STUDIES ON THE EFFECT OF RATIOS AND LEVELS OF NPK FERTILIZER NUTRIENTS ON THE PRODUCTIVITY OF HYBRID SUNFLOWER UNDER RAINFED FARMING SITUATIONS

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Abstract

Two field experiments to study the effect of ratios and levels of NPK fertilizer nutrients on the productivity of hybrid sunflower (cv. DSH 1) were conducted on medium Vertisols during the rainy seasons of 1999 and 2000 under rainfed farming situations at the Main Agricultural Research Station, University of Agricultural Sciences, India. Treatments consisted of different ratios of N/P (0.67, 0.80, 1.00, 1.20, 1.30, 1.60 and 2.00) with different levels of N (60 to 120 kg N/ha), P (56.25 to 120 kg P2O5) and K (45 to 60 kg K2O/ha) fertilizers. Results of the experiments indicated that N and P fertilizers applied in N/P ratios of either 1.00 or > 1.00 (1.20, 1.30, 1.60 and 2.00) in addition to K fertilization at 60 kg/ha (1.00) produced higher seed and oil yields of sunflower compared to an N/P fertilizer ratio of <1.00 (either 0.67 with 60 kg N, 90 kg P2O5 and 60 kg K2O/ha or 0.80 with 60 kg N, 90 kg P2O5 and 60 kg K2O/ha). The mean of the two years' data indicated that fertilizer management practices involving application of N and P in an N/P fertilizer ratio of either 1.0 or > 1.0 (1.20, 1.30, 1.60 and 2.00) in addition to K fertilization at 60 kg K2O/ha produced higher seed yield (2,143 to 2,553 kg/ha) and higher oil yield (840 to 1,063 kg/ha) compared to the fertilizer management practices involving application of N and P in an N/P fertilizer ratio of < 1.00 (1,906 to 2,007 kg seed yield and 744 to 788 kg oil yield/ha) and an N/P fertilizer ratio of 0.0 with 60 kg K2O/ha (1,358 and 491 kg seed and oil yield/ha, respectively). The results of another trial indicated that the productivity of sunflower tended to decrease with decreasing K fertilization from 60 to 45 kg K2O/ha at all the N/P ratios. Sunflower showed greater response to application of N and P at a higher dose of K fertilizer (60 kg K2O/ha). N/P fertilizer ratios of either 1.00 or > 1.00 with 60 kg K2O/ha produced 3.38 to 11.29% higher seed yield and 4.77 to 16.98% higher oil yield over N/P fertilizer ratios of 1.00 or

> 1.00 with 45 kg K2O/ha. Results also indicated that sunny weather during flowering and seed set produced higher seed yields of sunflower.

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. In India, sunflower has acquired the status of an important commercial oilseed crop within a span of three decades of its introduction. Though sunflower assumed global importance in recent years, the research efforts made in respect to its nutritional requirements are rather scanty. Also, as the crop has expanded to soils of low fertility the greater risk of nutritional disorders has become more evident. In India, inadequate and/or imbalanced use of fertilizers has been identified as one of the critical constraints in sunflower production. Sunflower, an energy rich crop, is often considered as a soil nutrient-depleting crop and in turn puts heavy demands on soil and applied nutrients (Kharwara and Bindra 1992; Mishra and Paikaray, 1994). It showed greater response to applied nutrients and application of different major nutrients (NPK) resulting in 50 per cent higher seed yield (Chorey and Thosar, 1997). Among the different nutrients required, N and P are the primary limiting nutrients under most environments where it is being cultivated (Devidayal and Agarwal, 1998; Baldev Raj et al., 1999). Further, it is also reported that sunflower has high N (Steer et al., 1994) and moderate P (Glass, 1988) requirements. Based on the results of the trials conducted in India under the All India Coordinated Research Project on Oilseeds (AICRPO) and State Agricultural University research programmes, fertilizer doses comprising 60 kg N, 90 kg P2O5 and 60 kg K2O/ha and 60 kg N, 75 kg P2O5 and 60 kg K2O/ha, respectively, have been recommended for sunflower cultivation. In these recommendations, N and P fertilizers are being applied in an N/P ratio of <1.0 (0.67 to 0.80). However, a few studies indicated that higher seed yields of sunflower can be realized if N and P are applied in an N/P fertilizer ratio of either 1.0 or > 1.0 (Devidayal and Agarwal, 1998). In view of foregoing observations, field trials were conducted to study the effect of different ratios and levels of N, P and K nutrients on the productivity of a newly developed hybrid sunflower (cv. DSH 1) during the rainy season under rainfed farming situations.

