

Effects of Phosphorus and Nitrogen Applications on Sesame (*Sesamum indicum* L.) Yield in Semi-Arid Climatic Conditions

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Abstract

The aim of this study is to determine the nitrogen and phosphate need of indigenous sesame (*Sesamum indicum* L.) variety as the second crop in Harran Plain conditions. This study was carried out in research field of GAP Training Extension and Research Center. This study which is designed according to "split plot" with three replications is researched effects of 5 different nitrogen and 4 different phosphate doses on sesame yield.

As the result of this study, two years mean sesame seed yield changed between 116.0 kg/da – 166.5 kg/da. The first year, the lowest sesame yield of 100.7 kg/da with the application of 12 kg P₂O₅/da - 16 kg N/da was obtained and the highest yield of 176.7 kg/da with the application of 8 kg P₂O₅/da - 0 kg N/da was obtained. The second year, the lowest sesame yield of 98,39 kg/da with the application of 4 kg P₂O₅/da - 12 kg N/da was obtained and the highest yield of 162,4 kg/da with the application 8 kg P₂O₅ /da - 4 kg N/da was obtained. The negative interaction on yield between the phosphorus and nitrogen application was found. Negative effects on yield were observed when the amount of both the phosphate and nitrogen simultaneously increased or decreased. However, the yield has increased when the amount of one nutrition was increased and the other was stabled.

Keywords: Fertilizer, Harran Plain, Secondary Crop, Sesame, Yield

1. Introduction

The need for foodstuffs increases in parallel with the growing population in the world. The oil which is obtained from the animal and plant sources has an important place in human nutrition.

The provinces in the GAP region have a great potential to increase production areas of oil crops. The sesame seed contains 40-60 % oil. Sesame oil is very resistant to degradation due to its content of antioxidant substances which are "sesamol and sesamol". Because of this feature, it used in the production of potato chips as well as its usage as margarine and liquid oil. It is important to apply balanced nitrogen and phosphorus to the soil which is poor in nutrients. NXP interaction synergistic on the non-legume plants. However, the effect of the interaction is mostly determined as negative on the oil-seed crops. The greatness and importance of NxP interactions depend on the type of plant, fertility status of the nitrogen and phosphorus in soil and climate conditions. The greatness of this interaction is very obvious when the soil is shortage of nitrogen and phosphorus and a high level yield is concerned (Hakerlerler, 2000).

The some studies are shown below on the fertilization of sesame

Vijay et al. (1987), The trial done in a fertilizer application of 4 kg/da N in the sesame variety of C-6 increased the yield from 73 kg/da to 98 kg/da, seed olive rate from 48.1% to 56.3% and the protein rate

from 19.4% to 20.9% in Gwalior, India. It was reported that an increase in the rate of nitrogen (up to 12 kg/da) applied had positive effect on the rate of grain protein but no effect to the other parameters.

Subramanian et al. (1979), It was reported that the highest yield in TMV. 3 variety was obtained in application of 3 kg N/da fertilizer in trial of 0, 3 and 4.5 kg N/da in summer season and application of 4.5 kg N/da fertilizer in monsoon season. The seed per capsule, capsules per plant and the number of branches per plant were increased by the applications of the N.

Sharma et al. (1995), 0-6 kg N/kg was applied to the variety of N-32 sesame in different periods in Medhya Pradesh district of Japalpur, India between 1990-91. The highest seed yield was obtained from the application of 4 kg N/da 50% of which was applied 15 days after plantation and the other 50% 40 days after plantation.

Prakasha and Tidmmegovde, (1992), Fertilizer applied with doses of the 0, 2, 4, 6 kg N/da and 2.5, 5 kg P₂O₅/da to the local variety of Kanakapura in Karnataka region of India in 1987. The grain yield increased from 40 kg/da with 0 kg N/da to 61 kg /da with 6 kg N/da and from 50 kg/da with 2.5 kg P₂O₅ /da to 53 kg/da with 5 kg P₂O₅ /da.

Ramakrishnan et al. (1994), It was reported that the 0-9 kg N/da was applied to five varieties of Sesame in Vrindhachalam(Tamil Nedum) region of India in 1986. Seed yield increased with application of 3.6 kg N/da. The rate of seed oil increased with the applications of nitrogen. Seed yield was positively associated with number of branches per plant, number of capsule per plant, seed number per capsule and 1000 seed weight. The number of capsules per plant and seed number per capsule had a positive effect on yield.

