N Stress Reduces: (a) Plant height, stem diam., leaf number and area (b) Rate of floret initiation (c) Total number of florets (d) Seed number and seed weight per plant (e) Protein per seed and per plant (f) Oil yield per plant.
N Stress does not alter: (a) Onset of floret initiation (b) Duration of floret initiation (c) Timing of bud burst (d) Timing of 3-row or full anthesis (e) Timing of seed maturity.
N Stress Increases (marginally): (a) Oil as % of seed dry wt.

Increasing N supply after the completion of floret initiation has no effect on leaf number or floret number because these have been determined already. As yet we have no information on the effects of N stress on embryo development during seed filling.

A field test for N sufficiency in sunflower?

In view of the stunted vegetative growth, depressed floret production and poor oil yields of N-deficient sunflowers, we believe that it is worthwhile to develop a test or index of N sufficiency for the crop. We feel that criteria for the test should be as simple as possible and allow for farm use. The test could be based on petiolar nitrate levels as these seem to be the most responsive to increasing nitrate in the rooting medium (see Table 4), possibly in conjunction with vegetative characters such as stem diameter, leaf number and leaf size. The test would need to be calibrated for changes in nitrate levels and vegetative characters as the plants age. In addition it would also need to take into account differences between cultivars. A rapid test for N sufficiency would be especially attractive where sunflowers are grown under irrigation and N fertiliser is applied in the irrigation water.

LITERATURE CITED

CHENG, S.F. and ZUBRISKI, J.S. 1978. Effects of nitrogen fertiliser on production of irrigated sunflower, plant uptake of nitrogen, and on water use. *Proceedings 8th International Sunflower Conference* pp. 400 — 409.

KAISER, J.J. and LEWIS, O.A.M. 1980. Nitrate-nitrogen assimilation in the leaves of *Helianthus annuus* L. *New Phytologist* 85:235 — 241.

KIRKBY, E.A. and MENGEL, K. 1970. Preliminary observations on the effect of urea nutrition on the growth and nitrogen metabolism of sunflower plants. In *'Nitrogen Nutrition of the Plant'* ed. E.A. Kirkby, Leeds. pp 35 — 38.

SALAMA, A.M.S.El-D.A. and WAREING, P.F. 1979. Effects of mineral nutrition on endogenous cytokinins in plants of sunflower *(Helianthus annuus* L.*) Journal of Experimental Botany* 30:971 — 981.

VREBALOV, T. 1974. Rate of NPK assimilative uptake of sunflower variety VNIIMK 8931. *Proceedings 6th International Sunflower Conference* pp. 205 — 212.

T1982AGR30

EFFECT OF NUTRITIONAL AND CULTURAL TREATMENTS ON SEED PRODUCTION OF WINTER GROWN SUNFLOWER.

R.C. SAMUI, P. BHATTACHARYYA and A. ROY
Department of Agronomy, Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani, Nadia, West Bengal, India.

ABSTRACT

An experiment on sunflower to study the effect of soil and foliar application of N and K (60 kg N and 40 kg K_2O ha^{-1}) and cultural treatments (inter cultivation, mulching and herbicide application) was carried out in a split plot design with three replications in the University farm during 1978 — 79 and 1979 — 80 winter seasons. Application of N and N with K significantly increased seed yield, stalk yield and oil yield over the control. Application of K either to soil or foliage also significantly increased seed and oil yield. Highest seed and oil yield was found with soil application of N with K. Thousand seed weight, number of filled seeds and head diameter was increased due to application of N and N with K. Intercultivation significantly increased seed, stalk and oil yield and influenced yield attributes over other cultural treatments, followed by mulching and herbicide application.

INTRODUCTION

Oilseed crops play an important role in the agricultural economy in India. To meet the acute shortage of oilseeds in this country, sunflower has been introduced as a potential oilseed crop. Commercial cultivation of sunflower in India has not yet become possible because of problems with the crop including the production of a sterile zone in the centre of the head, large yield fluctuation, poor seed setting, production of hollow or partly filled seeds and bird damage.