Materials and Methods

Two field experiments to study the response of a sunflower hybrid to different ratios and levels of N and P on medium Vertisols were conducted during the rainy season of 1999 and 2000 under a rainfed farming situation at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka), India. The initial soil test values of the experimental site are presented in Table 1. The weather parameters (rainfall, number of rainy days, evaporation, mean relative humidity, mean minimum and mean maximum temperatures) observed during the different growth stages of sunflower are presented in Tables 2 to 4. The details of the trials are given below.

Table 1. Chemical properties of soil of experimental field (1999 and 2000).

Particulars	Soil test values	
	1999	2000
Organic carbon (%)	0.62	0.59
Available nitrogen (kg N/ha)	270.61	235.38
Available phosphorus (kg P_2O_5/ha)	40.85	42.15
Available phosphorus (kg K_2O/ha)	436.57	393.18
pH (1:1.25 soil : water ratio)	7.7	7.7

Table 2. Rainfall, number of rainy days and evaporation during different growth stages of hybrid sunflower (Rainy season of 1999 and 2000).

Crop growth stages	Rainfall (mm)		Number of rainy days		Evaporation (mm)	
	1999	2000	1999	2000	1999	2000
Seedling (0 to 25 DAS)	106.2	35.6	08	03	22.8	68.4
Button (26 to 45 DAS)	11.0	23.7	02	03	28.4	33.4
Flowering (46 to 65 DAS)	0.0	75.3	00	04	32.1	44.5
Seed formation (65 to 77 DAS)	14.7	48.4	02	03	42.2	26.5
Maturity (78 to 87 DAS)	34.3	47.3	05	04	20.4	13.4
Total	**166.2**	**230.3**	**17**	**17**	**145.9**	**186.2**

Table 3. Relative humidity during different growth stages of hybrid sunflower (Rainy season of 1999 and 2000).

Crop growth stages	Relative humidity (%)			
	1999		2000	
	Mean	Range	Mean	Range
Seedling (0 to 25 DAS)	**93.4**	87.5 - 100.0	**74.6**	61.0 - 96.5
Button (26 to 45 DAS)	**83.6**	76.5 - 91.0	**81.3**	66.5 - 94.0
Flowering (46 to 65 DAS)	**86.4**	76.5 - 93.5	**75.6**	68.0 - 84.0
Seed formation (65 to 78 DAS)	**79.3**	70.5 - 85.5	**73.4**	65.0 - 81.0
Maturity (79 to 87 DAS)	**66.8**	77.5 - 89.0	**79.2**	71.5 - 94.5

Table 4. Mean minimum and mean maximum temperature during different growth stages of hybrid sunflower (Rainy season of 1999 and 2000).

Crop growth stages	Temperature (°C)							
	Mean Maximum				Mean minimum			
	1999		2000		1999		2000	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Seedling (0 to 25 DAS)	**24.7**	22.8 -29.1	**28.9**	22.9 - 32.2	**20.7**	19.8 - 21.5	**19.9**	18.2 - 22.2
Button (26 to 45 DAS)	**27.9**	25.5 - 29.6	**26.4**	23.9 - 30.3	**20.3**	19.3 - 20.9	**20.5**	19.2 - 22.7
Flowering (46 to 65 DAS)	**27.0**	25.0 - 29.2	**29.0**	26.8 - 31.2	**20.0**	18.7 - 20.4	**20.1**	19.1 - 21.6
Seed formation (66 to 78 DAS)	**29.8**	25.5 - 32.5	**29.9**	28.8 - 31.1	**20.2**	17.6 - 21.5	**20.8**	18.5 - 22.2
Maturity (79 to 87 DAS)	**23.8**	28.0 - 30.6	**28.6**	24.6 - 29.9	**17.2**	18.9 - 22.6	**21.0**	19.4 - 21.9