Awad et al. (1996), It was reported that the 7.15, 10.66, 14.3 kg N/da and 0, 7.15, 10.66 kg P₂O₅/da and 0, 5.7 kg K₂O/da fertilizer was applied to the Giza variety of sesame in Ismailia region of Egypt between 1995-96. The highest seed and oil yields were obtained from the application of 10.66 kg N/da + 10.66 kg P₂O₅/da. Seed oil ratio was not affected by the applications of fertilizer.

Balasubramaniyan (1996), Two sesame genotypes planted in densities of 3.0, 4.5 and 6.0 x10⁵ plants/ha during the summer with application of 0, 6 and 9 kg N/da in Waridhachalam(Tamil Nedu) region of India between 1992-93. The yield of VS-350 genotype(71.1 kg/da) was more higher than the yield of TMV-3 variety(63.6 kg/da). Plant density did not affect the yield but 3 kg N/da did.

Tiwari and Namdeo, (1997), A trial was conducted with application of nitrogen doses of 0, 3, 6 and 9 kg/da and different sowing densities in four sesame varieties (TKG 9, TKG 21, JLSC 8 and JT 7) in Madhya Pradesh district in Tikamgrah of India between 1990-91. The highest yield, 81 kg/da was obtained from the application of 9 kg/da nitrogen. The highest seed oil ratio was obtained by application of 0 and 3 kg N/da in both years. The higher the nitrogen applied the oil ratio declined. Seed protein percentage increased in accordance with the amount of fertilizer applied.

Ashfaq et al. (2001), Different rates of nitrogen and phosphorus(0, 4, 8 and 12 kg/da) were applied to the two genotypes of sesame(92001 and TS3) in Faisalabad of Pakistan between 1996-97. It was reported that stalk and seed yield increased significantly as well as oil and protein rate with the application of 12 kg N/da and 4 kg of P₂O₅/da.

Objective of this study was to determine the appropriate levels of nitrogen and phosphorus for obtaining a high seed yield from the cultivation of second crop sesame in Harran Plain conditions.

2. Materials and Methods

In this research the local sesame(village variety) population was used as material which were promising lines as a result of studies previously done by Gür et al., (1998) in the region. The research was carried out in Tatlica station of GAP Training Extension and Research Institute which was called Harran Agricultural Research Institute previously located in south west of Harran Plain.

The maximum temperature was 46.5 degree in July and the lowest temperature was -12.4 in February according to average of multi years. The average relative humidity is 61.22% according to meteorological average of multi years. The relative humidity is 46.23% in July(Anonymous. 2002).

The trials were established as a split plot design with three replications in growing seasons of sesame between 2001- 2002. The main plots consist of phosphorus and sub-plots consist of nitrogen applications. Fertilizer was applied completely by hand during cultivation at a level of 0-4-8-12 kg /da P₂O₅ for phosphorus and 0-4-8-12-16 kg/da N for nitrogen. Treflan chemical was applied to control the weed before planting as 150 cc da⁻¹ d. Plantings were done by trial drill into the dry soil on the rows with 70 cm distance between them on June 22 in both years. It was irrigated six times that included emergence irrigation during the growing season. The thinning was done in 20 cm intervals on rows 20 - 25 days after emergence.

3. Results and Discussion

Table 1a. The groups formed, the values of the protein ratio and oil yield (kg da⁻¹), oil ratio, average sesame grain yield (kg da⁻¹) of second crop sesame plantation which obtained under application of different doses of phosphorus and nitrogen between 2001-2002.

