Climatic conditions of 2013 (a- chernozem soil; b- reddish preluvosoil)

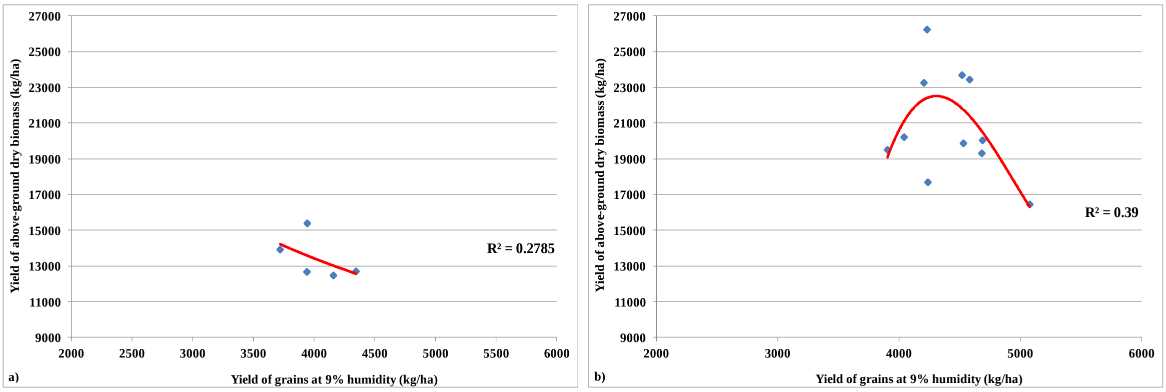


Climatic conditions of 2014 (a- chernozem soil; b- reddish preluvosoil)

Figure 3. Correlations of the yield of grains with the yield of above-ground dry biomass at sunflower at twin-rows of 75/45 cm and under different climatic and soil conditions

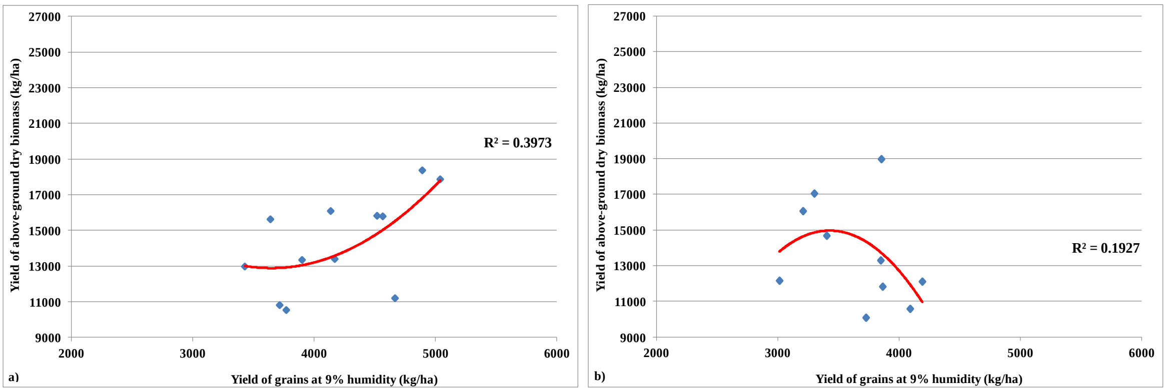


Climatic conditions of 2013 (a- chernozem soil; b- reddish preluvosoil)

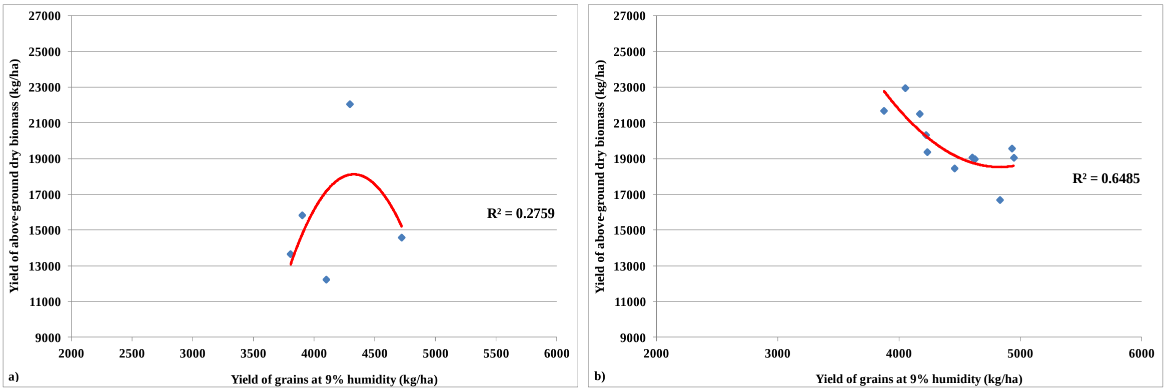


Climatic conditions of 2014 (a- chernozem soil; b- reddish preluvosoil)