Experiment I. This experiment studies the "Effect of different ratios and levels of N and P on yield components and yield of sunflower" and was conducted during two consecutive rainy seasons of 1999 and 2000. The experiment was laid out in a Randomized Complete Block Design (RCBD) with nine treatments comprising different N/P fertilizer ratios (0.0, 0.67, 0.80, 1.00, 1.20, 1.30, 1.60 and 2.00) with a fixed K fertilizer level of 60 kg K2O/ha (Tables 5 and 6). The treatments were replicated four times with an individual gross plot size of 30.24 sq. m

Experiment II. This experiment studied the "Effect of different ratios and levels of N, P and K on yield components and yield of sunflower" and was conducted during the rainy season of 2000. The experiment was laid out in RCBD with ten treatments comprising different N/P fertilizer ratios (0.67, 0.80, 1.00, 1.20, 1.30 and 1.60) at different levels of K fertilizer (45 and 60 kg K2O/ha) (Table 7). The treatments were replicated four times with an individual gross plot size of 30.24 sq. m.

In both the experiments, cv. DSH 1 (an early and downy mildew resistant hybrid sunflower) was grown with common production/cultivation practices. Redomyl MZ pre-treated (4 g/kg seed) sunflower seeds were hand dibbled at a spacing of 60 cm × 30 cm. Plant density of 55,555 plants/ha was maintained from seedling to harvest. N and P were applied in the form of diammonium phosphate (DAP); and K was applied in the form of muriate of potash (MOP). At the time of sowing, the required quantity of fertilizer mixture containing half the dose of N and entire dose of P and K was applied in the furrows as per the treatments to each plot. Top dressing of N in the form of urea was done through band placement at 35 DAS. Experimental plots were kept weed free by integrated weed management practices involving pre-emergence application of metolachlor at 1.0 kg a.i./ha plus two intercultivations (20 and 30 DAS), and one hand weeding at 30 DAS. The crop was kept disease and insect

Table 5. Experiment I. Head weight, seed weight/plant and 1000-seed weight of hybrid sunflower as influenced by ratios and levels of N and P (Rainy season of 1999, 2000 and Mean*).

Treatments								Head weight (g)			Seed weight (g/plant)			1000- Seed weight (g)		
Sl. No.	Nutrient ratios				Quantity of nutrients (kg/ha)			1999	2000	Mean*	1999	2000	Mean*	1999	2000	Mean*
	N	P2O5	K2O	N/P	N	P2O5	K2O									
T1	0.00	0.00	1.00	0.00	0	0	60	59.33	57.92	**58.63**	33.872	33.057	**33.465**	36.100	34.120	**35.110**
T2	1.00	1.25	1.00	0.80	60	75	60	82.39	58.59	**70.49**	52.800	38.175	**45.488**	44.158	39.622	**41.890**
T3	1.00	1.50	1.00	0.67	60	90	60	82.49	58.58	**70.53**	53.695	37.532	**45.614**	48.373	38.250	**43.311**
T4	1.50	1.25	1.00	1.20	90	75	60	87.60	71.21	**79.41**	53.918	46.333	**50.125**	44.445	38.700	**41.573**
T5	1.50	1.50	1.00	1.00	90	90	60	87.40	73.82	**80.61**	54.900	46.368	**50.634**	47.958	38.863	**43.410**
T6	2.00	1.00	1.00	2.00	120	60	60	94.11	65.44	**79.78**	62.455	43.432	**52.944**	40.982	39.547	**40.265**
T7	2.00	1.25	1.00	1.60	120	75	60	94.85	69.70	**82.27**	62.613	46.033	**54.323**	44.605	40.243	**42.424**
T8	2.00	1.50	1.00	1.30	120	90	60	95.44	67.72	**81.58**	62.650	44.468	**53.559**	47.757	42.012	**44.885**
T9	2.00	2.00	1.00	1.00	120	120	60	95.83	70.83	**83.33**	66.660	49.267	**57.964**	51.060	42.448	**46.754**
Mean								**86.60**	**65.98**	**76.29**	**55.951**	**42.741**	**49.346**	**45.049**	**39.312**	**42.180**
S.E ±								2.025	69.57	1.120	1.637	0.621	0.876	0.989	0.490	0.552
LSD (p=0.05)								5.911	2.79	3.18	4.778	1.814	2.489	2.889	1.431	1.570

Mean*: Pooled data of two years (Rainy seasons of 1999 and 2000).