App	Yield(kg/da)		Oil Ratio(%)		Protein Ratio(%)		Oil Yield(kg/da)	
	2001	2002	2001	2002	2001	2002	2001	2002
0-0	117.5 d-f	121.0 e-g	48.03 a-c	50.14 ab	21.28 c-f	22.79 ab	56.66 c-e	60.71 c-e
0-4	123.2 d-f	108.7 fg	46.41 a-c	47.12 bc	21.54 b-f	21.25 e	57.40 c-e	51.34 ef
0-8	124.0 d-f	130.2 b-f	48.20 a-c	49.89 ab	21.22 d-f	21.60 de	60.08 c-e	65.14 b-d
0-12	116.0 d-f	124.0 d-g	47.23 a-c	48.65 a-c	21.60 b-f	21.62 c-e	54.80 c-e	60.24 d-f
0-16	120.5 d-f	151.5 a-c	50.91 a	48.79 a-c	20.78 ef	22.46 b-d	61.43 b-e	73.77 a-d
4-0	131.1 c-f	127.8 c-f	47.29 a-c	47.25 a-c	21.52 c-f	21.5 de	62.05 b-e	60.36 de
4-4	137.0 b-f	153.0 a-c	48.18 a-c	49.88 ab	21.73 b-e	22.85 ab	66.11 a-d	76.35 ab
4-8	137.0 b-f	148.3 a-d	47.26 a-c	49.28 a-c	22.54 a-c	23.02 ab	55.87 c-e	73.38 a-d
4-12	151.4 a-d	98.39 g	46.86 a-c	47.36 a-c	22.48 a-d	22.48 b-d	70.40 a-d	46.64 f
4-16	161.2 a-c	154.9 ab	44.96 bc	47.81 a-c	23.15 a	22.64 a-d	72.41 a-c	74.25 a-c
8-0	176.7 a	156.3 ab	46.96 a-c	45.87 c	22.57 a-c	23.17 ab	83.00 a	71.86 a-d
8-4	167.8 ab	162.4 a	46.96 a-c	49.54 ab	22.83 ab	22.93 ab	79.01 ab	80.56 a
8-8	130.7 c-f	156.2 ab	47.85 a-c	48.99 a-c	20.34 f	22.92 ab	62.21 b-e	76.61 ab
8-12	134.6 b-f	135.9 a-e	48.09 a-c	49.00 a-c	21.00 ef	22.73 a-c	64.80 b-d	66.47 b-d
8-16	114.7 ef	139.3 a-e	49.16 ab	46.80 bc	21.39 c-f	23.59 a	56.58 c-e	65.26 b-d
12-0	132.8 b-f	140.8 a-e	44.17 c	48.82 a-c	20.67 ef	23.20 ab	58.92 c-e	68.79 a-d
12-4	113.5 ef	155.1 ab	48.07 a-c	48.24 a-c	21.15 ef	23.04 ab	54.71 de	74.82 ab
12-8	139.1 b-e	150.1 a-d	47.74 a-c	50.73 a	21.18 d-f	22.16 b-e	67.11 a-d	76.10 ab
12-12	130.5 c-f	149.0 a-d	47.98 a-c	48.31 a-c	21.16 ef	23.07 ab	61.83 b-e	72.04 a-d
12-16	100.7 f	143.0 a-e	45.91 bc	48.11 a-c	21.13 ef	22.38 b-d	46.70 e	68.41 a-d
Av.	132.06	140.03	47.41	48.52	21.56	22.58	62.60	68.15
LSD (0.05)	36.60	29.89	Ns	Ns	1.31	1.11	17.64	13.62

Table 1b. The groups formed, the values of the average number of branches, number of capsules per plant, plant height and 1000 grain weight of second crop sesame plantation which obtained under the application of different doses of phosphorus and nitrogen between 2001-2002.

App	Number of Branches		Number of Capsules per Plant		Plant Height		1000 Grain Weight	
	2001	2002	2001	2002	2001	2002	2001	2002
0-0	4.5 a-d	5.4	110.3 de	150.4	153.6	93.6	3.6	3.4
0-4	4.7 a-d	5.5	123.0 c-e	152.2	176.3	98.9	3.6	3.4
0-8	4.2 b-d	5.7	143.3 b-d	156.3	142.3	97.6	3.7	3.5
0-12	4.0 b-d	4.7	124.3 c-e	147.2	162.4	97.1	3.6	3.5
0-16	4.7 a-d	5.1	171.0 ab	147.1	164.9	95.9	3.6	3.7
4-0	3.5 d	5.2	100.7 de	129.2	153.7	91.7	3.8	3.3
4-4	5.7 a	5.0	142.0 b-e	142.1	147.6	96.7	3.6	3.4
4-8	3.9 cd	4.7	116.7 c-e	121.9	140.0	90.5	3.5	3.6
4-12	4.3 a-d	5.1	128.0 b-e	137.7	135.9	90.3	3.7	3.4
4-16	5.0 a-c	5.3	142.0 b-e	142.8	135.6	98.8	3.5	3.3
8-0	4.9 a-d	5.4	156.0 a-c	156.7	124.5	94.4	3.9	3.4
8-4	4.4 ad	5.0	196.0 a	170.0	136.1	103.1	3.6	3.6
8-8	4.3 a-d	5.0	116.0 c-e	154.6	165.9	101.8	3.7	3.4
8-12	4.3 a-d	4.8	132.3 b-e	160.5	162.6	100.9	3.6	3.4
8-16	3.5 d	5.0	114.0 c-e	136.9	160.4	97.6	3.8	3.5
12-0	4.7 a-d	5.3	130.0 b-e	148.5	148.5	97.1	3.8	3.4
12-4	3.8 cd	4.4	98.33 e	154.3	148.1	92.4	3.4	3.6
12-8	4.2 b-d	5.5	109.7 de	164.7	146.3	104.5	3.4	3.5
12-12	5.5 ab	5.1	131.3 b-e	149.8	155.6	100.2	3.8	3.5
12-16	4.7 a-d	4.9	109.0 de	139.7	150.7	102.1	3.8	3.5
Average	4.4	5.1	129.7	148.1	150.6	97.3	3.7	3.5
LSD (0.05)	1.5	Ns	44.7	Ns	Ns	ns	ns	ns