Figure 4. Correlations of the yield of grains with the yield of above-ground dry biomass at sunflower at plant density of 50,000 plants.ha^{-1}, under different climatic and soil conditions

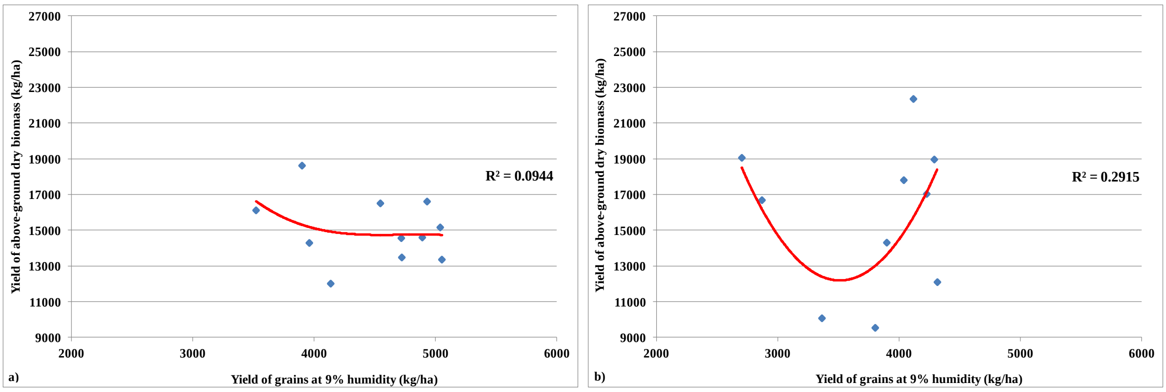


Climatic conditions of 2013 (a- chernozem soil; b- reddish preluvosoil)

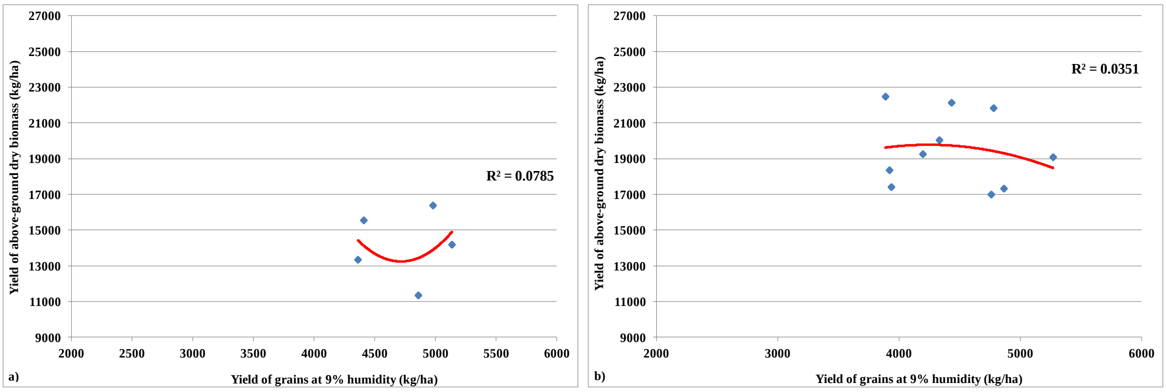


Climatic conditions of 2014 (a- chernozem soil; b- reddish preluvosoil)

Figure 5. Correlations of the yield of grains with the yield of above-ground dry biomass at sunflower at plant density of 60,000 plants.ha^{-1}, under different climatic and soil conditions



Climatic conditions of 2013 (a- chernozem soil; b- reddish preluvosoil)



Climatic conditions of 2014 (a- chernozem soil; b- reddish preluvosoil)

Figure 6. Correlations of the yield of grains with the yield of above-ground dry biomass at sunflower at plant density of 70,000 plants.ha^{-1}, under different climatic and soil conditions

CONCLUSIONS

Under the climatic conditions of 2013 and 2014 and in the two locations from South Romania with different soil conditions, the grain yield did not correlated very well with the yield of above-ground biomass, whatever was the row spacing and plant density. However, there are some differences according to row spacing and plant density. Generally, the grain yield correlated negatively with the yield of above-ground biomass, except the situations registered at narrow rows under less favorable climatic conditions, especially when these were associated with less favorable soil conditions, situations when the grain yield correlated positively with the yield of above-ground biomass.