Table 6. Experiment I. Seed yield (kg/ha), oil yield (kg/ha) and harvest index (%) of hybrid sunflower as influenced by ratios and levels of N, P and K (Rainy season of 1999, 2000 and Mean*).

Treatments								Seed yield (kg/ha)			Oil yield (kg/ha)			Harvest index (%)		
Sl. No.	Nutrient ratios				Quantity of nutrients (kg/ha)			1999	2000	Mean*	1999	2000	Mean*	1999	2000	Mean*
	N	P2O5	K2O	N/P	N	P2O5	K2O									
T1	0.00	0.00	1.00	0.00	0	0	60	1949	768	**1358**	705	277	**491**	29.04	20.18	**24.61**
T2	1.00	1.25	1.00	0.80	60	75	60	2800	1215	**2007**	1099	477	**788**	31.58	26.0	**28.99**
T3	1.00	1.50	1.00	0.67	60	90	60	2761	1051	**1906**	1122	426	**774**	32.29	25.50	**28.89**
T4	1.50	1.25	1.00	1.20	90	75	60	3009	1278	**2143**	1179	500	**840**	32.96	28.32	**30.64**
T5	1.50	1.50	1.00	1.00	90	90	60	2875	1487	**2181**	1174	606	**890**	31.82	31.24	**31.53**
T6	2.00	1.00	1.00	2.00	120	60	60	3188	1568	**2378**	1186	583	**885**	31.37	32.45	**31.91**
T7	2.00	1.25	1.00	1.60	120	75	60	3397	1386	**2391**	1333	543	**938**	32.62	29.62	**31.12**
T8	2.00	1.50	1.00	1.30	120	90	60	3220	1503	**2362**	1314	612	**963**	31.41	31.96	**31.69**
T9	2.00	2.00	1.00	1.00	120	120	60	3554	1553	**2553**	1481	645	**1063**	34.30	32.59	**33.45**
Mean								**2972**	**1312**	**2142**	**1177**	**519**	**848**	**31.93**	**28.70**	**30.31**
S.E ±								86.31	15.58	43.85	36.90	7.14	18.79	0.009	0.008	0.016
LSD (p=0.05)								252	45	125	108	21	53	0.02	0.03	0.05

Mean*: Pooled data of two years (Rainy seasons of 1999 and 2000).

free. The observations on head weight, seed weight/plant, 1000-seed weight, seed yield and harvest index, and oil yield were recorded.

Results and Discussion

Effect of Rainfall on the Productivity of Sunflower. In India, sunflower is generally grown under assured rainfall/protective irrigation in all types of soils during the monsoon (rainy) season and under receding soil moisture conditions in the post-monsoon (post-rainy) season in Vertisols; and under irrigated conditions in all types of soils in the summer season. It is generally observed that the productivity of sunflower under rainfed farming situations is very much affected/fluctuates by the amount and distribution of rainfall during its different growth stages particularly during the flowering to seed filling stage.

In the present investigation (Experiment I), with similar production management practices during 1999 and 2000 (rainy season), the seed yields of sunflower were quite high (1,949 to 3,554 kg/ha) in 1999 compared to 2000 (768 to 1,568 kg/ha). The higher seed yields during 1999 were due to favourable weather conditions prevailing during the crop growth period (Tables 2 to 4). The amount of rainfall received during the crop growth period of 1999 and 2000 was 166.2 mm (in 17 rainy days) and 230.3 mm (in 17 rainy days), respectively. Despite low rainfall, its distribution during the crop growth period was optimum during 1999 (Table 2). The crop in 1999 received 117.2 mm rainfall (in 10 rainy days) during the pre-flowering stage (sowing to 45 DAS) followed by rain-free days during the flowering stage and 49.00 mm rainfall (in 7 rainy days) after the flowering and pollination (66 DAS to maturity). On the contrary, in 2000, the crop received 59.3 mm rainfall (in 6 rainy days) during the pre-flowering period, 75.3 mm rainfall (in 4 rainy days) during the flowering and 95.7 mm rainfall (in 7 rainy days) during the seed filling to maturity stage. Although the crop raised in 1999 experienced rain-free days during the flowering and pollination period, the lower amount of evaporation (32.1 mm), higher mean relative humidity (86.4 mm) and lower mean maximum (27C) and mean minimum (20C) temperatures appeared to have favoured increased pollination and seed set which ultimately resulted in higher seed yield/plant and increased seed yields. In contrast, the crop grown in the rainy season of 2000 experienced unfavourable weather conditions (high rainfall during flowering and pollination stage), which resulted in reduced seed set affecting the seed yield. This may be one of the core reasons why the productivity of sunflower fluctuates greatly under rainfed farming situation in India.