According to the results of variance analysis, as fertilizer applications on sesame grain yield(0,05) were found significant(table 1a) in terms of interaction of nitrogen*phosphorus in both years, the impact of phosphorus and nitrogen on yield separately were found significant(0.05) (Table 2a, Table 3a) on yield only in 2001.

When table 1a is examined, the highest sesame yield, 176.7 kg/da, was obtained with the application dose of 8 kg P₂O₅ - 0 kg N per decare in 2001, 162.2 kg with the application of dose of 8 kg P₂O₅-4 kg N per decare in 2002, the lowest yield, 98.4 kg/da, was obtained with application dose of 12 kg P₂O₅ - 16 kg N per decare in the first year, 98.39 kg/da with application dose of 4 kg P₂O₅ - 12 kg N per decare in the second year respectively. It was found that the yield of application of 8 kg P₂O₅ - 4 kg N

per decare in 2001 similar to the yield(167.8 kg/da) of same dose in the second year. These results show similarities with the studies of Ashfaq et al. (2001). In our study, the emerged results as negative interaction between phosphorus and nitrogen is compatible with the results of Delgado et al. (1971).

When the sesame grain yields compared to the applied phosphorus doses, the highest sesame grain yields; 144.9 kg/da and 150.0 kg/ha, were obtained from the application of 8 kg/da and 12 kg/da P₂O₅ respectively in both years.

When nitrogen applications on sesame yield are compared, the yields; 139.5 and 135.4 kg/da were obtained from the nitrogen application doses of 0 and 4 kg/da respectively in the first year, the yields; 144.8 and 146.2 kg/da were obtained from the nitrogen application doses of 4 and 8 kg/da respectively (table 2a and table 3a) in the second year.

The findings of Vijay et al. (1987), Subramanian et al. (1979), Ramakrishnan et al. (1994), and Balasubramaniyan (1996), Sharma et al. (1995) support our results on nitrogen. Prakashan and Tidmmegovde (1992) reported the similar findings on applications of phosphorus.

The oil percentage, in the results of the variance analysis, the fertilizer applications if not significant(table 1a) on the sesame oil rate(% oil) in both years, the highest oil rate was obtained from the nitrogen application(table 3a) doses of 8 kg/da in two years. Similar findings were also reported by Awad et al. (1996).

The protein rate, in the results of the variance analysis, it is understood from table 1a, 2a and 3a the interaction of phosphorus x nitrogen is important on the protein rate in two years, the application of phosphorus alone significant(0.05) on the protein rate and the application of nitrogen not significant(0.05) on the protein rate.

It is seen that when look at the values which were obtained from the average protein rate of sesame seed and the groups formed (table 1a) combined with the applications of phosphorus and nitrogen, the highest rate was obtained from the 16 kg/da N in the phosphorus application doses of 4 and 8 kg/da in both years. The findings found by Ashfaq et al. (2001) Tiwari and Namdeo (1997), Vijay et al. (1987) support our study.

The number of capsules per plant in the applications of phosphorus and nitrogen were found insignificant in the results of the analysis in both years. It was emerged that(table 1b), in terms of phosphorus x nitrogen interaction the number of sesame capsule (capsule/plant) was significant(0.05) in the first year, insignificant (0.05) in the second year.

In the results of the variance analysis about the number of branch per plant; while the phosphorus x nitrogen interaction(0.05) had significant effect on the number of branches per plant in the first year, applications had insignificant effect on the number of branch in the second year (0.05). Vijay et al. (1987) reported that nitrogen application did not affect the number of branches per plant. This finding shows similarity with our data on nitrogen.

Plant height, When look at the results of the analysis, the applications dose of the phosphorus and nitrogen and the interaction had no significant effect to values of plant height (cm) in two years. Vijay et al. (1987) reported that increase in the proportion of nitrogen has no effect on the plant height. These findings support our data of two years on nitrogen studies.

When we look at the results of the variance analysis, phosphorus had no effect on the 1000 grain weight(0.05) in both application years. While the 1000 grain weight was observed significant in terms of nitrogen applications only in 2002, data of 1000 grain weight was not affected significantly by the applications in 2001.

