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Effect of crop geometry and split application of N on nutrient uptake and yield of rainfed sunflower

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Abstract: Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, during the Northeast monsoon (October-December) seasons of 1997 and 1998 in a split plot design to study the effect of crop geometry and split application of N on nutrient uptake and yield of rainfed sunflower. The main plot treatments consisted of three levels of crop geometry viz. 80, 100 and 120% of recommended population with a spacing 30 x 37.5 cm, 30 x 30 cm and 30 x 5 cm respectively and the sub-plot treatments formed six N split-levels and treatments were replicated thrice. The results revealed that the nutrient uptake of sunflower was higher with closer spacing of 30 x 25 cm than wider spacing of 30 x 37.5 cm. The plants under closer spacing (30 x 25 cm) extract more moisture than wider spacing of 30 x 37.5 cm. The seed yield was higher at closer spacing (30 x 25 cm) in 1997 (810 kg ha^{-1}) and at wider spacing (30 x 37.5 cm) in 1998 (1022 kg ha^{-1}). In both the years the split application of nitrogen resulted in higher nutrient uptake and seed yield as compared to entire dose as basal dressing.

Key words : Sunflower, Crop geometry, N split application, Nutrient uptake and Seed yield.

Introduction

Cultivable sunflower (*Helianthus annuus* L.) is a member of family asteraceae and one of the most important edible oil seed crops of the world. Sunflower with its versatile nature is expected to play a crucial role in the oil seed economy of the country. Its cultivation is expected to spread to different cropping system and areas including eastern and north eastern regions. Planting pattern has been observed to influence the yield of many crops. Sunflower expresses its full genetic potential when it is grown in an ideal ecological environment with optimum soil fertility and plant population levels. It is imperative to adopt optimum plant population for better utilization of all the available resources more efficiently. Subarad and Sheelavantar (1997) recorded significantly higher seed yield of (15.83 q ha^{-1}) at 0.83 lakh plants ha^{-1}, which was 13 per cent higher than grain yield produced at a population of 1.11 lakh plants ha^{-1}. Closer spacing was found to be advantageous in producing higher seed yield compared to wider spacing under no moisture stress conditions (Karami, 1997). Among the plant nutrients, nitrogen plays an important role in deciding growth and yield of sunflower. Nitrogen is the most common element influencing the sunflower yield (Ashnour *et al.* 1985 and Halder *et al.* 1998). With the advent of improved sunflower varieties and pressing demand to enhance the productivity, split application of nitrogen at critical stages is necessary for proper growth and yield. The present investigaion was carried out to study the effect of crop geometry and N split application on nutrient uptake and yield of rainfed sunflower.

Materials and Methods

Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, India during the Northeast monsoon (October-December) season of 1997 and 1998 to find out the influence of crop density levels and split application of N on nutrient uptake and yield of rainfed sunflower. The soil of the experimental field was low in available N (210

Table 1. Effect of crop geometry and N split application on nutrient uptake and yield (kg ha^{-1}) of rainfed sunflower (NEM 1997)

Treatments	Nitrogen 30 DAS	Nitrogen 50 DAS	Nitrogen Harvest	Phosphorus 30 DAS	Phosphorus 50 DAS	Phosphorus Harvest	Potassium 30 DAS	Potassium 50 DAS	Potassium Harvest	Seed yield
80% Rec. PP	21.28	39.43	68.66	1.53	5.65	11.690	8.51	47.70	99.14	741
100% Rec. PP	24.37	40.30	71.49	1.64	6.21	11.930	9.54	52.60	100.81	757
120% Rec. PP	25.03	43.09	76.17	1.70	6.38	12.990	9.71	53.96	109.89	810
CD (P=0.05)	0.55	0.66	1.09	0.003	0.03	0.080	0.44	0.69	0.56	24
Split application of N										
Basal 4[th] WAS 6[th] WAS										
100% - -	24.09	36.86	64.17	1.63	5.98	11.030	9.19	50.47	93.36	730
50% 50% -	23.21	41.30	71.12	1.62	6.1	12.130	9.08	51.69	102.49	762
50% - 50%	23.53	39.95	71.40	1.62	5.96	12.230	9.30	50.30	103.58	746
50% 25% 25%	23.57	40.96	75.01	1.62	6.10	12.520	9.21	51.63	106.35	812
33.3% 33.3% 33.3%	23.75	42.69	75.47	1.62	6.16	12.710	9.38	51.15	107.47	774
25% 50% 25%	23.18	43.89	75.50	1.62	6.17	12.600	9.37	52.29	106.41	792
CD (P=0.05)	NS	0.52	0.94	NS	0.016	0.072	NS	0.33	0.70	42

Rec.PP: Recommended Plant Population WAS : Week after sowing

Table 2. Effect of crop geometry and N split application on nutrient uptake and yield (kg ha^{-1}) of rainfed sunflower (NEM 1998)

