Plant Archives Vol. 19, Supplement 1, 2019 pp. 526-533 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

RESPONSE OF SUNFLOWER TO INTEGRATED NUTRIENT AND WEED MANAGEMENT PRACTICES ON WEEDS, GROWTH AND YIELD, QUALITY AND NUTRIENT UPTAKE

Kalaiyarasan, C., V. Vaiyapuri, K.Suseendran and S.Jawahar
Department of Agronomy, Faculty of Agriculture
Annamalai University, Annamalai Nagar, Tamil Nadu– 608 002, India
Corresponding Author: kalai77.agri@gmail.com

Abstract

The field experiments were made in irrigated sunflower to optimise the integrated nutrient and weed management practices for augmenting sunflower productivity, at Annamalai University Experimental Farm, Annamalai Nagar, Tamilnadu, India. The experiment was laid out in split plot design with three replications. The details of the treatment in mainplots are M_1-Control, M_2-RDF (40:20:20 kg NPK ha^{-1}) + FYM @ 12.5 t ha^{-1}, M_3-RDF+ Vermicompost @ 5 t ha^{-1} + seed treatment with Azospirillum (600 g ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of 1% KH_2PO_4 (twice at 25 and 55 DAS), M_4- RDF + FYM @ 12.5 t ha^{-1} + seed treatment with Azospirillum (600 g ha^{-1})+ $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of 1% KH_2PO_4 (twice at 25 and 55 DAS) M_5-RDF+ Vermicompost @ 5 t ha^{-1} + seed treatment with Azospirillum (600 g ha^{-1})+ $ZnSo_4$ @ 25 kg ha^{-1} and M_6- RDF+ FYM @ 12.5 t ha^{-1} + seed treatment with Azospirillum (600 g ha^{-1})+ $ZnSO_4$ @ 25 RDF+ FYM @ 12.5 t ha^{-1} + seed treatment with Azospirillum (600 g ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1}and the subplots are S_1- Unweeded control, S_2- Pre emg. Oxyflourfen @ 0.1 kg ha^{-1} + HW at 30 DAS, S_3- Pre sowing fluchloralin @ 1 kg ai ha^{-1} + HW at 30 DAS, S_4- Pre emg. Pendimethalin @1 kg ai ha^{-1}+ HW at 30 DAS and S_5- HW twice at 15 and 30 DAS. The results of the study evidently proved that application of recommended NPK+ vermicompost +Azospirillum+ $ZnSO_4$ + foliar spray of KH_2PO_4 along with fluchloralin + HW at 30 DAS (M_3S_5) as an agronomically efficient, eco-friendly and economically viable technology for improving sunflower yield and quality. This treatment (M_3S_5) combination registered lowest values for weed density, nutrient removal by weeds, weed biomass and maximum weed control index and maximum values for growth and yield attributes and yield, quality and nutrient uptake of sunflower in both the crops.

Key words : Sunflower, weeds, growth and yield, quality and nutrient uptake.

Introduction

The cultivated sunflower (*Helianthus annus* L.) is an annual oilseed plant of *compositae* family. Sunflower competes in the "world oilseed complex" with the other three major oilseeds produced in the world viz., soybean, groundnut and rapeseed. India occupies a premier position in global oilseed scenario accounting for 19 percent area and 9 percent production which has undergone a dramatic change in recent years, wherein the oilseed sector becomes a net foreign exchange earner leading to yellow revolution. India has the fourth largest area under sunflower in the world. It's share in total world production is about 4% and accounts for 9% of the world average. However, the yield of 566 kg ha^{-1} is the lowest among the major sunflower producing countries in the world as against 1232 kg ha^{-1} (Seshadri Reddy *et al.*, 2002 and Hedge, 2006). Sunflower has many advantages over other oilseeds crops. The crop is endowed with short growth period, photo-sensitiveness and presence of high degree of poly unsaturated fatty acid (PUFA) content. The sunflower oil has a pleasant flavour and excellent keeping quality when refined. Cholesterol lowering factor constitutes around 85-90% of the total fatty acid (Silver *et al.*, 1984). Fertilizer application as the major input through which the productivity can be increased by exploiting varietal potential. Chemical fertilizers have had a substantial impact on yield increments in the recent past and are today an indispensable part of modern agricultural practices (Reddy and Raja Reddy, 2002). Integration of organic manures and biofertilizers with chemical fertilizers is more emphasised not only to boost the production of sunflower from limited land resource but also for its sustainability. There is need to promote use of organics in addition to inorganic fertilizers for sustained maintenance of soil fertility (Devidayal and Agarwal, 1999). Though sunflower has several adventures over other oilseed crops, its cultivation has not been expanded widely in India. The biggest problem in sunflower cultivation is the large percentage of hollow seeds in its capitulum thus reducing the total seed yield. Poor seed filling is reflected in terms of higher percentage of hollow seeds and lower test weight. This problem demands greater attention due to its effect on yield and quality. Sunflower responds very well to nitrogen, phosphorus and potassium fertilizers. However, nutrient supply through inorganic fertilizer alone had not enhanced yield level in sunflower due to poor to moderate seed setting. The successful production of sunflower crop requires efficient weed management also, to realise the maximum yield and net returns. Sunflower which grows slowly during its initial stage provides congenial environment for weed growth in abundance. The weeds cause drastic reduction in seed yield of sunflower upto 83% (Legha *et al*., 1992). The critical period of weed competition is upto 30 DAS in sunflower (Muthusankaranarayan *et al*., 1995). The most promising single approach to weed control in land reported is to combine manual, cultural and mechanical methods with herbicides (Yaduraju and Mishra, 2003).

