Int.J.Curr.Microbiol.App.Sci (2017) *6*(7): 4315-4322

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 7 (2017) pp. 4315-4322**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.607.449

Growth and Yield of *Kharif* Sown Sunflower as Influenced by Plant Density and Nutrient Management

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Keywords

Kharif Sown, Sunflower, *Helianthus annuus.*

Article Info

Accepted:
29 June 2017
Available Online:
10 July 2017

A B S T R A C T

An attempt was initiated during two consecutive kharif seasons during 2015-16 and 2016-17 at the farm of the Tamil Nadu Agricultural University, Coimbatore to ascertain the response of plant density and nutrient management on hybrid sunflower (*Helianthus annuus* L.). The experiment comprised eleven treatments viz., 60 x 30 cm with single seedling and 100% RDF (T1), 60 x 30 cm with two seedling per hill and 150% RDF (T2), 60 x 30 cm with two seedling per hill and 200% RDF (T3), 60 x 45 cm with two seedlings per hill and 125% RDF (T4), 60 x 45 cm with two seedlings per hill and 150% RDF (T5), 45 x 45 cm with two seedling and 150% RDF (T6), 45 x 45 cm with two seedling with 200% RDF (T7), 45 x 30 cm with single seedling and 125% RDF (T8), 45 x 30 cm single seedling and 150% RDF (T9), 30 x 30 cm with single seedling and 150% RDF (T10), 30 x 30 cm with single seedling and 200% RDF (T11). The sowing density of 30 x 30 cm with single seedling and 200% had accumulated the highest amount of DMP which was 15% higher than the lower sowing density of 60 x 30 cm. The yield parameters like head diameter (cm), number of seeds per head, head weight, seed weight and seed volume weight were higher under the sowing density of 60 x 30 cm with single seedling and 100% RDF. The seed yield significantly higher by adoption of 30 x 30 cm with single seedling and application of 200% RDF. (Key words: Dry matter production, Head diameter, number of seeds per head, seed volume weight)

Introduction

Oil seeds play an important role in Indian agriculture as food and an industrial commodity. India is the largest producer of oilseeds in the world in terms of output and in terms of area (Rasool *et al.*, 2013). Among the oilseed crops, sunflower (*Helianthus annuus* L.) is an all-season crop. It is a crop with short duration and photo-insensitivity, suits well to rainy season (Thimmegowda *et al.*, 2007). Sunflower because of its quantity and quality of edible oil occupies an important position in the world among the new oil seed crops. Its ranked fourth among all oilseed crops of the world (Petcu *et al.*, 2010). It is the most important oilseed crop due to its wide adaptability and very high seed oil content ranging from 40 to 50 per cent, no cholesterol and high non saturated fatty acids content that ranged between 85-91%. Plant spacing effects are greatly prominent in various crops including sunflower because there is no option of filling gaps between plants by tillering and branching. Thus an appropriate plant stand may help in harnessing the entire renewable resources in a supplementary and proficient approach toward high crop yields. The increasing plant population in field incremental and negative effects were recorded on plant height and head diameter,

respectively (Mojiri and Arzani, 2003). Seed yield was increased up to a plant population of 85000 plants ha^{-1} while beyond this had a depressing outcome on production. Higher plant density produce taller plants, lighter seeds and more yield than low plant population (Beg *et al.,* 2003; Ullasa *et al.*, (2014). Nitrogen is a structural component of amino acids, protein and chlorophyll. Phosphorus is a constituent of ATP, ADP, nucleic acids and phospholipids. Potassium is involved in providing appropriate ionic environment for metabolic process, growth regulation, stomatal control, activation of enzymes and photosynthesis. Judicious application of N, P and K nutrient enhances the crop growth and development which helps in increasing seed yield, oil content. The greatest limitation for increasing the productivity of this crop is inadequate supply of nutrients and maintenance of optimum plant population. In view of above the present investigation was carried out to study the effect of plant density and nutrient management on growth and yield of sunflower.