Treatments	Nitrogen 30 DAS	Nitrogen 50 DAS	Nitrogen Harvest	Phosphorus 30 DAS	Phosphorus 50 DAS	Phosphorus Harvest	Potassium 30 DAS	Potassium 50 DAS	Potassium Harvest	Seed yield
80% Rec. PP	22.09	35.56	72.33	1.83	6.24	11.42	10.99	52.02	95.14	1022
100% Rec. PP	22.80	38.36	73.28	1.85	6.39	11.61	11.15	53.25	96.62	953
120% Rec. PP	23.60	41.91	75.77	1.92	6.63	11.99	11.52	55.27	100.14	838
CD (P=0.05)	0.680	0.72	0.87	0.018	0.038	0.09	0.09	0.31	0.63	11
Split application of N										
Basal 4[th] WAS 6[th] WAS										
100% - -	24.11	40.03	74.10	1.92	6.39	11.72	11.56	53.27	97.63	938
50% 50% -	22.97	42.01	75.65	1.88	6.74	11.99	11.30	56.17	99.45	998
50% - 50%	22.74	38.23	72.33	1.86	6.16	11.38	11.22	51.29	94.90	883
50% 25% 25%	22.69	39.53	72.97	1.87	6.37	11.59	11.24	53.10	96.59	932
33.3% 33.3% 33.3%	22.35	39.00	73.05	1.84	6.32	11.55	11.07	52.67	96.24	911
25% 50% 25%	22.16	40.89	74.68	1.82	6.54	11.82	10.97	54.59	98.5	964
CD (P=0.05)	0.39	0.80	0.60	0.015	0.15	0.10	0.08	1.23	0.92	13

Rec.PP: Recommended Plant Population WAS : Week after sowing kg N ha^{-1}), medium in available P (17.5 kg P_2O_5 ha^{-1}) and high in available K (460 kg K_2O ha^{-1}). The electrical conductivity of the soil was 0.42 dSm^{-1} and the pH was 8.2. The sunflower variety CO 2, with field duration of 87 days, was used in the trial. The seeds were sown by dibbling 2 to 3 seeds $hill^{-1}$ in a flat bed with a row spacing of 30 cm and plant spacing as per the treatment schedule. The experiments were laid out in a split plot design replicated three times. The treatment details were are follows :

I. Main plot : Plant population

P_1 : 80% of recommended plant population (30 x 37.5 cm) (88,888 plants ha^{-1})

P_2 : 100% of recommended plant population (30 x 30 cm) (1,11,111 plants ha^{-1})

P_3 : 120% of recommended plant population (30 x 25 cm) (1,33,333 plants ha^{-1})

II. Sub-plot : Split application of nitrogen

N_1 : Entire doses as basal (40 kg N ha^{-1})

N_2 : ½ basal + ½ in the 4th week after sowing with rain

N_3 : ½ basal + ½ in the 6th week after sowing with rain

N_4 : ½ basal + ¼ in the 4th week after sowing + ¼ in the 6th week after sowing with rain

N_5 : 1/3 basal + 1/3 in the 4th week after sowing + 1/3 in the 6th week after sowing with rain

N_6 : ¼ basal + ½ in the 4th week after sowing + ¼ in the 6th week after sowing with rain

The time of application of fertilizers was fixed based on the simple water balance model results. Fertilizers were scheduled to be applied only when there is greater chance for getting 15 mm of rainfall or more, during that particular week and soil moisture is sufficient enough. During 1997 a total rainfall of 21.9 mm and 45.5 mm were received during the 4th and 6th week after sowing and corresponding mean soil available moisture were 49.5 mm and 47.5 mm, respectively. The rainfall received in 1998 was 24.8 mm and 29.5 mm rainfall during the 4th and 6th week after sowing and the corresponding mean soil available moisture of 4th and 6th week was 23.6 mm and 44.8 mm respectively.

Of the recommended rate of N, P and K @ 40:20:20 kg ha^{-1}, nitrogen was applied in splits as per the treatment schedule, the entire doses of P_2O_5 and K_2O were applied basally to all the treatments. The amount of rainfall received during the cropping period was 598 mm and 571 mm distributed over 43 and 20 rainy days during 1997 and 1998 respectively. Since the study was conducted under rainfed conditions and the distribution of rainfall differed widely between the years (1997 and 1998), pooled analysis of data was not done and only the data for individual year are presented and discussed.

Results and Discussion

Influence of crop geometry on nutrient uptake and yield

Nutrient uptake

In general, the N, P and K uptake was influenced by the plant population levels irrespective of stages of crop growth and years of study. The population of 120 per cent of recommended level 1,33,333 plants ha^{-1} (30 x 25 cm) invariably resulted in maximum N, P and K uptake followed by level of 1,11,111 plants ha^{-1} under 100 per cent population (30 x 30 cm). The possible reason might be due to higher the dry matter production of 8018 and 8118 kg ha^{-1} at harvest stage. Similar findings of increased NPK uptake with higher plant density was reported by Subba Reddy *et al.* (1997).