Several workers have reported the beneficial effect soil and foliar application of N on yield and yield-contributing characters of sunflower (Simanskii, 1961; Singh *et al.*, 1975). Fabian-Galan, 1971 and Sobachkin (1974) agreed that K deficiency caused disturbances in N and carbohydrate metabolism and also delayed the translocation of assimilate in sunflower. Application of N, P, K led to an increased seed yield in sunflower (Galgoczi, 1968, 1969). Johnson (1972) reported the favourable effect of intercultivation and herbicide application on the seed yield of sunflower.

Information on desirable agronomic practices for sunflower under conditions in West Bengal is scanty. This investigation was carried out to study the effect of nutritional and cultural treatments on yield and yield components of sunflower.

MATERIALS AND METHODS

The experiment was conducted in split plot design with three replications at the University farm during winter seasons of 1978 — 79 and 1979 — 80. Plot size was 4 m x 3 m. The variety E.C.68414 (Peredovik) was sown at the end of November and was harvested by the 3rd week of March during both the years. Seed rate was 10 kg ha^{-1} and the seeds were treated with Brassicol, Brestanol and BHC before sowing. There were 7 main plot treatments combinations — control (without N and K), Nitrogen at 60 kg/ha as urea, potassium at 40 kg ha^{-1} as K_2SO_4 and their combinations (Nitrogen + Potassium) were applied both to the soil and foliage of sunflower. In case of the soil application, half of the dose of nutrients was applied at the time of sowing and the remaining half was applied one month after sowing. In the foliar treatments, nutrients were applied in 4 equal parts at 45, 60, 75 and 90 days after sowing. The concentrations of spray solutions were 1.85 percent urea, 1.23 percent potassium sulphate and in the case of combined application it was 3.0 percent. Lime was used to neutralize free acidity of the spray solution during spraying of nutrients. Subplot treatments were control, intercultivation (3 times at 2, 4 and 6 weeks after sowing), mulching with paddy straw (at 2 tonnes ha^{-1}) and herbicide application (twice at 3 and 5 weeks after

sowing). Herbicide used was Ansar-529 (Monosodium acid methyl arsenate) as post emergence application (directed spray) at 5 litre ha^{-1} in 600 litre of water ha^{-1}.

Phosphorus at 40 kg P_2O_5 ha^{-1} as superphosphate was applied as basal dressing in all the plots. The soil of the experimental site was a sandy loam, having a pH of 7.2, organic carbon of 0.50 percent, total nitrogen of 0.10 percent, available P_2O_5 (Olsen) 35 kg ha^{-1} and available K_2O ($N.NH_4OAC$) 116 kg ha^{-1}). Petroleum either (60 —80°C) B.P.) was used to extract oil from crushed seed by a solvent extraction method using Soxhlet's apparatus.

RESULTS

I. Effect on seed yield.

It is apparent from Table 1 that both soil and foliar application of N or N with K significantly increased the seed yield of sunflower over the control in both years. Combined soil application of N with K also outyielded (2.21 t ha^{-1}) the combined foliar application (1.99 t ha^{-1}) in the 1978 — 79 experiment and in the pooled analysis. Application of K and N with K either to soil or to foliage was found to increase the seed yield significantly over the control during 1978 — 79 and in the pooled data.

Cultural treatments (*viz.* intercultivation, mulching and herbicide application) significantly increased the seed yield of sunflower over the control (without any cultural treatments) in both years experiments as well as in the pooled analysis. Both intercultivation and mulching produced significantly higher yield over herbicide application and again intercultivation gave significantly higher yield over mulching (Table 1).

Table 1. Effect of nutritional and cultural treatment on yield (t ha^{-1}) of sunflower.

