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.

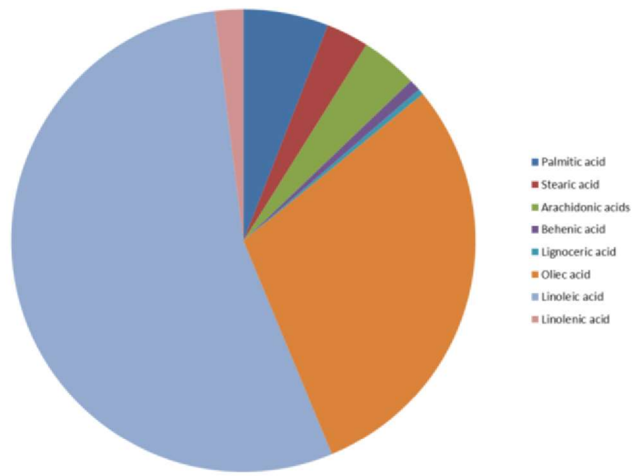

Figure 18: Oil content of sunflower (Nas, 2010).

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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