EFFECT OF SPACING AND NITROGEN ON THE YIELD AND YIELD COMPONENTS OF SUNFLOWER UNDER RAINFED CONDITIONS

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INTRODUCTION

During 1981—82 the total edible oil requirements of Pakistan were 825 thousand tons, out of which 265 thousand tons were produced in the country and 491 thousand tons were imported (Qureshi, 1982).

Sunflower can be considered as one of the promising oil-seed crops for bridging the gap of oil requirements and production in the country. In Pakistan research on sunflower was undertaken in the early sixties. The research findings so far obtained are encouraging. Afzal (1972) reported significant grain yields by application of 68 kg N and 56 kg P_2O_5 per hectare. Increase in plant height was also reported with the increase in nitrogen. Zubriski and Zimmerman (1974) have reported 2,800 kg and 3,000 kg/ha seed yields with application of 95 kg and 150 kg nitrogen/ha, respectively. Morris (1975) has reported that seed yield increased from 1.72 tons to 2.18 tons/ha with the increase in nitrogen from 58 to 144.25 kg per hectare. Cheng and Zubriski (1978) found out that by application of 112 kg N/ha, seed yield increased up to 4,195 kg against 2,734 kg from the control. Usman (1980) observed that nitrogen alone or in combination with phosphorus and potasium, produced significant increase in plant height, head diameter and seed yield. Robinson et al. (1978) reported that the average yield increased from 1,841 kg to 2,946 kg/ha when plant population was increased from 17 to 62 thousand plants per hectare. The increase in plant population reduced the other two components i.e. number of seed per head and weight per seed. Swaller and Fick (1973) showed that increased plant density reduced head size and the percentage of large-size seeds and it had no effect on seed yield.

Keeping in view the importance of sunflower with limited research findings in the country, the study on the effect of spacing and nitrogen fertilizer on the yield and yield components of sunflower under rainfed conditions was initiated.

MATERIALS AND METHODS

The experiment was carried out at the National Agricultural Research Centre, Islamabad during the years 1978 and 1979. This station is situated about 10 kilometres north of Islamabad at an altitude of 683 m and latitude of 33.39 N. The soil of the station is sandy-loam with a pH range of 7.8 to 8.2. The annual rainfall varies from 834 mm to 1,112 mm. An open pollinated variety of sunflower Noor was subjected to four levels of nitrogen fertility viz. 0, 56, 112 and 168 kg per hectare in four plant spacings viz. 23 cm (57,970 plants/ha), 30 cm (44,444 plants/ha), 38 cm (35,088 plants/ha) and 45 cm (29,630 plants/ha) in a split plot design. Plant spacing treatments were assigned to main plots and the fertilizer levels to sub-plots. Each sub-plot consisted of four rows 5 meter long and 75 cm apart. Planting was done on 8th July, 1978 and 22nd July, 1979. Two seeds per hill were planted by dibbling method. The plants were thinned to one plant per hill when they attained about 20 cm height. Half quantities of nitrogen doses with basic dose of 50 kg per ha of phosphorus were applied when the plants were 45 cm in height. The crop was hoed and weeded once followed by earthing-up. Data were recorded according to the treatment schedule. The plots were harvested on 8 to 10 October, 1978 and 5 to 6 November, 1979. Data were statistically analysed.

RESULTS AND DISCUSSION

Grain yield per hectare. Mean grain yield kg per hectare was significantly affected by different levels of nitrogen, spacings and their interaction. All fertilizer treatments gave significantly higher yields over control. Maximum average yield of 1,732.7 kg/ha was produced by application of 112 kg nitrogen per ha, while the control plots yielded only 832.7 kg/ha. The yield increased with increased nitrogen level up to 112 kg/ha, beyond which a slight but not

Table 1

Mean grain yield (kg/ha) as affected by fertilizer and spacing and their interaction

Levels of nitrogen (kg/ha)	Plant spacing (cm)				
	23	30	38	45	Mean
0	832.7	774.0	692.7	657.9	739.0
56	1 060.7	1 108.7	939.3	806.7	979.0
112	1 732.7	1 487.9	1 246.7	1 034.4	1 378.0
168	1 534.7	1 353.3	1 233.4	1 003.3	1 281.0
Mean	1 290.0	1 181.0	1 028.0	877.0	[redacted]

S.E. for fertilizer mean = 0.319
cd_1 = 0.401
cd_2 = 0.536
S.E. for spacing mean = 0.376
cd_1 = 1.190
cd_2 = 1.369
S.E. for spacing x fertilizer =0.880
cd_1 = 2.390
cd_2 = 3.460

significant decrease was observed at the highest level of nitrogen. Similar results have been reported by Cheng and Zubriski (1978), Usman (1980), and Morris (1975). The significant yields are attributed to the proper requirement of nitrogen, which is a major plant food nutrient. The plants established with vigorous growth and broader and greenish leaves which helped in proper photosynthesis.