Experiment 1. The seed yield of sunflower increased with increasing the N/P fertilizer ratio from 0.67 to 2.00 in both years (rainy seasons of 1999 and 2000) (Table 6). The treatments receiving N/P fertilizer ratios of 1.0 or >1.0 produced higher seed yield and higher oil yield as compared to the treatments receiving an N/P fertilizer ratio of either <1.0 (0.67 and 0.80) or an N/P fertilizer ratio of 0.0 (no N and P fertilizer with 60 kg K2O/ha). The extent of increase in seed and oil yield due to an increase in the N/P fertilizer ratio from 0.67 to 2.0 was low in 2000 compared to 1999. During 1999, the treatment receiving an N/P fertilizer ratio of 1.60 with fertilizer levels of 120 kg N, 75 kg P2O5 and 60 kg K2O/ha produced higher seed yield (3,397 kg/ha) and higher oil yield (1,333 kg/ha), while in 2000, the treatment receiving an N/P fertilizer ratio of 2.00 with fertilizer levels of 120 kg N, 60 kg P2O5 and 60 kg K2O/ha produced higher seed yield (1,568 kg/ha). In both the years maximum seed yields (3,554 and 1,553 kg/ha) and maximum oil yields (1481 and 645 kg/ha)

were obtained with fertilizer management practices involving the application of N and P in an N/P ratio of 1.00 with a fertilizer dose of 120 kg N, 120 kg P2O5 and 60 kg K2O/ha.

Pooled data of two years (Mean of 1999 and 2000) also indicated that application of N and P fertilizer in an N/P ratio of 1.0 with fertilizer levels of 120 kg N, 120 kg P2O5 and 60 kg K2O/ha produced maximum seed and oil yields (2,553 and 1,063 kg/ha, respectively) over the rest of the treatments. On the contrary, the recommended dose of NPK (T2 and T3) carrying N/P fertilizer ratio of <1.00 (0.67 with 60 kg N, 75 kg P2O5 and 60 kg K2O/ha or 0.80 with 60 kg N, 90 kg P2O5 and 60 kg K2O/ha) produced lower seed and oil yields (Table 6).

Head weight and seed weight/plant; 1000-seed weight and harvest indexes were favourably influenced by the fertilizer management practices involving application of N and P fertilizers in N/P ratios of either 1.0 or >1.0 as compared to recommended fertilizer management practices with an N/P fertilizer ratio of < 1.0 (Tables 5 and 6).

Experiment II. The studies on the response of a sunflower hybrid to ratios and the levels of N and P at varied rates of K fertilizer during 2000 indicated increased seed yield by increasing an N/P fertilizer ratio from 0.67 to 1.6 with a K level of either at 45 kg/ha or at 60 kg K2O/ha (Table 7). The fertilizer management practices involving the application of N and P in N/P fertilizer ratios of 1.00 and >1.00 either with lower (45 kg K2O/ha) or with higher (60 kg K2O/ha) rates of K fertilizer resulted in higher seed (1,479 to 1,865 kg/ha) and oil yield (603 to 732 kg/ha). Among the treatments receiving an N/P fertilizer ratio of >1.00, the treatment with an N/P fertilizer ratio of 1.60 either with higher or with lower rates of K fertilizer (90 kg N, 56.25 kg P2O5 and 45 kg K2O/ha or 120 kg N, 75 kg P2O5 and 60 kg K2O/ha) produced the highest seed and oil yield compared to other treatments receiving N/P fertilizer ratios of 1.20 and 1.30 (Table 7).