Material and Methods

The field experiments were conducted to study the effect of integrated nutrient and weed management on sunflower at Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar (TN). The soil of experimental field was clayey loam with low in available nitrogen (212.4 kg ha^{-1}), medium in available phosphorus (28.3 kg ha^{-1}) and high in available potassium (348.1 kg ha^{-1}). The pH and E.C. were 7.5 and 0.45 dsm^{-1} respectively. The experiment was laid out in a split plot design with three replication. The details of the treatment in mainplots are M_1-Control, M_2-RDF(40:20:20 kg ha^{-1}) + FYM @ 12.5 t ha^{-1}, M_3-RDF+ Vermicompost @ 5 t ha^{-1}+seed treatment with Azospirillum (600 g ha^{-1})+ $ZnSO_4$ @ 25 kg ha^{-1}+ foliar spray of 1% KH_2PO_4 (twice at 25 and 55 DAS), M_4- RDF + FYM @ 12.5 t ha^{-1}+seed treatment with Azospirillum (600 g ha^{-1})+ $ZnSo_4$ @ 25 kg ha^{-1} + foliar spray of 1% KH_2PO_4 (twice at 25 and 55 DAS) M_5- RDF+ Vermicompost @ 5 t ha^{-1} + seed treatment with Azospirillum (600 g ha^{-1}) + $ZnSo_4$ @ 25 kg ha^{-1}, M_6- RDF+ FYM @ 12.5 t ha^{-1}+seed treatment with Azospirillum (600 g ha^{-1}) + $ZnSo_4$ @ 25 RDF+ FYM @ 12.5 t ha^{-1}+seed treatment with Azospirillum (600 g ha^{-1}) + $ZnSo_4$ @ 25 kg $ha^{-1}$and the subplots are S_1-Unweeded control, S_2- Pre emg. Oxyflourfen @ 0.1 kg ha^{-1} + HW at 30 DAS, S_3- Pre sowing fluchloralin @ 1 kg ai ha^{-1} + HW at 30 DAS, S_4- Pre emg. Pendimethalin @1 kg ai ha^{-1}+ HW at 30 DAS, S_5- HW twice at 15 and 30 DAS. Recommended dose of 40:20:20 kg of NPK ha^{-1} was applied. N was applied in the form of urea while phosphorus and potassium were applied in the form of SSP and MOP respectively. Entire dose of P_2O_5, K_2O and half of N was applied as basal and remaining "N" at 30 DAS. Weed management practices were carried out as per the treatment schedule. The pre emergence herbicides (Pendimethalin, oxyflourfen and metalachlor) at required quantities were taken and sprayed at 3 DAS using the hand operated knapsack sprayer fitted with a flood a jet nozzle. A spray volume of 500 litres of water was used per hectare.