Table 2a. The groups formed, values of the oil yield(kg da⁻¹), protein ratio, oil ratio and average sesame seed yield(kg da⁻¹) of second crop sesame plantation which obtained under applications of different doses of phosphorus in 2001-2002.

App.	Yield(kg/da)		Oil Ratio(%)		Protein Ratio(%)		Oil Yield(kg/da)	
	2001	2002	2001	2002	2001	2002	2001	2002
Phosphorus								
0	120.3	127.1	48.16	48.92	21.28	21.94	58.07	62.24
4	139.7	136.5	46.91	48.31	22.28	22.51	65.37	66.20
8	144.9	150.0	47.81	48.04	21.62	23.07	69.12	72.15
12	123.3	147.6	46.77	48.84	21.06	22.77	57.86	72.03
Average	132.1	140.0	47.41	48.52	21.56	22.58	62.60	68.15
LSD (0.05)	*	Ns	Ns	Ns	*	*		*

Table 2b. The groups formed, values of the 1000 grain weight, plant height, number of capsules per plant, average number of branches of second crop sesame plantation which obtained under applications of different doses of phosphorus in 2002-2003.

App.	Number of Branches per Plant		Number of Capsules per Plant		Plant Height		1000 Grain Weight	
	2001	2002	2001	2002	2001	2002	2001	2002
Phosphorus								
0	4.4	5.3	134.4	150.6	159.9	96.6	3.63	3.49
4	4.5	5.1	125.9	134.7	142.6	93.6	3.62	3.42
8	4.3	5.0	142.9	155.7	149.9	99.6	3.73	3.47
12	4.6	5.0	115.7	151.4	149.8	99.3	3.62	3.49
	4.4	5.1	129.7	148.1	150.6	97.3	3.65	3.47
LSD (0.05)			Ns		Ns	Ns		

Table 3a. The groups formed, values of the oil yield(kg da⁻¹), protein ratio, oil ratio and average sesame seed yield(kg da⁻¹) of second crop sesame farming which obtained under applications of different doses of nitrogen in 2001-2002.

App.	Yield(kg/da)		Oil Ratio(%)		Protein Ratio(%)		Oil Yield(kg/da)	
	2001	2002	2001	2002	2001	2002	2001	2002
Nitrogen								
0	139.5	136.5	46.61	48.02	21.51	22.68	65.16	65.43
4	135.4	144.8	47.41	48.69	21.51	22.52	64.30	70.77
8	128.0	146.2	47.76	49.72	21.32	22.43	61.32	72.81
12	133.1	126.8	47.54	48.33	21.56	22.48	62.96	61.35
16	124.3	147.2	47.74	47.88	21.61	22.77	59.28	70.42
	132.1	140.0	47.41	48.52	21.56	22.58	62.60	68.15
LSD (0.05)	*	Ns	Ns	Ns	ns	Ns	Ns	*

Table 3a. The formed groups, values of the 1000 grain weight, plant height, number of capsules per plant, average number of branches of second crop sesame farming which obtained under applications of different doses of nitrogen in 2002-2003.

App	Number of Branches per Plant		Number of Capsules per Plant		Plant Height		1000 Grain Weight	
	2001	2002	2001	2002	2001	2002	2001	2002
Nitrogen								
0	4.4	5.3	124.3	146.2	145.1	94.2	3.77	3.37 b*
4	4.7	4.9	139.8	154.6	152.0	97.8	3.56	3.54 a
8	4.2	5.2	121.4	149.4	148.6	98.6	3.55	3.51 a
12	4.5	4.9	129.0	148.8	154.1	97.1	3.67	3.45 ab
16	4.5	5.1	134.0	141.6	152.9	98.6	3.68	3.46 ab
	4.4	5.1	129.7	148.1	150.6	97.3	3.65	3.47
LSD (0.05)			Ns		ns	Ns	ns	0.1018

When values which were obtained from the result of research in 2001-2002 are compared, the highest yield was obtained from the applications of 8 kg P₂O₅ - 0 kg N and 8 kg P₂O₅ - 4 kg N per decare in 2001. It was determined that the highest yield of sesame seed was obtained by the applications of 8 kg P₂O₅ and 4 kg of N per decare in 2002.

Consequently, it was determined that the doses of 8 kg of pure P₂O₅ and 4 kg of pure N per decare can be suggested in the light of the analysis and values derived from the applications of different doses of phosphorus and nitrogen on the second crop sesame cultivation in irrigated condition for the region.

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