Treatments	Seed yield (t ha^{-1})			Stalk yield (t ha^{-1})		
	1978 — 79	1979 — 80	Pooled	1978 — 79	1979 — 80	Pooled
Main Plot						
Control (w/out N, K)	1.40	1.22	1.31	2.03	1.71	1.87
N soil	1.78	1.52	1.65	3.94	3.48	3.71
N foliar	1.69	1.47	1.58	3.38	3.08	3.23
K soil	1.52	1.33	1.42	2.60	1.91	2.26
K foliar	1.53	1.36	1.44	2.53	2.02	2.27
N, K soil	2.21	1.61	1.91	3.91	3.60	3.75
N, K foliar	1.99	1.53	1.76	3.26	3.20	3.23
S.E.	0.032	0.057	0.031	0.268	0.079	—
Sub-Plot						
Control (cultural)	1.37	1.21	1.29	2.52	1.95	2.24
Intercultivation	2.06	1.60	1.82	3.37	2.58	2.98
Mulching	1.92	1.54	1.73	3.25	2.27	2.76
Herbicide application	1.58	1.38	1.48	3.21	2.06	2.64
S.E.	0.016	0.037	0.021	0.106	0.044	—

II. Effect on stalk yield.

Soil and foliar application of N and N with K significantly increased the stalk yield of sunflower over that of the control in both the winter experiments and stalk yield was found to be doubled by combined soil application of N with K (Table 1). Intercultivation, mulching and herbicide application significantly increased the stalk yield over the control in both the winter experiments (Table 1). Intercultivation was found to produce significantly higher yield than mulching or herbicide application (Table 1).

III. Effect on yield attributing characters.

Soil and foliar application of N alone and N combined with K significantly influenced the 1,000 seed weight in the 1979 — 80 experiment only. N with or without K also increased the head diameter and number of filled seeds per head in both years and also reduced the number of unfilled seeds per head over no nutrient application during both years. Of the two methods of applications, combined soil application of N with K always appeared to be superior to combined foliar application of N with K, the increase being statistically significant in case of head diameter and number of filled seeds per head (Tables 2a and 2b).

Tables 2(a) and 2(b) clearly show that soil and foliar application of K significantly increased the head diameter, 1,000 seed weight (1979 — 80 only), number of filled seeds and caused a significant reduction in the number of unfilled seeds per head over the control. Among the three cultural treatments, intercultivation significantly increased the head diameter over control in both years as well as in the pooled data, 1,000 seed weight and number of filled seeds per head in 1979 — 80 experiment only and it also significantly reduced the number of unfilled seeds per head over the control in 1978 — 79 experiment. The mulching treatment gave a significant reduction in number of unfilled seeds per head over control in both the winter experiments (Tables 2a and 2b). The herbicide treatment showed some positive effects on sunflower yield components but the effects were less pronounced than those induced by intercultivation and mulching.

Table 2a. Effect of nutritional and cultural treatments on Sunflower 1,000 seed weight (gm) and head diameter (cm).

Treatments	1000 seed weight (gm) 1978 — 79	1979 — 80	Pooled	Head diameter (cm) 1978 — 79	1979 — 80	Pooled
Main Plot						
Control (w/out N, K)	54.03	55.41	54.72	11.74	10.54	11.14
N soil	59.66	62.79	61.22	16.43	15.54	15.98
N foliar	62.51	63.01	62.76	15.67	13.67	14.67
K soil	55.90	59.95	57.92	13.81	12.36	13.08
K foliar	56.88	61.92	59.40	13.79	11.77	12.78
N, K soil	62.20	62.24	62.22	16.58	15.70	16.14
N, K foliar	60.72	63.32	62.02	14.76	12.96	13.86
S.E.	n.s.	0.91	1.66	0.52	0.39	0.38
Sub-Plot						
Control (cultural)	57.45	57.23	57.34	13.92	11.58	12.75
Intercultivation	58.59	63.49	61.04	15.50	14.83	15.16
Mulching	58.51	62.59	60.55	14.79	13.84	14.31
Herbicide application	57.39	61.62	59.50	14.52	12.63	13.57
S.E.	n.s.	0.52	0.42	0.31	0.22	0.22

Table 2b. Effect of nutritional and cultural treatments on number of filled and unfilled seeds/heads of sunflower.