As regards plant spacing effect, the maximum yield of 1,732.7 kg/ha was obtained with 23 cm plant spacing. It was significantly higher than the rest of the spacings. The results (Table 1) indicate that the yield increased with the increase in plant population. The low yield in wider row spacings seems to be due to lesser crop stand as compared to narrower spacings. Those findings are in line with the ones reported by Zubriski and Zimmerman (1974) and Robinson et al. (1978) where minimum row spacings gave the highest grain yield. Sunflower compensates for differences in plant population by producing larger seeds and heads at low populations. Plant population per unit area should remain the same regardless of row width, so that each plant may get the required amount of nutrients and sunlight.

Head diameter. The results regarding head diameter presented in Table 2 showed significant differences among the different nitrogen levels and plant spacings, but interaction between the two factors was non-significant. Maximum head diameter was 12.2 cm with 112 kg/ha nitrogen and 8.9 cm in the control. The optimum level of nitrogen was 112 kg/ha. The increase or decrease from this dose resulted in narrower head diameter. Similar observations have also been reported by Usman (1980) and Swaller and Fick (1973).

The plots with 45 cm plant spacing produced plants with maximum head diameter of 15.4 cm whereas plots with 23 cm plant spacing produced plants with 12.2 cm head diameter, though the nitrogen fertility level was the same. Similar trend was observed in the other treatments. Messey (1971) was also of this opinion. Wider spacing provided more plant food nutrients and sunlight penetration, resulting its sound growth.

Table 2

Mean head diameter (cm) as affected by fertilizer, spacing and their interaction

Levels of nitrogen (kg/ha)	Plant spacing (cm)				
	23	30	38	45	Mean
0	8.9	10.3	11.2	11.9	10.5
56	10.9	11.6	12.2	14.3	12.6
112	12.2	13.5	14.2	15.4	13.8
168	11.5	13.2	13.6	14.6	13.2
Mean	10.9	12.3	13.1	14.0	

S.E. for fertilizer mean = 0.30
cd_1 = 0.77
cd_2 = 1.09
S.E. for spacing mean = 0.25
cd_1 = 0.76
cd_2 = 1.12
S.E. for spacing x fertilizer = 0.59 N.S.

Number of grains per head. The mean number of grains per head was significantly affected by different nitrogen doses and plant spacing and their interaction. The average number of filled grains per head, presented in Table 3 also revealed that the maximum number of 575 grains per head were produced by application of 112 kg nitrogen per/ha as against 312 grains in control. The number of grains increased with increased fertilizer, but it decreased beyond 112 kg nitrogen per hectare.

Table 3

Mean number of grains/head as affected by fertilizer and spacing and their interaction

Level of nitrogen (kg/ha)	Plant spacing (cm)				
	23	30	38	45	Mean
0	312	371	393	447	381
56	365	474	512	515	466
112	575	604	615	623	604
168	538	547	596	609	569
Mean	444	499	529	548	

S.E. for fertilizer mean = 10.42
cd_1 = 29.98
cd_2 = 40.27
S.E. for spacing mean = 6.30
cd_1 = 20.13
cd_2 = 27.94
S.E. for spacing x fertilizer = 20.84
cd_1 = 55.03
cd_2 = 74.11

In case of increased spacings, the number of grains per head increased, which may be due to more nutrition space and less competition among the plants. These results confirmed the observations of Robinson et al. (1978) who reported that by increasing the plant population from 17 to 62 thousand plants/ha the number of seeds/head decreased from 1,223 to 826.