Materials and Methods

A field experiments were conducted at Tamil Nadu Agricultural university, Coimbatore during *Kharif* season of2015-16 and 2016-17 to investigate the effect of planting density and nutrient management on growth, yield and quality of sunflower. The experimental site is geographically situated in the western agro-climatic zone of Tamil Nadu at 11° N latitude and 77° E longitude and at an altitude of 426.7 meters above mean sea level (MSL). The study was conducted in randomized block design and replicated thrice. The treatment comprised of 60x30 cm with single seedling and 100% RDF (T_1), 60x30 cm with two seedling per hill and 150% RDF (T_2), 60x30 cm with two seedling per hill and 200% RDF (T_3), 60 x 45 cm with two seedlings per hill and 125% RDF(T_4), 60 x 45 cm with two seedlings per hill and 150% RDF (T_5), 45 x 45 cm with two seedling and 150% RDF (T_6), 45 x 45 cm with two seedling with 200% RDF (T_7), 45 x 30 cm with single seedling and 125% RDF (T_8), 45 x 30 cm single seedling and 150% RDF (T_9), 30 x 30 cm with single seedling and 150% RDF (T_{10}), 30 x 30 cm with single seedling and 200% RDF (T_{11}). The soil of the experimental field was sandy clay loam in texture belonging to *TypicUstropept.* The nutrient status of the soil during start of the experiment was low in available nitrogen, medium in available phosphorus and high in available potassium. The field experiments were conducted during *kharif* (June – September) season of 2015 and 2016. The sunflower hybrid, TNAU Sunflower Hybrid CO2 was used as test crop. The recommended fertilizer dose followed for sunflower was 90:60:60 kgNPK ha^{-1}. Half dose of N and K and full dose of P were applied basally to all the treatments. The remaining N and K were top dressed at 30 DAS. The crop was harvested at maturity stage, seed yield per net plot of each treatment was recorded. Five plants were selected in each net plotarea for measuring nutrients uptake. The various biometric observations on 90 DAS, analytical data of plant sample and the computed data were subjected to statistical scrutiny as per the procedures given by (Gomezand Gomez, 1984). The treatment differences were worked out at five per cent probability level.

Results and Discussion

Growth parameters (Table 1)

Dry matter production (DMP) of sunflower plants at the harvest stage significantly influenced by plant density and nutrient management levels. Spacing of 30 x 30 cm with single seedling and 200% (T_{11}) was accumulated the highest amount of DMP (6938 kg/ha) which was 15% higher than the lower plant density of 60 x 30 cm. The data

suggest that the highest DMP recorded at the optimal planting geometry may be as a consequence of large canopy spread area and leaf area index. Effective utilization of natural resources such as water, soil nutrients and solar radiation would have supported the plants to gain greater net assimilation rate and produced higher DMP in 30 x 30 cm with single seedling and 200% (T_{11}). The results are in conformity with the findings of Singh and Pacheria (1981).

At 90 DAS significant influence on number of leaves per hill was observed during *kharif* and *rabi* season of 2015-16 and 2016-17. The treatment 60 x 30 cm with two seedlings per hill and application of 200% RDF significantly recorded 42.8 and 43.1 leaves per hill during *kharif*2015-16and*kharif*2016-17 respectively. This may be due to the two plants accommodated in a hill in the treatment resulted in higher number of leaves.

At harvest, T_1 (60 x 30 cm with single seedling and 100% RDF) significantly recorded higher stem girth of 3.90 cm and 4.17 cm during *kharif* 2015-16 and 2016-17 respectively. This was due to less competition between the plants which leads to the better utilization of available resources *viz.,* light, moisture and nutrients at optimum plant population. The lower stem girth was recorded at closer spacing due to the high competition between the plants for nutrient, moisture and light. These results are in concurrence with those of Vijayakumar and Ramesh (Vijayakumar and Ramesh, 2005). The root volume (68.3 and 74.3) and root dry weight (58.7 and 59.3 g) was higher under the 60x30 cm with single seedling and 100% RDF.

Growth analysis (Table 2)

The plant population favourably influenced the LAI and the high plant population (T_4) registered the higher LAI at all the stages. LAI of 16.37 and 16.55 during *kharif* 2015 and 2016 was recorded under T_4. Significant influence on CGR and RGR was observed during the course of investigation. The highest CGR and RGR value was recorded in T_{11}30 x 30 cm with single seedling and 200%. This may be due to the higher number of leaves per hill and higher leaf area per hill which reflected on the higher value of LAI. Moreover, wider space availability between the rows and optimum intra row spacing might have increased the root spread which eventually utilized the applied nutrients and water effectively, which reflected on higher leaf area and more number of leaves per hill and was due to the lesser value of spacing (900 cm^2) in numerator might have increased the CGR and RGR of the treatment.

Yield parameters and seed yield (Table 3 and 4)

During *kharif* season of 2015-16 and 2016-17, the T_1 (60x30 cm with single seedling and application of 100% RDF) recorded higher head diameter (33.1 cm and 32.4 cm respectively) as against the lower head diameter (16.5cm and 17.5 cm respectively) recorded in 45 x45 cm with two seedling per hill and application of 150% RDF (T_6). The same treatment registered higher number of seeds per head, 100 seed weight and seed volume weight.

This may be ascribed to the overall improvement in crop vigour and production of sufficient photosynthates owing to higher availability of nutrients (Ashwathi *et al.,* 1991). The sowing density and different nutrient levels had exerted a significant positive influence on seed yield of sunflower. Sunflower grown at 30x30 cm with single seedling and 200% RDF (T_{11}) produced higher seed yield (2992 and 3232 kg ha^{-1}) over 60x30 cm with single seedling and 100% RDF (T_1).