Results and Discussion

Weeds (Table 1 and 2)

The nutrient management treatments significantly influenced the weed characters in sunflower. Among the nutrient management practices tried, the treatment M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) recorded lower weed population (378.20 and 448.60 m^{-2}) and (390.00 and 462.00m^{-2}), lesser weed biomass (97.23 and 107.26 kg ha^{-1}) and(104.34 and 102.47 kg ha^{-1}), higher weed control index (77.01 and 80.45 %) and (76.63 and 81.73 %) at 15 and 30 DAS in first and second crop respectively. This treatment also record lesser nitrogen removal by weeds (16.10 and 17.20 kg ha^{-1}), phosphorus removal by weeds (4.03 and 4.20 kg ha^{-1}), potassium removal by weeds (13.44 and 12.56 kg ha^{-1}) at 30 DASin first and second crop respectively. The reason for low weed population under these treatments might be due to better uptake of nutrients by the crop from the initial stage and did not provide enough time for the weeds to utilise the nutrients and other factors. Similar result was reported by Patel *et al*. (1995). This was followed by M_4 (RDF + FYM + Azospirillum + $ZnSO_4$ + KH_2PO_4). Highest values for weed density, weed biomass and nutrient removal were recorded in M_1(No NPK/ Organics).

Profound influence on weed count was noticed due to weed management treatments. Among the different weed management practices tried, S_3 (fluchloralin + HW at 30 DAS) registered the lowest weed count (263.83 and 279.16 m^{-2}) and (338.5 and 350.00m^{-2}), lowest weed biomass (89.12 and 95.01 kg ha^{-1}) and (79.21 and 85.2kg ha^{-1}), highest weed control index (78.93 and 78.72%) and (85.56 and 81.79%) at 15 and 30 DAS in first and second crop respectively.S_5 (HW twice at 15 and 30 DAS) recorded a lesser nutrient removal nitrogen removal by weeds (14.54 and 15.54 kg ha^{-1}), phosphorus removal by weeds (3.70 and 3.70 kg ha^{-1}) and potassium removal by weeds (13.52 and 12.62 kg ha^{-1}) at 30 DASin first and second crop respectively. It may be due to the efficiency of the sowing herbicide in supporting germination of weed seeds. This findings is in conformity with the studies of Vedharethinam (2004). The unweeded control (S_1) treatment recorded higher weed density, weed biomass, poor weed and maximum NPK removal the crops at all the stages. This is due to poor weed management.

Significant interactions were noticed between the nutrient and weed management practices in both the crops. The Interaction between nutrient management (M_3) with the weed management treatment (S_5) proved efficiency by registering lowest weed density, biomass, nutrient removal by weeds and maximum weed control index. This might be due to the herbicidal effect of fluchloralin might be due to the inhibition of cell division through tubulin inactivation mechanism which might have curtailed the density and growth of weeds Patel *et al*. (1995).

Crop Growth Attributes (Table 3)

Among the nutrient management practices tried, the treatment M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) recorded maximum plant height (145.34 cm) at harvest stage, leaf area index (6.46) at flowering stage and dry matter production (4449.13 kg ha^{-1}) at harvest stage the maximum values for growth attributes under M_3 might be production of vigorous plants due to synergistic and cumulative effect of organics and inorganics with micronutrient and foliar spray of KH_2PO_4 (Torray, 1976; Tomati *et al*., 1983). Lowest plant height, leaf area index and dry matter production recorded under M_1 (control) in all stages of crop growth. This is due to low uptake of nitrogen, phosphorus and potassium in this treatment due to absence of all the nutrients (Menaka, 2004).

Among the weed management treatments, S_5 (HW twice at 30 DAS) recorded maximum plant height (141.37 cm) at harvest stage, leaf area index (6.22) at flowering stage and dry matter production (4006.97 kg ha^{-1}) at harvest stage. The reason for the better performance of these treatments might be due to effective control of weeds, which might have reduced the stiff competition for nutrients, moisture, space and radiant energy and have encouraged higher uptake of nutrients and better utilization of other resources by the crop (Veenkateshchauhran, 2004). This was followed by the treatment S_3 (fluchloralin + HW at 30 DAS). The minimum values for plant height, leaf area index and dry matter production recorded under S_1 (unweeded control) in all stages of crop growth.

The Interaction effect between the nutrient and weed management on plant growth attributes is significant. Treatment M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) with S5 (HW twice at 30 DAS) maximum plant height, leaf area index (7.35) at flowering stage and dry matter production (4521.13 kg ha^{-1}) at harvest stage, root length (31.2cm), root volume (18.6 cm^{-3} $plant^{-1}$). Lowest plant height, leaf area index and dry matter production recorded under M_1S_1 (control) in all stages of crop growth.