The seed and oil yield of sunflower tended to increase with increased rates of K fertilizer from 45 to 65 kg K2O/ha in addition to the application of N and P applied in N/P fertilizer ratios of 1.0 or > 1.0 (1.20, 1.30 and 1.60). Results obtained in this experiment also indicate that sunflower showed greater response to the application of a higher proportion of N fertilizer than P fertilizer. It is evident that the treatment with recommended rates of NPK (60 kg N, 75 kg P2O5 and 60 kg K2O/ha or 60 kg N, 90 kg P2O5 and 60 kg 60 kg K2O/ha) (T9 and T10) resulted in low seed and oil yield compared to the other treatments (Table 7).

The yield components such as head weight/plant, seed weight/plant, 1000-seed weight and harvest index were favourably influenced by the fertilizer management practices involving application of N and P fertilizers in N/P fertilizer ratios of 1.0 or >1.0 in addition to K fertilizer (45 or 60 kg K2O/ha) compared to an N/P fertilizer ratio of <1.00 (0.67 and 0.80) (Table 7).

Conclusions

Field studies conducted on medium Vertisols during the monsoon (rainy) season under rainfed farming situations indicated that higher seed and oil yields of a hybrid sunflower (cv. DSH 1) were realized with the fertilizer management practices involving application of N and P in an N/P fertilizer ratio of either 1.0 or >1.0 (1.20, 1.30, 1.60) in addition to K fertilization either at 60 kg K2O/ha or at 45 kg K2O/ha. The fertilizer management practices involving application of N and P either in an N/P fertilizer ratio of 1.00 with a fertilizer dose of 120 kg N, 75 kg P2O5 and 60 kg K2O/ha or in an N/P fertilizer ratio of 1.60 with a fertilizer level of

Table 7. Experiment II. Head weight (g), seed weight (g/plant), 1000-seed weight (g), seed yield (kg/ha), oil yield (kg/ha) and harvest index (%) of hybrid sunflower as influenced by ratios and levels of N, P and K (2000#).

Sl. No.	Treatments							Head weight g)	Seed weight (g/plant)	1000-Seed weight (g)	Seed yield (kg/ha)	Oil yield (kg/ha)	Harvest index (%)
	Nutrient ratios				Quantity of nutrients (kg/ha)								
	N	P2O5	K2O	N/P	N	P2O5	K2O						
T1	2.00	2.00	1.00	1.00	90.00	90.00	45.00	69.03	24.719	36.66	1479	603	28.50
T2	2.00	2.00	1.00	1.00	120.00	120.00	60.00	76.69	28.625	37.00	1646	682	29.70
T3	2.00	1.50	1.00	1.30	90.00	67.50	45.00	63.72	23.888	36.50	1357	530	29.30
T4	2.00	1.50	1.00	1.30	120.00	90.00	60.00	71.00	26.445	37.33	1521	620	29.60
T5	2.00	1.25	1.00	1.60	90.00	56.25	45.00	83.20	30.405	38.00	1726	632	30.00
T6	2.00	1.25	1.00	1.60	120.00	75.00	60.00	89.81	32.866	38.00	1865	732	30.01
T7	1.50	1.25	1.00	1.20	67.50	56.25	45.00	80.67	29.826	36.83	1681	608	29.90
T8	1.50	1.25	1.00	1.20	90.00	75.00	60.00	77.37	28.570	36.66	1626	637	29.70
T9	1.00	1.25	1.00	080	60.00	75.00	60.00	61.43	22.629	36.00	1319	517	29.10
T10	1.00	1.50	1.00	0.67	60.00	90.00	60.00	60.78	22.191	34.33	1305	530	29.00
Mean								**73.37**	**27.016**	**36.73**	**1552**	**609**	**29.50**
S.E ±								2.85	1.047	0.980	60	24	0.003
LSD (p=0.05)								8.45	3.111	NS	178	24	0.009

- Rainy season of 2000; **NS** – Non-significant.

90 kg N, 56.25 P2O5 and 45 K2O/ha was advantageous for higher productivity. Further, optimum rainfall during the first 45 days after sowing (DAS) and during seed set (seed filling to maturity) coupled with rain-free days with high relative humidity, low evaporation, low mean minimum and mean maximum temperatures during the period of flowering and pollination had favourable effects on seed and oil yield of sunflower.

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