Table.1 Effect of planting density and nutrient management on number of leaves per hilland dry matter production (kg ha-1)at 90 DAS of sunflowerduring kharif season

		No. of leaves per hill		DMP (kg ha^{-1})	
	Treatment	**2015-16**	**2016-17**	**2015-16**	**2016-17**
T_1	**60 x 30 cm with single seedling with 100% RDF**	28.1	28.3	5631	6284
T_2	**60 x 30 cm with two seedling with 150% RDF**	42.8	41.6	8510	8954
T_3	**60 x 30 cm with two seedling with 200% RDF**	45.7	46.5	9285	9805
T_4	**60 x 45 cm with two seedling with 125% RDF**	37.0	37.1	6511	6897
T_5	**60 x 45 cm with two seedling with 150% RDF**	39.9	38.2	6535	7306
T_6	**45 x 45 cm with two seedling with 150% RDF**	34.1	32.2	7169	8502
T_7	**45 x 45 cm with two seedling with 200% RDF**	36.2	35.0	7432	8536
T_8	**45 x 30 cm with single seedling with 125% RDF**	27.0	26.5	6643	7573
T_9	**45 x 30 cm with single seedling with 150% RDF**	27.9	27.6	6712	7876
T_{10}	**30 x 30 cm with single Seedling with 150% RDF**	24.0	22.5	10057	10652
T_{11}	**30 x 30 cm with single Seedling with 200% RDF**	25.3	26.2	10826	11524
	SEd	1.3	1.4	411	426
	CD (0.05)	2.8	2.9	859	890

Table.2 Effect of planting density and nutrient management on stem girth (cm), root volume (cc) and root dry weight (g) of sunflower at 90 DAS during kharif season

		Stem girth (cm)		Root volume (cc)		Root dry mass (g)	
	Treatment	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
T_1	**60 x 30 cm with single seedling with 100% RDF**	6.75	7.18	68.3	74.3	58.7	59.3
T_2	**60 x 30 cm with two seedling with 150% RDF**	4.68	4.72	39.6	43.0	24.6	26.8
T_3	**60 x 30 cm with two seedling with 200% RDF**	4.97	5.02	41.1	44.7	25.2	27.4
T_4	**60 x 45 cm with two seedling with 125% RDF**	5.12	5.17	42.6	46.4	26.8	29.1
T_5	**60 x 45 cm with two seedling with 150% RDF**	5.15	5.23	45.2	49.1	26.9	29.3
T_6	**45 x 45 cm with two seedling with 150% RDF**	4.54	4.51	30.7	33.4	19.8	21.5
T_7	**45 x 45 cm with two seedling with 200% RDF**	4.63	4.67	32.7	35.5	22.7	24.7
T_8	**45 x 30 cm with single seedling with 125% RDF**	5.72	6.12	58.0	63.2	48.5	51.1
T_9	**45 x 30 cm with single seedling with 150% RDF**	6.23	6.64	62.9	68.4	54.5	55.1
T_{10}	**30 x 30 cm with single Seedling with 150% RDF**	5.18	5.44	49.6	52.8	39.5	43.1
T_{11}	**30 x 30 cm with single Seedling with 200% RDF**	5.20	5.56	53.3	57.9	43.5	47.1
	SEd	0.25	0.24	0.25	2.2	2.4	1.7
	CD (0.05)	0.52	0.51	0.51	4.6	5.1	3.6

Table.3 Effect of planting density and nutrient management on growth analytical parameters of sunflower during kharif season

		LAI		CGR ($g\ m^{-2}\ day^{-1}$)		RGR ($mg\ g^{-1}\ day^{-1}$)	
	Treatment	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
T_1	**60 x 30 cm with single seedling with 100% RDF**	6.44	6.58	2.33	2.02	2.21	2.43
T_2	**60 x 30 cm with two seedling with 150% RDF**	14.26	14.44	2.51	2.75	4.25	3.69
T_3	**60 x 30 cm with two seedling with 200% RDF**	16.37	16.55	2.60	3.15	4.65	5.32
T_4	**60 x 45 cm with two seedling with 125% RDF**	7.18	7.46	1.45	1.64	2.23	2.45
T_5	**60 x 45 cm with two seedling with 150% RDF**	8.16	8.25	1.68	1.69	2.28	2.50
T_6	**45 x 45 cm with two seedling with 150% RDF**	7.78	7.76	1.91	1.78	2.34	2.57
T_7	**45 x 45 cm with two seedling with 200% RDF**	9.28	8.64	2.02	2.19	2.47	2.72
T_8	**45 x 30 cm with single seedling with 125% RDF**	7.48	7.68	2.15	2.53	2.76	3.03
T_9	**45 x 30 cm with single seedling with 150% RDF**	7.96	8.72	2.42	2.54	2.95	3.24
T_{10}	**30 x 30 cm with single Seedling with 150% RDF**	6.02	6.78	2.76	3.41	5.25	5.81
T_{11}	**30 x 30 cm with single Seedling with 200% RDF**	10.16	10.20	3.38	3.74	5.68	6.24
	SEd	0.47	0.47	0.46	0.11	0.12	0.18
	CD (0.05)	0.99	0.98	0.97	0.23	0.25	0.37