This might be due to the effective interaction between the nutrient and weed management treatments, which could have increased the availability of better nutrition from vermicompost and other components along with the efficient control of weeds by the respective treatments. Similar trend of results was reported by Patel *et al*. (1994).

Yield Attrinuttes and Yield (Table 4)

Among the nutrient management practices tried M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) recorded maximum values for head diameter (18.5cm), total number of seeds $head^{-1}$ (866.2 $head^{-1}$), number of filled seeds $head^{-1}$ (513.7), seed filling percentage (94.8), test weight (7.73g), seed yield (1671 kg ha^{-1}) and stalk yield (5752 kg ha^{-1}) over other treatments. The appreciable increase obtained in growth parameters reflected in yield attributing characters and yield also (Kene *et al*., 1990). This might be also due to greater availability of nutrients and assimilate partitioning as reflected by higher NAR value which resulted in maximum hundred seed weight and seed yield (Yadava *et al.,* 1999). This was followed by M_4 (RDF + FYM + azospirillum + $ZnSO_4$ + KH_2PO_4). M_1 (control) recorded lower value for head diameter (14.03cm),total number of seeds $head^{-1}$ (827.18.$head^{-1}$), number of filled seeds $gead^{-1}$ (466.22), seed filling percentage, test weight (6.10g), seed yield (503kg ha^{-1}) and stalk yield.

Among the weed management treatments S_5 (HW twice at 30 DAS) registered higher head diameter (18.7cm), total number of seeds $head^{-1}$ (837.4 $head^{-1}$), number of filled seeds $head^{-1}$ (786.4), seed filling percentage (93.5), test weight (7.60g), seed yield (1201kg ha^{-1}) and stalk yield (5622kg ha^{-1}) over other treatments. This might be due to sustained availability of nutrients to the crop as a results of effective control of weeds at the appropriate crop growth stages. This was followed by S_3 (fluchloralin + HW at 30 DAS). Unweeded control (S_1) recorded lowest head diameter, total number of seeds $head^{-1}$, number of filled seeds $head^{-1}$, seed filling percentage ,test weight, seed yield and stalk yield. The Interaction effect between the nutrient and weed management was significant. Treatment M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) with S_5 (HW twice at 30 DAS) registered higher head diameter (20.31cm), total number of seeds $head^{-1}$ (946.21 $head^{-1}$), number of filled seeds $head^{-1}$ (929.25), seed filling percentage, test weight(8.13g), seed yield (1901kg ha^{-1}) and stalk yield (6225kg ha^{-1}) over other treatments. This was followed by M_3S_3 and lowest yield was recorded by M_1S_1 head diameter, total number of seeds $head^{-1}$, number of filled seeds $head^{-1}$, seed filling percentage, test weight, seed yield and stalk yield. These findings are in conformity with the findings of Babusasravanan (1992) in groundnut. These results indicated that integrated nutrient management under comparatively weed free environment can influence the sunflower yield components and seed yield significantly.

Quality Characters (Table 5)

Among INM practices, the highest oil content (39.18 %) and crude protein content (18.82%) was recorded in M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) over the treatments. This might be due to increased availability and uptake of nutrients by sunflower in vermicompost applied plots, the spray ofKH_2PO_4, micronutrients along with RDF played significant role in enhancing the glucoside content in seed resulted in higher oil content (Krishnamoorthy and Madhan, 1996). The lowest oil content (37.30 %) and crude protein content was noticed in M_1.This might be due to lesser availability and uptake of nutrients for the oil and protein synthesis in the crop (Renugadevi and Balamurugan, 2002).

Among the weed management treatments S_5 (HW twice at 30 DAS) registered maximum oil content (38.95%) and crude protein content (18.78%) over other treatments. The lowest oil content and crude protein content was noticed in S_1. This might be due to efficient control of weeds in both the crops (Mani, 1986).

The Interaction effect between the nutrient and weed management was significant on oil content and no significant in protein content. The treatment combination of M_3S_5 recorded higher quality characters in crops.

This results indicates that good nutrition under comparatively weed free environment had enhanced the quality of sunflower seeds. Similar findings was reported by Singh and Giri (2001).