ACKNOWLEDGEMENTS

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TOWARD REAL TIME INSPECTION OF QUALITY IN SUNFLOWER SEEDS: MACHINE VISION

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ABSTRACT

Quality assurance is one of the most important and challenging tasks of industries before export of food and agricultural produce. Sunflower seed and oil sector is one of the main industries in Turkey. The key quality parameters for safety evaluation of sunflower seeds includes heat damage, insect-infestation, mold growing, heterochromatic appearance and rancidity. Currently, time consuming and inconsistent conventional methods are generally utilized for inspecting the products, which are sampled individually or in large batches. Man-made visual inspection methods are generally performed by trained technicians to detect defects, colors, sizes or abnormalities, and classify the product in its appropriate category. In addition, the variety of sunflower seeds hinders their classification in terms of color, texture or different types of defects. Machine vision is an emerging technology that combines mechanics, optical instrumentation, electromagnetic sensing, digital video and image processing. Integrating mechanical, optical, electronic devices, this non-destructive method has been widely accepted in a broad range of sectors. The food industry is among the fastest growing segments of machine vision systems. Recent research has highlighted the possible application of machine vision in other areas of agriculture. Since it is of critical importance to readily acquire the quality characteristics of sunflower seeds in order to meet the demands of high-quality food processing industry, machine vision can be utilized as a promising novel tool for real time examining, monitoring and controlling quality characteristics of sun flower seeds.

Key Words : sunflower seeds; image processing; machine vision

POTENTIAL OF HYPERSPECTRAL IMAGE PROCESSING FOR CLASSIFICATION AND QUALITY EVALUATION OF SUNFLOWER SEEDS

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops grown in the world. Current methods for safety evaluation of sunflower seeds mainly depend on spot check, sampling inspection and frequent analysis, requiring destructive, expensive and time consuming treatments. Moreover, conventional imaging systems can hardly distinguish the inferior seeds due to presence of hard shells, hindering photoelectric information from the kernel. There is a growing interest in hyperspectral imaging (HSI) for being a promising, non-destructive and real-time tool for inspecting quality, safety and authenticity features of food products. Unlike conventional imaging systems, which operate at visible wavelengths in the form of monochromatic or discrete color images (red, green and blue), hyperspectral systems collect images in several contiguous and/or regularly spaced bands. Therefore, HSI produces a fuller spectrum of wavelength information for each pixel of the image. In HSI, spatial and spectral information can be simultaneously obtained. Combining visual imaging and computer based vision techniques, HSI has been successfully implemented in monitoring and prediction of physical parameters, determination of chemical composition, assessment of quality attributes, detection of microbial spoilage and inspection of contaminants. There is an urgent need for a reliable, rapid and accurate automatic detection technique for assessing the quality parameters of sunflower seeds. Up to date no research has been reported on hyperspectral imaging in sunflower seeds. However previous studies have shown that the hyperspectral imaging holds potential for future on-line and real-time monitoring of grains.

Key Words : sunflower seed, hyperspectral imaging , quality

SOME MORPHOLOGICAL CHARACTERISTICS OF CONFECTIONARY SUNFLOWER GENOTYPES OBTAINED THROUGH SELECTION BREEDING

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ABSTRACT

Sunflower is cultivated in many countries including Turkey because of high adaptation capacity and various uses. Sunflower is grown primarily to meet the cooking oil demands of households and industry, but it is also used in cookies, bakeries and various other foodstuffs. Turkey has 180 thousand tons/year confectionary sunflower production with an average yield level of 155 kg/da (Tüik, 2015). In Turkey, Ankara, Aydın, Denizli, Izmir, Kayseri, Sivas, Yozgat, Kırıkkale, Aksaray, Nigde, Nevsehir, Kırsehir, Hatay, Kahramanmaras, Osmaniye and many other provinces are the primary confectionary sunflower growers. Despite the sufficient potential and cultivation area, yield levels are quite low in Turkey due to lack of sufficient availability of certified seeds. Poor quality effects seed size and homogeneity desired by consumers. Confectionary sunflower has been ignored in most countries except for a few countries in the world. The USA is the leading country in confectionary sunflower marketing. International agricultural organizations usually consider confectionary sunflower with oilseed sunflowers. This study was conducted to purify confectionary sunflower cultivars in Turkey to meet consumer demands and to improve adaptation capacity of the cultivars. For this purpose, confectionary sunflower lines were sown and their head diameters, head shapes and self-pollination ratios were determined.