Treatments	Number of filled seeds/head 1978 — 79	1979 — 80	Pooled	Number of unfilled seeds/head 1978 — 79	1979 — 80	Pooled
Main Plot						
Control (w/out N, K)	425.88	308.88	366.98	273.42	255.17	264.29
N soil	565.85	379.33	472.59	193.33	240.82	217.33
N foliar	453.54	342.25	397.89	174.35	220.83	197.59
K soil	484.25	330.42	407.33	188.94	184.92	186.93
K foliar	484.81	327.50	404.15	194.48	206.17	200.32
N, K soil	601.38	351.92	476.65	210.00	194.33	202.16
N, K foliar	485.46	338.83	412.14	216.48	194.50	205.49
S.E.	16.60	7.74	9.89	9.13	7.62	—
Sub-Plot						
Control (cultural)	483.81	300.10	391.95	227.19	226.33	226.76
Intercultivation	517.64	389.76	453.70	202.44	208.81	205.42
Mulching	496.43	351.86	424.14	183.92	197.24	190.58
Herbicide application	504.50	317.33	410.91	216.29	222.90	219.59
S.E.	n.s.	7.38	8.85	7.16	7.26	—

IV. Effect on oil percent and oil yield.

None of the nutritional treatments had any significant beneficial effect on oil content in seed. The pooled analysis suggested slight increases in oil percentage from combined N/K fertilizers and intercultivation (Table 3).

Table 3. Effect of nutritional and cultural treatments on oil percent and oil yield (t ha^{-1}) in sunflower.

Treatments	Oil percent 1978 — 79	1979 — 80	Pooled	Oil yield (t ha^{-1}) 1978 — 79	1979 — 80	Pooled
Main Plot						
Control (w/out N, K)	40.0	39.1	39.5	0.56	0.47	0.51
N soil	40.5	39.3	39.9	0.72	0.59	0.65
N foliar	40.9	39.1	40.0	0.69	0.57	0.63
K soil	40.0	39.6	39.7	0.61	0.52	0.56
K foliar	40.0	39.8	39.9	0.61	0.54	0.57
N, K soil	41.5	40.8	41.2	0.91	0.65	0.78
N, K foliar	40.8	40.6	40.7	0.81	0.62	0.71
S.E.	n.s.	n.s.	n.s.	0.01	0.02	0.01
Sub-Plot						
Control (cultural)	40.2	38.9	39.6	0.55	0.47	0.51
Intercultivation	41.3	40.2	40.7	0.84	0.64	0.74
Mulching	40.5	39.9	40.2	0.77	0.61	0.70
Herbicide application	40.3	39.9	40.1	0.63	0.55	0.60
S.E.	n.s.	n.s.	n.s.	0.008	0.014	0.008

Oil yield (t ha^{-1}) followed the same trend as was observed in seed yield. Soil and foliar application of N alone and N combined with K significantly increased the oil yield of sunflower over the control in both years. Soil and foliar application of K significantly increased the oil yield of sunflower over the control in 1978 — 79 only. In general, soil applications were better than foliar applications. All the cultural treatments (viz. intercultivation, mulching and herbicide application) were found effective in increasing the oil yield significantly over the control during both years. Intercultivation produced the highest oil yield (.74 t ha^{-1}) followed by mulching (0.70 t ha^{-1}) and herbicide application (0.59 t ha^{-1}).

DISCUSSION

Seed yield of sunflower was significantly increased by soil and foliar application of either N alone and N combined with K (Table 1) in both years. Such increases in seed yield might have resulted from the corresponding improvement in the yield components (Table 2a and 2b) through the beneficial roles played by the applied nutrients in photosynthesis, carbohydrate metabolism and translocation of assimilates from source to sink. Yadav *et al.,* (1964) noted that increases in the number of filled seeds per plant and weight of seeds per plant were involved in yield improvement in safflower. Numerous workers have also reported the beneficial effect of N applied either alone or in combination with K to the soil or fed through foliage in increasing the yield of sunflower crop (Simanskii, 1961; Singh *et al.,* 1977; Galgoczi, 1968 and 1969).