Nutrient Uptake (Table 6)

Among INM practices, M_3 (RDF + vermicompost + azospirillum + $ZnSO_4$ + KH_2PO_4) recorded highest uptake of 100.68, 26.80 and 96.28 kg ha^{-1} of N, P and K in the crops. This was followed by M_4 (RDF + FYM + azospirillum + $ZnSO_4$ + KH_2PO_4). This might be due to the better soil environment offered by the cumulative and synergeistic effect of organic and inorganic same of the nutrients and increased microbial activity in vermicompost applied plots and consequent nitrate accumulation in sunflower (Roy *et al*., 1994). The lowest uptake registered by the treatment, which recorded an uptake of 50.80, 13.18 and 45.96 kg ha^{-1} of N, P and K in the crop.

Among the weed management treatments S_5 (HW twice at 30 DAS) registered maximum uptake of 94.14, 25.01and 90.76 kg ha^{-1} of N, P and K in the crops. This could be due to weed free environment provided during the critical period of the crop growth (Poonguzhalan, 1993). The unweeded control recorded the minimum nutrient uptake of 59.52, 15.99 and 54.72 kg ha^{-1} of N, P and K in the crops.

The Interaction effect between the nutrient and weed management was significant on nutrient uptake. The treatment combination of M_3S_5 recorded highest uptake of 126.96, 33.81 and 114.89 kg ha^{-1} of N, P and K in the crops.

These results indicate that good nutrition under comparatively weed free environment might have enhanced higher nutrients uptake by the crop.

Table 1: Effect of integrated nutrient and weed management practices on weed characters of sunflower

Treatments	Mean Weed population (M^2)				Weed biomass (Kg ha^{-1})			
	I Crop		II Crop		I Crop		II Crop	
Main Plot	**15 DAS**	**30 DAS**	**15 DAS**	**30 DAS**	**15 DAS**	**30 DAS**	**15 DAS**	**30 DAS**
M_1	417.00 (20.29)	529.60 (22.84)	448.40 (21.03)	543.40 (23.14)	387.7	435.7	384.8	436.5
M_2	403.60 (19.95)	516.00 (22.54)	420.80 (20.38)	532.20 (22.89)	345.9	386.6	343.1	388.25
M_3	378.20 (19.25)	448.60 (20.97)	390.00 (19.56)	462.00 (21.30)	97.23	107.3	104.3	102.5
M_4	386.00 (19.47)	456.60 (21.18)	401.00 (19.86)	469.00 (21.47)	134.5	115.9	116.6	114.6
M_5	394.00 (19.69)	486.20 (21.84)	411.00 (20.12)	495.20 (22.04)	303.2	356.6	317.9	360.6
M_6	397.40 (19.79)	503.40 (22.23)	414.80 (20.23)	517.80 (22.56)	328.3	374.4	327.8	367.9
SEd	0.038	0.41	0.55	0.05	3.90	1.95	4.88	3.96
CD (P=0.05)	0.08	0.093	0.12	0.12	7.85	3.92	7.70	7.96
Sub Plot								
S_1	505.83 (22.49)	695.16 (26.36)	524.16 (22.90)	710.66 (26.55)	422.9	548.73	446.7	560.9
S_2	393.00 (19.81)	573.66 (23.94)	422.16 (20.50)	588.66 (24.25)	291.9	416.87	301.3	412.9
S_3	263.81 (16.24)	373.33 (19.50)	279.16 (16.71)	386.00 (19.63)	89.1	108.9	95.0	96.4
S_4	310.83 (17.64)	469.66 (21.67)	326.33 (18.07)	481.00 (21.93)	180.6	326.6	165.2	319.8
S_5	506.66 (22.51)	338.50 (18.39)	519.83 (22.80)	350.00 (18.70)	346.0	79.2	307.2	85.3
S.Ed	0.05	0.05	0.073	0.005	2.76	1.38	3.45	3.26
CD (P=0.05)	0.101	0.11	0.14	0.011	6.16	3.08	9.82	

Table 2: Effect of integrated nutrient and weed management practices on weed control index (WCI) and Nutrient removal by weeds on Sunflower