Table 4

Mean 1000-grain weight as affected by fertilizer spacing and their interaction

Level of nitrogen (kg/ha)	Plant spacing (cm)				
	23	30	38	45	Mean
0	47.7	48.7	50.0	50.8	49.3
56	49.2	51.2	52.5	53.2	51.6
112	53.4	55.2	55.7	56.1	55.1
168	50.7	53.7	54.5	55.2	53.5
Mean	50.3	52.3	53.2	53.8	

S.E. for fertilizer mean = 0.17
cd_1 = 0.49
cd_2 = 0.66
S.E. for spacing mean = 0.20
cd_1 = 0.63
cd_2 = 0.91
S.E. for spacing x fertilizer = 0.37 N.S.

The plants spaced wider utilized more nutrients, resulting more vigorous plants because of lesser competition among the plants.

1000-grain weight. 1000-grain weight like head diameter and number of grains/head, is also an important yield component contributing towards the total yield per hectare. The rezults in Table 4 reveals that with application of 112 kg nitrogen per hectare, the 1000-grain weight was 53.4 g whereas it was 47.7 g when no fertilizer was applied. 1000-grain weight varied from 53.4 to 56.1 g with 23 cm to 45 cm spacing. It showed that incrcased spacing resulted in increased 1000-grain weight. The increase was significant. These results showed the same trend as in the case of grain yield per hectare. However, the extent of difference varied with different doses of nitrogen and spacing. Similar findings were reported by Robinson et al. (1978). The reasons for significance of 1000-grain weight with higher doses of nitrogen (112 kg per ha) and with wider space (45 cm) over control in 23 cm spacing, is that nutrient availability was according to the requirement of the plants and there was lesser competition for the nutrients and other plant establishment factors like light and moisture among the plants, as compared with the control plots with 23 cm spacing.

Yield per head. The mean yield per head showed significant differences among different nitrogen levels and plant spacings, but the interaction between fertilizer and spacing was not significant. Maximum yield of 30.2 g per head was obtained from the plots treated with 112 kg N/ha, whereas it was 14.5 g from the control plots. Considering plant spacing, it was 35.0 g when spacing was 45 cm. The results in Table 5 indicate that yield per head was increased with increased plant spacing. These results are in accordance with the ones reported by Massey (1971).

The better yield per head with increase in nitrogen over control plots was mainly due to the proper requirement of nitrogen (112 kg p/ha), because there was decrease in yield per head with increase or decrease in nitrogen. With increase in plant spacing the yield per head increased which was due to the lesser competition of plants for the nutrients and proper sunlight penetration for efficient photosynthesis.

Table 5

Mean yield per head as affected by fertilizer spacing and their interaction

Level of nitrogen (kg/ha)	Plant spacing (cm)				
	23	38	30	45	Mean
0	14.5	17.8	19.7	22.6	18.7
56	18.4	24.6	27.0	26.9	24.2
112	30.2	33.0	34.2	35.0	33.1
168	26.3	29.3	33.1	34.2	30.7
Mean	22.4	26.2	28.5	29.7	

S.E. for fertilizer mean = 0.57
cd_1 = 1.64
cd_2 = 2.20
S.E. for spacing mean = 0.46
cd_1 = 1.46
cd_2 = 2.11
S.E. for spacing x fertilizer = 1.40 N.S.

Empty and filled ratio. The empty and filled ratio is the most important character in sunflower, because the filled grains are the ones which contribute towards the oil content. The empty/filled ratio was significantly affected by fertilizer, spacing and their interaction (Table 6). The number of filled grains increased with increased nitrogen dose, but it decreased beyond 112 kg/ha which can be attributed to the fact that plant receiving higher doses attained vigorous vegetative growth and thus the time for head setting was reduced. The greater number of filled grains/ha may be due to more nutrition space, and moisture availability and less plant competition. The empty/filled ratio was 0.201 with application of 112 kg N/ha as against 0.310 from the con-

Table 6

Mean empty/filled ratio as affected by fertilizer, spacing and their interaction

Level of nitrogen (kg/ha)	Plant spacing (cm)				
	23	30	38	45	Mean
0	0.310	0.267	0.260	0.217	0.264
56	0.278	0.260	0.238	0.170	0.234
112	0.201	0.218	0.211	0.145	0.194
168	0.230	0.204	0.188	0.146	0.191
Mean	0.243	0.237	0.224	0.169	

S.E. for fertilizer mean = 0.039
cd_1 = 0.027
cd_2 = 0.036
S.E. for spacing mean = 0.014
cd_1 = 0.045
cd_2 = 0.064
S.E. for spacing x fertilizer = 0.013
cd_1 = 0.018
cd_2 = 0.245

trol plots. The empty filled ratio was 0.145 when plant spacing was 45 cm. The number of filled grains increased with increased spacing (Table 6).

