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EFFECTS OF DIFFERENT PHOSPHORUS RATE AND APPLICATION TIME ON SUNFLOWER SEED YIELD AND YIELD COMPONENTS

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SUMMARY

This research was carried out to determine the effects of six phosphorus (P_2O_5) rates and two application time on sunflower *(Helianthus annuus L.)* seed yield and yield components. The sunflower hybrid used in the experiments was Edirne-87. The research lasted for two years, 1991 and 1992, and it was conducted at the Thrace Agricultural Research Institute in Edirne, Turkey.

The experiments were established in a split plot arrangement in randomized complete block design in three replicates. Phosphorus application times were used as main plots. These were autumn and spring time applications. Six rates of phosphorus were used as sub-plots: 0, 20, 40, 60, 80, and 100 kg/ha P_2O_5.

Mean values of time to flowering, time to physiological maturity, plant height, head diameter, seed yield/ha, 1000 seed weight, oil content, and oil yield were determined in each plot and analyzed using ANOVA.

According to the two-year results of this research, relationship between sunflower grain yield and phosphorus rates was found significant (R=0.922**) in Edirne conditions. Phosphorus rates can be expressed by following regression equation Y: $1321 + 10.39\,X - 0.066\,X^2$. Based on 1996 phosphorus fertilizer and sunflower crop prices for optimum economical sunflower production it was recommended that the application rate of phosphorus should be 70 kg/ha in Edirne conditions.

Key words: Sunflower, phosphorus, yield, yield components.

INTRODUCTION

Sunflower *(Helianthus annuus L.)* is a most important edible oil plant in Turkey. The majority of Turkey's sunflower production area is located in Thrace - Marmara (73%) region. This crop is also grown in Central Anatolia (13%), the Black Sea coast (10%), the Aegean coast (3%), and the South East Anotolia (1%).

In Turkey, first sunflower experiments were conducted in 1920's and the crop reached 100,000 ha production area by 1946. The significant culture of this crop commenced about 1943 and by 1956 it had reached 168,000 ha. This high point was followed by a decline to 81,000 ha in 1962, largely because of the disease caused by broomrape *(Orobanche cumana* Wallr.) which is a seed - producing root parasite. Resistance to this parasite was introduced with Russian cultivars VNIIMK 1646 and VNIIMK 8931. These cultivars also had much higher oil content than those previously grown. These new cultivars led to a rapid recovery in planting to 495,000 ha in 1972. After 1980's sunflower hybrids were started to be planted and an almost explosive increase in planting area, to 600,000 ha, occured in 1990's. Sunflower provideds 45.0% of edible oil in Turkey.

Besides nitrogen deficiency, phosphorus deficiency is generally the most limiting nutritional disorder to sunflower production. Significant responses to phosphorus fertilization have been obtained on both alkaline and acid soils. Many research results suggest that phosphorus deficiency in sunflower is wide-spread, and that significant yield responses to applied phosphorus may occur. The study of phosphorus nutrition has not received as much research attention as it has in other crops (Blamey *et al.*, 1987).

Thrace region, in the northwest of Turkey, has great agricultural production potential arising out of its ecological and climatic conditions, soil properties and rich crop pattern. The cultivated sunflower is among the four most important annual crops in the Thrace region which are grown for edible oil, the others being wheat, rice, and sugarbeet. Turkey vegetable oil consumption is increasing per year due to population increase. To satisfy this increasing vegetable oil consumption, Turkish farmers should get more yield from per hectare using high yielding hybrids, good soil tillage, irrigation, pest management, rotation and fertilization. Appropriate fertilization is especially important for getting high yield per hectare. In order to do the adequate fertilization, soil analyses tests and field fertilizer experiments need to be introduced in sunflower production.

Total sunflower plant phosphate uptake is 0.30-0.35 g/plant according to Merrien *et al.* (1988), while crop uptake is roughly 1.5-2.3 of $P_2 0_5$/quintal of seed, according to Bonary *et al.* (1992). Sunflower plant is generally responsive to phosphorus fertilizer when the Olsen soil test level is less than 90 kg/ha. It is possible to construct phosphorus recommendations that satisfy crop removal requirements and slowly build the soil test levels a bit above this "critical level" (Blamey *et al.*, 1987; Mohammed and Quresh, 1991).

The objective of this research was to determine effects of different rates of phosphorus and application time on sunflower seed yield and yield components in Edirne, Turkey, conditions.