Treatments	WCI (%)				Nutrient removal by weeds (kg ha^{-1}) at 30 DAS					
	I Crop		II Crop		I Crop			II Crop		
Main plot	15	30 DAS	15	30 DAS	N	P	K	N	P	K
M_1	8.33	20.60	13.85	22.18	22.7	5.51	19.94	23.9	5.73	18.5
M_2	18.22	29.55	23.19	30.77	18.1	4.68	16.93	19.5	4.64	15.64
M_3	77.01	80.45	76.63	81.73	16.1	4.03	13.44	17.2	4.20	12.6
M_4	68.19	78.87	73.90	79.56	16.7	4.19	15.78	17.8	4.35	14.8
M_5	28.31	35.01	28.83	35.76	17.0	4.29	15.86	18.2	4.42	14.9
M_6	22.38	31.76	26.61	34.40	17.4	4.43	16.06	18.8	4.50	15.02
S.Ed					0.078	0.09	0.0039	0.043	0.011	0.017
CD (P=0.05)					0.157	0.019	0.007	0.086	0.023	0.0035
Sub Plot										
S_1	-	-	-	-	28.7	6.72	25.09	29.9	6.86	23.7
S_2	30.97	24.03	32.55	26.37	17.1	4.56	15.45	18.7	4.66	14.2
S_3	78.93	30.16	78.72	82.81	14.8	3.76	13.72	15.9	3.92	12.8
S_4	57.29	41.047	63.01	42.97	15.0	3.85	13.90	16.1	4.0	12.9
S_5	18.19	85.56	31.22	84.79	14.5	3.70	13.52	15.5	3.76	12.6
S.Ed					0.055	0.006	0.0027	0.030	0.008	0.0012
CD (P=0.05)					0.123	0.015	0.006	0.067	0.018	0.0027

Table 3 : Effect of integrated nutrient and weed management practices on growth attributes of sunflower

Treatments	Plant height (cm) (At harvest)		LAI (At flowering)		DMP (Kg ha^{-1}) (At harvest)		Root length (cm) (At 60 DAS)		Root volume (Cm^{-3}/ plant) (At 60 DAS)	
	I	II	I	II	I	II	I	II	I	II
Main plot										
M_1	103.0	79.9	4.15	4.06	3297	2954	20.5	18.2	13.7	12.9
M_2	125.8	105.0	5.41	5.28	3958	3637	25.1	22.8	15.9	15.4
M_3	145.3	124.9	6.46	6.31	4449	4103	27.9	26.2	17.2	16.9
M_4	138.6	118.6	6.10	6.03	4291	3953	26.4	24.5	16.6	16.4
M_5	135.6	116.2	5.95	5.88	4230	3898	26.0	24.2	16.4	16.2
M_6	131.7	112.1	5.75	5.65	4099	3756	25.6	23.9	16.2	15.9
S.Ed	0.409	0.37	0.002	0.003	14.9	16.3	0.19	0.15	0.043	0.048
CD (P=0.05)	0.91	0.84	0.051	0.01	29.8	32.7	0.39	0.32	0.088	0.098
Sub Plot										
S_1	111.8	88.9	4.69	4.64	3509	3250	22.3	20.8	14.7	14.1
S_2	121.9	101.7	5.27	5.15	3848	3481	24.2	21.9	15.4	15.1
S_3	139.1	118.9	6.08	5.98	4219	3951	26.5	24.8	16.7	16.3
S_4	135.9	116.4	5.93	5.81	4220	3879	26.2	24.4	16.5	16.1
S_5	141.4	121.3	6.22	6.09	4402	4006	27.0	25.4	16.9	16.5
S.Ed	0.213	0.07	0.018	0.003	12.7	14.1	0.20	0.09	0.036	0.039

Table 4: Effect of integrated nutrient and weed management practices on yield attributes of sunflower