CONCLUSIONS

From the results obtained in this study it can be concluded that sunflower responds favourably to nitrogen under rainfed conditions. With increased plant spacing, the yield components, head diameter, number of grains per head, 1000-grain weight and the number of filled grains/ha, increased but the total yield per ha decreased which is attributed to lower population. The total yield per ha increased with decreased plant spacing (up to 23 cm).

Of the different doses of nitrogen and plant spacings, 112 kg N per ha in combination with 23 cm plant to plant spacing in rows of 75 cm apart, yielded the maximum grain (1,732.7 kg/ha).

In the light of the present study, it is recommended that sunflower crop under rainfed conditions be cultivated in 75 cm wide rows with plant to plant distance of 23 cm, which will give a crop stand of 58,000 plants per ha. If this population is supplied with 112 kg nitrogen per ha, an ideal crop could be obtained. However, the fertilizer dose may be increased or decreased, depending upon the soil fertility levels.

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EFFET DE LA DENSITÉ DES PLANTES ET DE L'AZOTE SUR LE RENDEMENT ET LES COMPOSANTES DU RENDEMENT DU TOURNESOL EN CONDITIONS DE CULTURE SÈCHE

Résumé

Au Centre National de Recherches Agricoles d'Islamabad on a étudié l'effet de quatre niveaux de fertilisation à l'azote et de quatre densités des plantes sur le le rendement et les principales composantes du rendement du cultivar de tournesol Noor. Les doses d'engrais à l'azote ont été de 56, 112 et 168 kg/ha, à coté du témoin non-fertilisé. Les quatre densités (57.970, 44.440, 35.088 et 29.630 plantes/ha) ont été réalisées en maintenant l'écartement des lignes à 75 cm et en variant l'espacement des plantes sur la ligne.

Le rendement maximum, de 1 733 kg/ha, a été obtenu lors de l'application de la dose de 112 kg/ha, l'espacement des plantes sur la ligne étant de 23 cm (57.970 plantes/ha), comparé au rendement du témoin non-irrigué et de la même densité, de 833 kg/ha.

Le rendement en graines par unité de surface a augmenté parallèlement à la densité, toutefois le diamètre du capitule, le nombre de graines par capitule et le rendement par capitule ont diminué presque proportionnellement à l'augmentation de la densité des plantes sur la ligne.

Les résultats obtenus ont démontré que les plantes de tournesol compensent beaucoup les différences entre parcelles à densités variables, en produisant des capitules et de graines plus grandes aux densités plus réduites.

EFECTO DE LA DENSIDAD DE LAS PLANTAS Y DEL NITRÓGENO SOBRE LA PRODUCCIÓN Y LOS ELEMENTOS DE PRODUCTIVIDAD DEL GIRASOL EN CONDICIONES DE SIN REGADIO

Resúmen

En el Centro Nacional de Investigaciones Agricolas de Islamabad de estudió durante dos años el efecto de cuatro niveles de fertilización con nitrógeno de cuatro densidades sobre la producción y sobre los principales elementos de productividad en la variedad de girasol Noor.

Las dosis de abonos con nitrógeno fueron : 56, 112 y 168 kg/ha, junto el testigo sin fertilizar. Las cuatro densidades (57 970, 44 444, 35 088 y 29 630 plantas/ha) se realizaron manteniendo la distancia entre hilas de 75 cm y variando la distancia entre plantas por hila.

La producción máxima, de 1 733 kg/ha se obtuvo por la aplicación de la dosis de 112 kg N/ha y con la densidad entre plantas por hila de 23 cm (57 970 plantas/ha) comparando con la producción del testigo no irrigado y con la misma densidad, de 833 kg/ha.

La producción de semillas por unidad de superficie aumentó a la vez con la densidad, en cambio el diametro del capítulo, el número de semillas por capítulo y la producción por capítulo disminuyeron casi proporcionalmente con la espesura de las plantas por hila.

Los resultados obtenidos mostraron que las plantas de girasol compensan mucho las diferencias entre parcelas en cuanto a la densidad de las plantas, produciendo capítulos y semillas mayores a densidades menores.