MATERIALS AND METHODS

This research was conducted over two seasons during 1991 and 1992 at the Thrace Agricultural Research Institute which is located in the European side

Table 1: Main properties of soil used in the field experimets

Year	Depth (cm)	pH	$CaCO_3$ (%)	Organic matter (%)	P_2O_5 available (kg/ha)	K_2O available (kg/ha)	Total salt (%)	Sand (%)	Silt (%)	Clay (%)	Texture class	Field ca-pa. (%)	Wilting point (%)
1991	0-30	7.19	0.25	0.9	76	630	0.043	45.5	29.9	24.6	Sandy	20.1	9.7
1992	0-30	5.74	0.14	1.2	68	390	0.035	40.3	32.2	27.5	Silty Clay	20.6	12.4

Table 2: Mean comparisons between yield and yield components on six phosphorus levels in two application times based on combined data of 1991 and 1992

No	P_2O_5 Application time	P_2O_5 levels (kg/ha)	Seed yield kg/ha	Oil in seed (%)	Oil yield (%)	1000 Seed weight (g)	Test weight (kg/Hl)	Seed hull weight (%)	Plant height (cm)	Head diameter (cm)	Flowering time (day)	Physiol. maturity (day)
1	Fall	0	1,412 et	40.0	565 et	42.5	44.3 be	28.4	150.5	14.0	61.7	95.3
2	Fall	20	1,545 de	40.0	618 de	43.2	45.0 ab	28.4	157.2	15.7	61.7	94.8
3	Fall	40	1,612 bed	39.9	643 bed	43.9	45.4 a	28.8	158.5	14.8	61.7	95.2
4	Fall	60	1,593 ode	39.9	636 td	43.8	45.2 ab	28.4	159.0	14.8	61.7	95.3
5	Fall	80	1,819 a	40.2	731 a	45.0	45.3 ab	28.8	159.0	15.5	61.7	95.0
6	Fall	100	1,731 abc	40.3	698 ab	45.4	45.3 ab	28.9	159.3	15.3	61.7	95.3
7	Spring	0	1,354 f	39.6	536 f	43.4	44.4 bc	28.8	150.3	14.8	62.0	95.0
8	Spring	20	1,519 def	40.6	617 de	43.4	44.7 ab	28.6	160.7	15.7	61.7	95.3
9	Spring	40	1,454 def	40.0	582 def	45.1	44.9 ab	28.7	158.5	15.5	61.5	95.7
10	Spring	60	1,610 bed	40.4	650 de	43.8	44.7 ab	28.5	158.2	15.8	61.5	95.0
11	Spring		1,781 ab	40.1	714 a	44.9	44.7 ab	28.0	159.7	15.0	61.7	95.2
12	Spring	100	1,750 abc	39.3	688 abc	43.5	44.9 ab	28.3	161.3	15.2	61.5	94.8
	Mean		1,598	40.0	640	44.2	44.9	28.6	157.6	15.2	61.7	95.2
	C.V. (%)		9.8	2.2	8.2	4.3	2.3	2.6	2.5	6.5	0.6	0.7

(Thrace) of Turkey. Main properties of soil used in the field experiment are presented in Table 1. The experiment was set up in a split plot arrangement in RCBD in three replicates. Phosphorus application times were used as main plots. These were fall and spring time applications of phosphorus. The sub plots consisted of six levels of phosphorus, 0, 20, 40, 60, 80, and 100 kg/ha. Phosphorus sources were triple super phosphate (42-44% P_2O_5). In the experiment, with the exception of phosphorus, the level of the nitrogen remained constant at 80 kg N/ha.

All the fertilizer required for the experiment was broadcast by hand at preplanting to all plots and mixed into the soil. The trials were carried out in rotation with wheat crop.

The intra-row spacing was 30 cm, in rows spaced 70 cm apart. Plot size at planting 3.5 x 10.5 m = 36.75 m^2 (5 rows), and plot size at harvest 2.10 x 9.80 m = 20.58 m^2 (3 rows). The experiments were sown in the second half of April in both years. The seeds were overplanted per hill and thinned to one plant per hill three weeks after sowing. The experiments were not irrigated but received rain during growing season. Weed control was accomplished by using both chemicals and cultural practices. A herbicide EPTC (S-ethyl dipropyl carbamathioate) was used at a rate of 4,500 cc per hectare.

Mean values of time to flowering, time to physiological maturity, plant height, head diameter, seed yield/ha, 1000 seed weight, seed hull rate, oil content, and oil yield were determined in each plot and analyzed using ANOVA. Correlation coefficients were calculated between all characteristics. Regression analysis was applied to find the relationships between fertilizer and seed yield (Little and Hills, 1978; Yurtsever, 1984; Russel, 1986).