Treatments	50% flowering		Head diameter (cm)		Total no. of seeds head^{-1}		Number of filled Seeds head^{-1}		Seed filling^{-1}	
	I	II	I	II	I	II	I	II	I	II
Main Plot										
M_1	56.0	58.5	14.0	13.8	578.7	479.8	466.2	365.6	79.5	78.8
M_2	51.8	52.8	16.4	16.2	753.7	643.5	683.5	574.7	90.4	89.1
M_3	50.2	50.9	18.5	18.2	866.2	774.0	513.7	721.2	94.8	93.7
M_4	50.8	51.5	18.1	17.8	826.1	734.3	770.9	676.5	93.0	91.8
M_5	51.0	51.7	17.8	17.4	814.0	718.7	753.2	651.8	92.6	91.3
M_6	51.4	52.3	17.2	17.0	785.6	678.9	723.7	614.4	92.0	90.1
S.Ed	0.25	0.029	0.005	0.0057	3.82	3.44	2.29	1.48	0.058	0.054
CD (P=0.05)	0.51	0.06	0.0112	0.0166	8.53	6.92	4.61	2.98	0.126	0.109
Sub Plot										
S_1	53.9	55.9	14.7	14.6	648.3	546.4	544.3	453.5	83.0	82.1
S_2	52.3	53.8	15.8	15.6	727.3	622.7	653.7	544.9	89.7	88.0
S_3	50.9	51.9	18.41	17.9	827.2	731.4	772.2	676.8	93.2	91.9
S_4	51.3	51.9	18.44	17.6	814.1	712.2	752.9	653.5	92.5	91.3
S_5	50.7	51.4	18.7	18.1	837.4	744.9	786.4	691.4	93.5	92.2
S.Ed	0.19	0.024	0.004	0.0056	3.53	2.94	0.129	1.21	0.056	0.046
CD (P=0.05)	0.39	0.05	0.009	0.0114	7.1	6.55	2.61	2.43	0.118	0.093

Table 5: Effect of integrated nutrient and weed management practices on yield and quality of sunflower

Treatments	Test Wt. (g)		Seed yield (1 Kg ha^{-1})		Stalk yield (Kg ha^{-1})		Oil Content (%)		Protein Content %	
	I	II	I	II	I	II	I	II	I	II
Main Plot										
M_1	6.10	6.07	503	489	4279	4121	37.30	37.31	18.26	17.14
M_2	7.29	7.28	826	817	5160	5054	38.48	38.34	18.63	17.61
M_3	7.73	7.70	1671	1591	5752	5536	39.18	39.03	18.82	18.04
M_4	7.58	7.56	1263	1212	5550	5368	38.83	38.81	18.75	17.90
M_5	7.51	7.48	182	1085	5471	5311	38.73	38.68	18.73	17.85
M_6	7.41	7.39	988	979	5326	5187	38.63	38.50	18.69	17.76
S.Ed	0.020	0.019	22.96	16.37	17.46	83.94	0.0069	0.0029	0.0079	0.003
CD (P=0.05)	0.041	0.04	46.24	32.91	34.97	19.93	0.014	0.006	0.016	0.006
Sub Plot										
S_1	6.60	6.58	833	801	4644	4544	37.79	37.74	18.45	17.27
S_2	7.13	7.10	1009	967	4987	4903	38.29	38.33	18.54	17.55
S_3	7.54	7.52	1169	1128	5546	5352	38.83	38.76	18.76	17.92
S_4	7.47	7.46	1116	1088	5483	5278	38.76	38.66	18.72	17.87
S_5	7.60	7.58	1201	1161	5622	5404	38.95	38.74	18.78	17.96
S.Ed	0.016	0.014	15.57	15.35	15.94	17.40	0.0059	0.0019	0.071	0.002
CD (P=0.05)	0.033	0.03	31.31	30.86	31.92	34.99	0.012	0.004	0.014	0.004

Table 6: Effect of integrated nutrient and weed management practices on nutrient uptake

Treatments	Nutrient uptake (Kg ha^{-1})					
	I Crop			II Crop		
	N	P	K	N	P	K
Main Plot						
M_1	50.8	13.2	45.9	46.2	12.2	42.1
M_2	74.1	19.6	71.9	71.9	19.3	69.7
M_3	100.7	26.8	96.3	96.7	25.4	91.1
M_4	88.3	23.8	85.4	86.1	23.3	82.1
M_5	84.9	22.9	80.5	82.9	22.4	78.3
M_6	79.9	21.5	76.8	78.2	21.1	73.4
S.Ed	0.78	0.27	0.21	0.58	0.32	0.97
CD (P=0.05)	1.57	0.55	0.43	1.17	0.62	1.96
Sub Plot						
S_1	59.4	15.9	54.7	56.8	15.3	50.8
S_2	69.1	18.3	63.6	66.7	17.3	60.7
S_3	90.6	24.3	87.5	87.4	23.5	84.6
S_4	85.7	23.1	84.2	82.9	22.6	80.6
S_5	94.1	25.0	90.8	91.3	24.4	87.2
S.Ed	0.55	0.19	0.15	0.41	0.22	0.69
CD (P=0.05)	1.23	0.43	0.33	0.92	0.49	1.54

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