Seed yield

The sunflower seed yield was significantly influenced by the various spacing tested in both years. A closer spacing of 30 x 25 cm (133,333 plants ha^{-1}) gave a significantly higher yield than wider spacings of 30 x 30 cm and 30 x 37.5 cm in 1997. Though the yield attributes had higher values on per plant basis under the widest plant spacing of 30 x 37.5 cm, the yield was higher under closer spacing due to the greater number of plants ha^{-1}. The increased plant population per unit area compensated the percentage yield loss due to competition at higher density. The higher values of yield components at higher plant density were the result of the better utilization of rainfall in a favourable environment and effective moisture utilization during high rainfall years (Reddy and Gajendra Giri, 1997). During 1998, the increase in yield parameters at the lowest plant density of 88,888 plants ha-1 produced a higher seed yield on per hectare basis. The spacing of 30 x 37.5 cm gave a significantly higher seed yield when compared to closer spacings of 30 x 30 and 30 x 25 cm. This may possibly be due to the severe competition between the plants under closer spacing, especially during the moisture stress experienced in the vegetative and early reproductive stages of the crop. Though the total rainfall received in the cropping period of 1998 (571 mm) was 78 per cent higher than the normal seasonal rainfall of 321 mm, the distribution was not uniform since there was a higher intensity of rainfall on a smaller number of rainy days. This situation led to a greater soil moisture deficit at higher plant population levels because of greater competition between the plants. It was also evident from other studies on sunflower that in relatively dry years, an increased plant population cannot compete with the yields obtained at lower plant densities on per plant basis (Dhoble *et al.* 1988). Rao and Reddy (1995) also repored the advantages of sub optimal plant populations under moisture stress conditions.

Influence of split application of nitrogen on nutrient uptake and yield

Nutrient uptake

In general nitrogen, phosphorus and potassium uptake of sunflower was higher from 30 DAS to harvest stage. However, the nutrient uptake of sunflower was not influenced by split application of N in a well distributed high rainfall year, 1997 at 30 DAS. This might be due to the high intensity rainfall at the initial stages, which nullified the effect of split application of N through loss of N by leaching (Reddy and Gajendra Giri, 1996). However, during later stages split application of N exerted significant difference in nutrient uptake. Application of nitrogen in three splits (¼ basal + ½ in the 4^{th} week after sowing + ¼ in the 6^{th} week after sowing with rain) led to more uptake of N, P and K (Table 1). Split application of nitrogen have supplied N rationally at right stages for efficient utilization of N by sunflower plants which helped better growth and in turn increased the nutrient uptake. During the year 1998, full basal application of N (40 kg ha^{-1}) at sowing registered higher N, P and K uptake of 30 DAS. However, in the later stages (at 50 DAS and at harvest) application of nitrogen in two equal splits tend to extract more N, P and K due to staggered N supply from the soil (Table 2).

Seed yield

The split application of N resulted in significant improvement in the seed yield of sunflower. Application of nitrogen in three splits (½ basal + ¼ in the 4^{th} week after sowing + ¼ in the 6^{th} week after sowign with rain) increased the seed yield (812 kg ha^{-1}) by 11.2 per cent over full basal application (730 kg ha^{-1}) (Table 1). The higher seed yield obtained with split application of N was due to better growth and yield attributes of sunflower in the favourable monsoon seasons in the year 1997, where there were fewer dry spells during the crop season. The better translocation of photosynthates to the reproductive parts was responsible for the improvement in the yield attributes and yield of sunflower (Reddy and Gajendra Giri, 1997). However, in 1998 the application of nitrogen in two equal splits (½ basal + ½ in the 4^{th} week after sowing with rain) resulted in 9.53 per cent higher seed yield (998 kg ha^{-1}) compared with the seed yield (932 kg ha^{-1}) of three splits of N (½ basal +

¼ in the 4[th] week after sowing + ¼ in the 6[th] week after sowing with rain). (Table 2). This might be due to intermittent dry spells after the 4th week, which created a soil moisture deficit resulting in reduced nutrient uptake by sunflower at the active vegetative and flowering stages thus leading to a reduced seed yield in the three-split N application.

Thus, the study indicated that the highest plant population of 1,33,333 plants ha^{-1} combined with N in 3 splits (½ N basal + ¼ in the 4[th] week after sowing + ¼ in the 6[th] week after sowing with rain situations) and lowest plant population of 88,888 plant ha^{-1} combined with recommended N in 2 splits (½ basal + ½ in the 4[th] week after sowing with rain) are the ideal combinations (for the high and uniform distribution of rainfall and moisture stress in the vegetative and flowering stages due to the uneven distribution of rainfall), for obtaining higher yield and nutrient uptake in rainfed sunflower.

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