RESULTS AND DISCUSSION

The effect of increasing levels of phosphorus fertilizer on seed yield and yield components in two application time during 1991 and 1992 is presented in Table 2. Phosphorus levels had a significant effect ($P<0.01$) on seed yield and oil yield (Table 2). Relationship were found significant ($R=0.922^{**}$). This relationship between seed yield and phosphorus rates can be expressed by the following regression equation: $Y= 1{,}321.0 + 10.9 X - 0.066 X^2$ (Figure 1). Economical phosphorus rate for economic optimum seed yield calculated from regression equations as a response of fertilizer is given in Table 3. Maximum seed yield (1,730 kg/ha) was obtained with 80 kg/ha phosphorus rate, however seed yield at economic optimum level (1,725 kg/ha) was obtained with 70 kg/ha phosphorus rates. Comparable results were reported by Radenović and Todorić (1976), Usman *et al.* (1980), Girase *et al.* (1977), Süzer *et al.* (1994), Süzer and Uludere (1997). Relationship between sunflower seed yield and phosphorus rates is given in Figure 1. Economical phosphorus rates for economic optimum seed yield calculated from regression equations as a response of fertilizer is given in Table 3. A correlation coefficient matrix between agronomic traits is given in Table 2.

Table 3: Economical phosphorus rates with marginal analysis method for hybrid sunflower Edirne-87

Amount of fertilizer	Marginal fertilizer rates	Triple super phosphorus (42-44% P_2O_5 kg/ha)	Cost of margina fertilizer (US $/ha)	Total crop (kg/ha)	Amount of marginal crop (kg/ha)	Marginal crop income (US $ /ha)
0	0	0	0	1,321	0	0
10	10	23	4.14	1,418	97	33.95
20	10	23	4.14	1,502	84	29.40
30	10	23	4.14	1,573	71	24.85
40	10	23	4.14	1,631	58	20.30
50	10	23	4.14	1,676	45	15.75
60	10	23	4.14	1,707	31	10.85
70	10	23	4.14	1,725	18	6.30
80	10	23	4.14	1,730	5	1.75
90	10	23	4.14	1,722	-8	-2.80
100	10	23	4.14	1,730	-22	-7.70

Table 4: Correlation coefficient between yield and yield components based on mean values of 1991 and 1992

Yield component	1	2	3	4	5	6	7	8	9	10	11
1. P_2O_5 levels (kg/ha)	1.000										
2. Seed yield (kg/ha)	0.904**	1.000									
3. Oil in seed (%)	-0.037	0.087	1.000								
4.Oil yield (kg /ha)	0.890**	0.996**	0.179	1.000							
5. 1000 seed weight (g)	0.665*	0.572*	0.260	0.593**	1.000						
6. Test weight (kg/hl)	0.572*	0.599*	0.073	0.600*	0.552	1.000					
7. Seed hull rate (%)	-0.116	-0.192	0.173	-0.171	0_273	0.365	1.000				
8. Plant height (cm)	0.725**	0.720**	0.233	0.731**	0.507	0.630*	-0.150	1.000			
9. Head diameter (cm)	0.298	0.300	0.430	0.334	0.372	0.307	0.148	0.619*	1.000		
10. Time to flowering	-0.474	-0.348	-0_.103	-0.349	-0.199	-0.216	0.265	-0.607*	-0.399	1.000	
11. Time to phys. mat.	-0.131	-0.294	0.344	-0.254	0.372	0.005	0.208	0.104	-0.181	-0.150	1.000

*,**: Significant at 0.05 and 0.01 probability levels, respectively

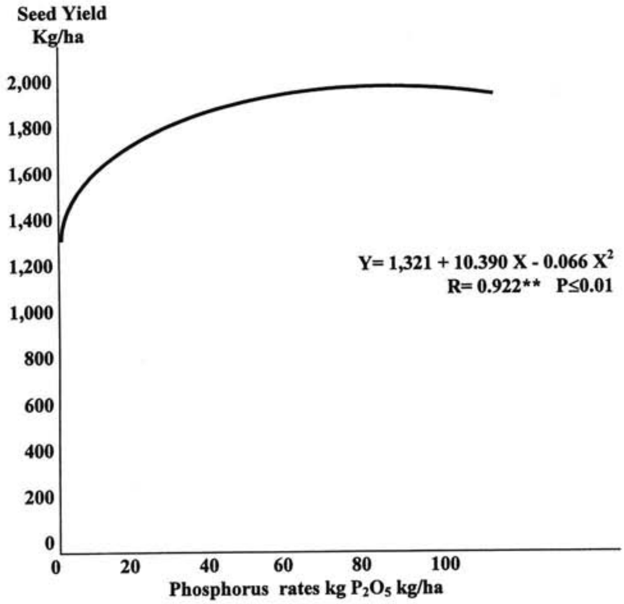

Figure 1: Relationships beetwen sunflower seed yield and phosphorus rates

As seen in Table 2, phosphorus rates had a significant effect ($P<0.01$) on oil yield. This effect is due to seed yield increase by applying increasing phosphorus rates. On the other hand, phosphorus application time only had a significant effect ($P<0.05$) on test weight of seed. A trend toward increased 1000 seed weight with increased phosphorus rates was also evident in Table 2 but statistically not significant. Both phosphorus application times and six rates of phosphorus did not have a significant effect on the other yield components. Similar results were reported by Süzer *et al.* (1994), Süzer and Uludere (1997).