Key words: Confectionary sunflower, Selection, Self-pollination

INTRODUCTION

Today, sunflower is largely used to meet the demands for cooking oil. In some countries, beside oil seed cultivars, confectionary cultivars are also produced (Lofgren, 1978). The confectionary seeds are rich in nutrients and they are commonly used in confectionary production through mixing them with salt, butter and honey, used as seasoning over vegetable, fish and salads, they are also consumed as snack food in roasted or non-roasted type (Millete, 1974).

Sunflower production is widespread in Black Sea, Thrace-Marmara, Aegean, Central Anatolia and Çukurova regions of Turkey. It is cultivated in almost every part of the country under dry or irrigated conditions. Despite quite well adaptation capacity of sunflower, the cultivated lands are limited with 500-600 thousand hectares in Turkey. Confectionary sunflower production of Turkey is 180 thousand tons/year and the average yield level is 155 kg/da (Tüik, 2015).

Confectionary use of sunflower is quite common both in Turkey and various other parts of the world and it is most commonly consumed as snack food in several countries.

Sunflower has been used for confectionary purposes for a long time and it is used in more than a hundred foodstuffs worldwide including bakery, ice-cream, chocolate, cookies and etc.

(Lofgren, 1997). As it was in Turkey, confectionary sunflower production is a great income source for world farmers, but it is usually considered in world literature with oilseed sunflowers. It is nationally qualified separately as oilseed and confectionary in practice, confectionary statistics are not usually presented by international agricultural organizations (OECD, FAO, ISA and etc.). The USA, Hungry, Argentina, Spain, Israel, China, Turkey, Moldova and some Eastern European countries are the leading confectionary sunflower producers. Today, the USA has the greatest confectionary sunflower production. On the other hand, Germany, Denmark, the Netherlands, Canada, Mexico, The United Kingdom and Belgium are the leading shelled confectionary sunflower buyers and Spain, China, Turkey, Jordan, Canada, Mexico, Israel, Germany and Japan are the primary unshelled confectionary sunflower buyer countries.

In Turkey, commercial confectionary sunflower production activities are commonly implemented in Kahramanmaras, Elazıg, Ankara, Aksaray, Balıkesir, Bursa, Usak, Burdur, Yozgat, Kırsehir, Amasya, Corum, Erzurum, Kayseri, Igdır, Isparta, Eskisehir, Tekirdag and Edirne provinces (Tan, 2011). The seeds used in productions are mostly open-pollinating village-type populations (Tan, 2011), however, certified cultivars have recently been used. Some of these certified seeds are foreign breeds (Avesa Çrz 2012, Marker, Confeta CL and Shelly), but there are some local breeds and local confectionary sunflower cultivars (Çiğdem 1, Palancı 1, 09 TR Ç 004, Çetinbey and İnegöl alası).

Confectionary sunflower is commonly cultivated in Central and Eastern Anatolia provinces and village populations called based on physical appearance like Alaca, Kıbrıs, Inegöl and etc are used. Unit area yield levels are quite lower under dry conditions than the yield levels obtained from hybrid oilseed cultivars (Kaya, 2004). Previous researches revealed that confectionary types have low oil content, but high protein content. Low shell ratio and wide seeds are desired parameters in confectionary sunflowers (Kaya et al., 2008; Hladni et al., 2011).

The primary objective of the present study was to purify confectionary sunflower cultivars with high adaptation capacities and consumer desired quality parameters. In this way, new cultivars may be developed and registered to meet the country needs and further breeding will also be possible to develop advanced cultivars. Along with these objectives, head height, head shape and self-pollination ratios were determined.

MATERIAL AND METHOD

The present study was conducted to purify 12 genotypes collected from Central and Eastern Anatolia regions in 2002 and went through selection works for 10 years. During the purification study, head of each plant of 12 confectionary sunflower genotypes planted to field (50 plants per genotype) was isolated to prevent external pollination and plants were allowed to self-pollinate. Beside purification of the lines, self-pollination which is a significant parameter for sunflowers, ratios were determined.