Table.4 Effect of planting density and nutrient management on yield parameters of sunflower during kharif season

	Head diameter (cm)		No. of seeds $head^{-1}$		Head weight (g)		Seed volume weight (g)	
Treatment	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
T_1	33.1	32.4	1391	1356	24.3	24.9	38.5	38.4
T_2	20.9	19.5	924	933	15.2	15.0	28.5	28.5
T_3	21.4	21.3	941	950	15.7	15.6	29.1	28.5
T_4	21.8	22.0	957	966	16.3	16.2	29.1	28.7
T_5	23.7	22.7	977	986	16.8	16.8	29.5	29.2
T_6	16.5	17.5	871	850	13.8	14.1	26.8	24.2
T_7	18.2	19.0	891	900	14.2	14.8	28.3	24.7
T_8	27.5	25.5	1194	1145	21.0	21.5	33.4	32.9
T_9	30.2	28.2	1295	1250	22.7	23.1	36.1	35.7
T_{10}	24.8	24.2	987	997	18.2	18.3	30.1	29.7
T_{11}	26.7	25.0	1085	1038	18.5	19.9	30.3	30.2
SEd	1.1	1.2	46	46	0.7	0.7	1.3	1.4
CD (0.05)	2.3	2.4	95	96	1.6	1.6	2.7	2.9

Table.5 Effect of planting density and nutrient management on seed yield (kg ha-1)and nutrient uptake (kg ha-1) of sunflower during kharif season

Treatments	Seed yield (kg ha^{-1})		N Uptake (kg ha^{-1})		P Uptake (kg ha^{-1})		K Uptake (kg ha^{-1})	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	2035	2034	33.8	37.7	11.3	12.6	78	88
T_2	2249	2469	46.4	52.1	14.9	17.6	108	126
T_3	2489	2719	51.2	57.4	16.4	19.4	119	138
T_4	2041	2084	39.1	41.4	13.0	13.8	91	96
T_5	2050	2090	39.2	43.8	13.1	14.6	91	102
T_6	2062	2241	39.9	45.4	13.3	15.1	93	106
T_7	2084	2264	40.3	47.3	13.4	15.8	94.	110
T_8	2159	2364	43.0	48.5	14.3	17.1	100	118
T_9	2180	2466	44.6	49.1	14.9	17.2	104	120
T_{10}	2730	2971	55.0	62.1	18.0	21.3	131	149
T_{11}	2992	3232	61.2	69.1	20.4	23.0	142	161
SEd	114	115	2.2	2.5	0.7	0.7	5.4	5.2
CD (0.05)	238	240	4.6	5.2	1.5	1.6	10.7	10.9

The percentage increase of T_{11} over T_1 was 32% and 37% during *kharif*2015-16 and 2016-17 respectively. The increased yield in T_{11} (30x30 cm with single seedling and 200% RDF) might be due to higher number of plants per unit area, which contributed to more number of head per unit area. Moreover may be due to the optimum level of the nutrient elements in soil and their availability to sunflower crop during its all physiological growth and development stages (Ullasa *et al.*, 2014).

Nutrient uptake (Table 5)

Nutrient uptake pattern of sunflower hybrid has significantly affected by the sowing density and nutrient management levels. T_{11} (30x30 cm with single seedling with 200% RDF) significantly recorded higher nutrient uptake during *kharif* season 2015-16 and 2016-17. As the nutritional status of T_{11} plants was higher, the plants were enable to produce higher biomass and seed yield (Ishfaq *et al.*, 2009). The improved nutritional status of sunflower is mainly attributed to higher DMP and to a lesser extent caused by the increased N, P and K nutrient concentrations.

In conclusion, sowing density of 30 cm apart row to row and 30 cm plant to plant distances with single seedling and 200% RDF provided high productivity in sunflower hybrid SFH CO2. Therefore SFH CO2 should be planted with a 30x30 cm with single seedling and 200% RDF in order to exploit its maximum yield potential.

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How to cite this article:

Ravichandran, S., and Srinivasan, K. 2017. Growth and Yield of Kharif Sown Sunflower as Influenced by Plant Density and Nutrient Management. *Int.J.Curr.Microbiol.App.Sci.* 6(7): 4315-4322. doi: https://doi.org/10.20546/ijcmas.2017.607.449