Table 4 indicates that there were significant positive correlations between phosphorus rates, and seed yield, oil yield, 1000 seed weight, test weight, plant height ($r = 0.904^{**}$, $r = 0.890$, $r = 0.665^{*}$, $r = 0.572^{*}$, and 0.725^{**}, respectively). Comparable results were reported by Radenović and Todorić (1976), Mohammed and Quresh (1991), Süzer *et al.* (1994).

CONCLUSIONS

Four main conclusions can be drawn from the results of this 2-year experiment:

1. Phosphorus had a significant effect on sunflower seed yield and oil yield.
2. Phosphorus application time only had a significant effect on sunflower test weight.

3. Regression of phosphorus rates with seed yield and oil yield may be fitted to the quadratic equation.
4. Consequently, according to the two-year results of this research conducted in Edirne conditions, the relationship between sunflower grain yield and phosphorus rates was found significant (R=0.922**). Phosphorus rates can be expressed by the following regression equation $Y=1321+10.39X-0.066X^2$. Based on 1996 phosphorus fertilizer and sunflower crop prices for optimum economical sunflower production it was recommended that the application rate of phosphorus should be 70 kg/ha in Edirne, Turkey conditions.

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EFECTO DE DIFERENTES DOSIS DE FÓSFORO Y TIEMPO DE APLICACIÓN EN EL RENDIMIENTO DE GIRASOL Y COMPONENTES DE RENDIMIENTO

RESUMEN

Esta investigación se llevó a cabo para determinar los efectos de seis niveles de fósforo (P_2O_5) y dos fechas de aplicación en los componentes de rendimiento del girasol (*Helianthus annuus* L.). El híbrido de girasol utilizado en los experimentos fué Edirne 87. La investigación duró dos años, 1991. y 1992., y fué conducida en el Instituto de Investigaciones Agrarias de Tracia en Edirne, Turquía. Los experimentos fueron establecidos en un diseño de parcelas divididas en bloques al azar con tres repeticiones. La fecha de aplicación de fósforo fueron utilizadas como parcela principal. Estas, fueron otoño y primavera. Seis dosis de fósforo fueron utilizadas como subparcelas: 0, 20, 40, 60, 80 y 100 kg/ha de P_2O_5. Los valores medios de la fecha de floración, tiempo a maduración, altura de planta, diámetro de capitulo, rendimiento por hectárea, peso de 1000 semillas, contenido de aceite y rendimiento de semilla fueron determinadas en cada parcela y analizados utilizando ANOVA. De acuerdo con los resultados de dos años en las condiciones de Edirne, la relación entre el rendimiento en grano del girasol y los niveles de fósforo fueron signitificativos ($R=0.922$). Los niveles de fósforo pueden ser expresados siguiendo la ecuación de regresión $Y=1321+10.39X - 0.066 X^2$. En base a los precios del cultivo y del fósforo en 1996. para una producción económica óptima del girasol fué recomendado una dosis de fósforo de 70 kg/ha en las condiciones de Edirne.

EFFETS DE DIFFÉRENTES DOSES ET DATES D'APPLICATION DE PHOSPHORE SUR LE RENDEMENT DU TOURNESOL ET SES COMPOSANTES

RÉSUMÉ

Cette recherche a été conduite pour déterminer les effets de six doses de phosphore (P_2O_5) et de deux dates d'application sur les composantes du rendement du tournesol (*Helianthus annuus* L.). L'étude a duré deux ans, 1991., 1992. et a été menée à l'Institut de Recherche Agricole de Thrace, Edirne, en Turquie. Les expériences sont établies selon un dispositif split-plot avec randomisation complète des blocs en trois répétitions. Les dates d'application du phosphore constituaient les parcelles principales. Les applications ont eu lieu en automne et au printemps. Six doses de phosphore (P_2O_5): 0, 20, 40, 60, 80 et 100 kg/ha, ont été utilisées en sous parcelles. Les valeurs moyennes de durée semis floraison, de maturité physiologique, de taille, du diamètre de capitule, de production grainière, de teneur en huile, du poids de 1000 grains, de teneur en huile et du rendement en huile ont été détérminées pour chaque parcelle et analysées par ANOVA. Les résultats de cette étude de deux années dans les conditions d'Edirne, montrent une relation significative ($R=0.922^{**}$) entre le rendement en grains et la dose de phosphore. Les doses de phosphore peuvent être exprimées selon l'équation de régression $Y=1321+10.39X-0.066X^2$. Compte tenu du coût de la fertilisation phosphorique de 1996 et du prix de la graine de tournesol il a est recommandé l'application d'une dose de phosphore de 70 kg/ha pour une production économique optimale de tournesol, dans les conditions d'Edirne.