The 12 lines obtained through single plant selection were sown in a single row. Proper care practices were implemented throughout the experiments. Before flowering (head formation), randomly selected 6 plants were bagged with isolation bags to provide self-pollination. Bags were removed when the seed formation was completed. Heads of each line were harvested and relevant measurements and counts were performed. The results for 10 lines with successful self-pollination (7, 12, 18, 21, 25, 27, 28, 34, 37 and 38) were assessed. The empty/full seed ratios (%), head diameter (cm), head shape and head central spot diameter (cm) are provided in Table 1.

Table 1. Results for self-pollinated confectionary sunflower genotypes

Line No	Replication	Average number seeds per head	Average number of full seeds per head	Self-pollination ratio (%)	Average head diameter, cm	Head shape	Average central spot diameter, cm
7	2	1222	10	0.8	17.5	Smooth conical	0
12	4	538.5	40	7.4	11.3	Smooth-Smooth	1.8
18	2	972	175	18.0	16.7	Smooth conical	2.7
21	5	708	59.8	8.4	13	Smooth-Smooth	4.2
25	1	232	34	14.6	9.5	Smooth	0
27	2	709.5	49	6.9	12.2	Smooth conical	0
28	10	767	62.8	8.1	14.3	Smooth-Smooth	1.4
34	4	1063.5	55	5.1	18.5	Smooth-Invert	2.8
37	2	577	35.5	6.1	13.7	Smooth conical-	1.2
38	3	547	56.6	10.3	11	Smooth-Smoot	2.2

RESULTS

Of the 12 lines used to homogenize the genotypes, 10 exhibited self-pollination and two lines were not self-pollinated. Since self-pollination is a significant parameter in breeding works, these two lines were omitted. Considering the remaining 10 lines, the greatest self-pollination ratio was observed in line 18 with 18.0%. It was followed by line 25 (14.6%) and line 38 (10.3%). Self-pollination ratios of the other lines were below 10% level. The lines with a self-pollination ratio over 10.0% (lines 18, 25 and 38) were considered as promising lines. These lines had smooth or smooth conical heads as desired. Considering the head diameters, line 18 had larger heads than the promising lines 25 and 38. With regard to non-seed formation at central spot, line 25 was full, line 18 had 2.7 cm and line 38 had 2.2 cm central spot without seeds.

CONCLUSION

The lines 18, 25 and 38, which were identified as promising lines with regard to self-pollination, should be self-pollinated for couple more years. Then, during this further self-pollination period, the ones preserving or improving self-pollination ratios can be used in further breeding works as advanced promising genotypes.

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A PRELIMINARY STUDY ON CONTROL OF SUNFLOWER DOWNY MILDEW (PLASMOPARA HALSTEDII) WITH CULTURE FILTRATES OF ANTAGONISTIC FUNGI

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ABSTRACT

Sunflower downy mildew caused by *Plasmopara halstedii* (Farl.) Berl. and de Toni is a serious disease on sunflower grown worldwide. Occurrence of fungicide-tolerant races of the pathogen limits chemical control and the use of resistant cultivars to overcome the disease. Biological control is one of the alternative environment-friendly methods for managing this disease. Culture filtrates of the fungal isolates, AS3 (non-aflatoxigenic *Aspergillus flavus* Link), TRIC7 and TRIC8 (*Trichoderma harzianum* Rifai) from soils (Tekirdağ/Turkey), which controlled black mold disease in onion, were tested for their effects on sporulation density caused by *P. halstedii* on cotyledon leaf of sunflower. Fungal isolates were cultured on potato dextrose broth (PDB) for 15 days at 24oC. The fungal biomass was centrifuged at 5000 rpm for 20 min and the supernatant was filtered using a sterile membrane filter (0.22 µm). The filtrates were analysed by gas chromatography/mass spectrometer (GC/MS). Sunflower seeds surface-sterilized with sodium hypochlorite (10%) for 1 min were treated with the filtrate of each potential antagonists by shaking the seeds for 6 hour. Pathogen was inoculated to the roots of pre-germinated seeds for three days. All treatments significantly reduced sporulation density of pathogen, representing the effectiveness of 87%, 66% and 60% by AS3, TRIC7 and TRIC8, respectively. GC/MS analysis showed that culture filtrates of the tested antagonist fungi contained several compounds known for their antifungal activity such as amines, amides, fatty acids and esters, ketones, phenols and, derivatives of imidazole, inden, indole and thiazole, differing to the isolates.

Key Words : *Plasmopara halstedii*, biological control, *Aspergillus flavus, Trichoderma harzianum*, antagonistic fungi, antifungal activity