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

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ABSTRACT

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 seedlings 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 and 200% RDF (T7), 45 x 30 cm with single seedling and 125% RDF (T8), 45 x 30 cm with 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)

Keywords
Kharif Sown, Sunflower, *Helianthus annuus*.

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. Judicial 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 of 2015-16 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 150% RDF (T\(_4\)), 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 Typic Ustropept. 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 plot area 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 (Gomez and 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% (T11). 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 2015-16 and 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, T1 (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 (T4) registered the higher LAI at all the stages. LAI of 16.37 and 16.55 during kharif 2015 and 2016 was recorded under T4. Significant influence on CGR and RGR was observed during the course of investigation. The highest CGR and RGR value was recorded in T11 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 cm²) 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 T1 (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 (16.5 cm and 17.5 cm respectively) recorded in 45 x 45 cm with two seedling per hill and application of 150% RDF (T6). 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 (T11) produced higher seed yield (2992 and 3232 kg ha⁻¹) over 60x30 cm with single seedling and 100% RDF (T1).
Table 1 Effect of planting density and nutrient management on number of leaves per hill and dry matter production (kg ha⁻¹) at 90 DAS of sunflower during kharif season

| Treatment                                      | No. of leaves per hill | DMP (kg ha⁻¹) |
|------------------------------------------------|------------------------|--------------|
| T₁ 60 x 30 cm with single seedling with 100% RDF | 28.1                   | 5631         |
| T₂ 60 x 30 cm with two seedling with 150% RDF  | 42.8                   | 8510         |
| T₃ 60 x 30 cm with two seedling with 200% RDF  | 45.7                   | 9285         |
| T₄ 60 x 45 cm with two seedling with 125% RDF  | 37.0                   | 6511         |
| T₅ 60 x 45 cm with two seedling with 150% RDF  | 39.9                   | 6535         |
| T₆ 45 x 45 cm with two seedling with 150% RDF  | 34.1                   | 7169         |
| T₇ 45 x 45 cm with two seedling with 200% RDF  | 36.2                   | 7432         |
| T₈ 45 x 30 cm with single seedling with 125% RDF | 27.0                   | 6643         |
| T₉ 45 x 30 cm with single seedling with 150% RDF | 27.9                   | 6712         |
| T₁₀ 30 x 30 cm with single Seedling with 150% RDF | 24.0                   | 10057        |
| T₁₁ 30 x 30 cm with single Seedling with 200% RDF | 25.3                   | 10826        |

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

| Treatment                                      | Stem girth (cm) | Root volume (cc) | Root dry mass (g) |
|------------------------------------------------|-----------------|------------------|-------------------|
| T₁ 60 x 30 cm with single seedling with 100% RDF | 6.75            | 68.3             | 58.7              |
| T₂ 60 x 30 cm with two seedling with 150% RDF  | 4.68            | 39.6             | 24.6              |
| T₃ 60 x 30 cm with two seedling with 200% RDF  | 4.97            | 41.1             | 25.2              |
| T₄ 60 x 45 cm with two seedling with 125% RDF  | 5.12            | 42.6             | 26.8              |
| T₅ 60 x 45 cm with two seedling with 150% RDF  | 5.15            | 45.2             | 26.9              |
| T₆ 45 x 45 cm with two seedling with 150% RDF  | 4.54            | 30.7             | 19.8              |
| T₇ 45 x 45 cm with two seedling with 200% RDF  | 4.63            | 32.7             | 22.7              |
| T₈ 45 x 30 cm with single seedling with 125% RDF | 5.72            | 58.0             | 48.5              |
| T₉ 45 x 30 cm with single seedling with 150% RDF | 6.23            | 62.9             | 54.5              |
| T₁₀ 30 x 30 cm with single Seedling with 150% RDF | 5.18            | 49.6             | 39.5              |
| T₁₁ 30 x 30 cm with single Seedling with 200% RDF | 5.20            | 53.3             | 43.5              |