Application of K either to soil or to foliage led to an increase in the seed yield with corresponding increases in head diameter and also a reduction in the number of unfilled seeds per head (Tables 2a and 2b). Such improvement in the yield components might have resulted from improved synthesis of carbohydrate and its translocation to the seeds. Fabian-Galan (1971) and Sobachkin (1974) observed that K deficiency caused disturbances in N and carbohydrate metabolism and also delayed the translocation of assimilates.

Cultural treatments like intercultivation, mulching and herbicide application might have created less competition between weeds and the sunflower crop for light, moisture and nutrients. This would improve the effective utilization of applied nutrients and soil moisture by the crop and ultimately increase the seed yield (Table 1). Johnson (1972) reported that seed yield of sunflower was found to be increased considerably by intercultivation and herbicide application. Garg and Bhan (1978) also stated that practice of intercultivation and mulching helped in reducing the loss of moisture from the soil surface due to evaporation and weed growth and there by considerably increased the yield of mustard (brown Sarson).

Application of N, K or N and K together, either to soil or to foliage enhanced the vegetative growth and development as well as the total dry matter production and thereby increased the stalk yield of sunflower in both years. Such results corroborate the findings of Bhan (1976). Cultural treatments also increased the stalk yield of sunflower through increased dry matter production by effective utilization of applied nutrients and water.

Since oil percent in seeds was not greatly affected by the application of N, the significant increase in oil yield (Table 3) was only due to corresponding increases in seed yield (Table 1). Tomov (1976) also obtained increased oil yield due to N fertilization. Our results (Table 3) indicated that lipid synthesis in the seeds of sunflower was probably enhanced appreciably with both soil and foliar application of N plus K. Cultural treatments were found to increase the seed yield as well as the oil content in seeds which ultimately increased the total oil yield.

ACKNOWLEDGEMENT

The authors are grateful to the Council of Scientific and Industrial Research, New Delhi, for awarding a Senior Research Fellowship to the second author and also to the Head, Department of Agronomy for providing necessary facilities.

LITERATURE CITED

SIMANSKII, N.K. 1961. The effect of fertilizers on yield and oil content of sunflower seeds. *Agrobiologija* 6:849 — 853.

GALGOCZI, J. 1968. 3 years results of sunflower fertilization trials on sandy soils in Szaboles county. *Novenytermeles* 17:35 — 47.

GALGOCZI, J. 1969. 3 years results of foliar fertilization of sunflower on sandy soils of county Szaboles, Hungary. *Novenytermels* 18:13 — 25.

BURNES, E.R. 1970. Headsize of sunflower as an indicator of plot yields. *Agronomy Journal* 62:112.

FABIAN-GALAN, G. 1971. P & K influence on photosynthesis and its products in sunflower leaves. *Revue Ronmaine de Biologie Botanique* 16:357 — 363.

JOHNSON, B.J. 1972. Sunflower can be grown with minimum cultivation. *Georgia Agricultural Research* 13:6 — 7.

SOBACHKIN, A.A. 1974. The physiological role of K in increasing the productivity of farm crops. *Pot. Res. and Agr. Prod. int. Nat. Pot. Inst.* 147 — 152.

YADAV, S.C., MANDLOI, K.K and RITHI, G.S. 1974. Effect of N and P on yield and yield attributes of Safflower. J.N.K.V.V. *Research Journal* 8:143 — 145.

GAUR, B.L., TOMER, D.S. and DUNGARWAL, H.S. 1975. The efficacy of different methods of N applications in sunflower. *Indian Journal of Agronomy* 20:188 — 189.

BHAN, S. 1976. Agronomic practices for sunflower in Uttar Pradesh. *Indian Farming* 26:21 — 22.

TOMOV, T. 1976. Effect of fertilizers on oil content in sunflower seeds. *Agrokhimiva* 11:65 — 71.

SINGH, R.A., SINGH, O.P., SHARMA, H.C. and SINGH, MAHATIM 1977. Effects of levels of N and P on yields, oil content and moisture use pattern of rainfed winter sunflower. *Indian Journal of Agricultural Sciences* 47:96 — 99.

GARG, T.S. and BHAN, S. 1978. Rapeseed and mustard production in India. *Indian Farming* 27:13 — 18.