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

| Treatment | LAI 2015-16 | LAI 2016-17 | CGR 2015-16 | CGR 2016-17 | RGR 2015-16 | RGR 2016-17 |
|-----------|-------------|-------------|-------------|-------------|-------------|-------------|
| T1        | 6.44        | 6.58        | 2.33        | 2.02        | 2.21        | 2.43        |
| T2        | 14.26       | 14.44       | 2.51        | 2.75        | 4.25        | 3.69        |
| T3        | 16.37       | 16.55       | 2.60        | 3.15        | 4.65        | 5.32        |
| T4        | 7.18        | 7.46        | 1.45        | 1.64        | 2.23        | 2.45        |
| T5        | 8.16        | 8.25        | 1.68        | 1.69        | 2.28        | 2.50        |
| T6        | 7.78        | 7.76        | 1.91        | 1.78        | 2.34        | 2.57        |
| T7        | 9.28        | 8.64        | 2.02        | 2.19        | 2.47        | 2.72        |
| T8        | 7.48        | 7.68        | 2.15        | 2.53        | 2.76        | 3.03        |
| T9        | 7.96        | 8.72        | 2.42        | 2.54        | 2.95        | 3.24        |
| T10       | 6.02        | 6.78        | 2.76        | 3.41        | 5.25        | 5.81        |
| T11       | 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

| Treatment | Head diameter (cm) | No. of seeds head⁻¹ | Head weight (g) | Seed volume weight (g) |
|-----------|--------------------|---------------------|----------------|------------------------|
| T1        | 33.1               | 1391                | 24.3           | 38.5                   |
| T2        | 20.9               | 924                 | 15.2           | 28.5                   |
| T3        | 21.4               | 941                 | 15.7           | 29.1                   |
| T4        | 21.8               | 957                 | 16.3           | 29.1                   |
| T5        | 23.7               | 977                 | 16.8           | 29.5                   |
| T6        | 16.5               | 871                 | 13.8           | 26.8                   |
| T7        | 18.2               | 891                 | 14.2           | 28.3                   |
| T8        | 27.5               | 1194                | 21.0           | 33.4                   |
| T9        | 30.2               | 1295                | 22.7           | 36.1                   |
| T10       | 24.8               | 987                 | 18.2           | 30.1                   |
| T11       | 26.7               | 1085                | 18.5           | 30.3                   |

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  |
| T1         | 2035     | 2034     | 33.8     | 37.7     | 11.3     | 12.6     | 78.0     | 88.0     |
| T2         | 2249     | 2469     | 46.4     | 52.1     | 14.9     | 17.6     | 108.0    | 126.0    |
| T3         | 2489     | 2719     | 51.2     | 57.4     | 16.4     | 19.4     | 119.0    | 138.0    |
| T4         | 2041     | 2084     | 39.1     | 41.4     | 13.0     | 13.8     | 91.0     | 95.0     |
| T5         | 2050     | 2090     | 39.2     | 43.8     | 13.1     | 14.6     | 91.0     | 102.0    |
| T6         | 2062     | 2241     | 39.9     | 45.4     | 13.3     | 15.1     | 93.0     | 106.0    |
| T7         | 2084     | 2264     | 40.3     | 47.3     | 13.4     | 15.8     | 94.0     | 106.0    |
| T8         | 2159     | 2364     | 43.0     | 48.5     | 14.3     | 17.1     | 100.0    | 118.0    |
| T9         | 2180     | 2466     | 44.6     | 49.1     | 14.9     | 17.2     | 104.0    | 120.0    |
| T10        | 2730     | 2971     | 55.0     | 62.1     | 18.0     | 21.3     | 131.0    | 149.0    |
| T11        | 2992     | 3232     | 61.2     | 69.1     | 20.4     | 23.0     | 142.0    | 161.0    |
| 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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