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# Growth and Yield of Sunflower in Response to Planting Geometry and Nitrogen Foliar Application at Various Crop Stages

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**Abstract:** In order to assess the interactive effect of planting geometry and foliar application of nitrogen at different crop stages in sunflower, the study was carried out during 2011-12. Treatments comprised of T1= 44289 plants ha$^{-1}$ (75 x 30 cm = Control), T2= 29526 plants ha$^{-1}$ (75 x 45 cm + 3% N ha$^{-1}$ at leaf development stage), T3= 36852 plants ha$^{-1}$ (60 x 45 cm + 3% N ha$^{-1}$ at flower bud stage), T4= 49284 plants ha$^{-1}$ (45 x 45 cm + 3% N ha$^{-1}$ at flowering stage), T5= 55278 plants ha$^{-1}$ (60 x 30 cm + 3% N ha$^{-1}$ at seed development stage) and T6= 73926 plants ha$^{-1}$ (60 x 30 cm + 3% N ha$^{-1}$ at seed maturity stage). The experiment was laid out in a randomized complete block design in three replicates. The plot size was 3.0 x 5m (15m$^2$). The results revealed planting density and foliar spraying with urea at different crop growth stages had significant ($P<0.05$) effect on all the growth and seed yield components as well as on oil percentage in sunflower. On the basis of seed yield (2181.70 kg ha$^{-1}$), sunflower sown in 60 x 30 cm plant x row spacing (55278 plants ha$^{-1}$ + 3% N ha$^{-1}$ at seed development stage), ranked 1$^{st}$ with 166.59 cm plant height, 6.82 cm stem girth, 15.67 leaves plant$^{-1}$, 18.19 cm head diameter, 1408.70 seeds head$^{-1}$, 60.54 g weight of seeds head$^{-1}$, 53.05 g seed index and 40.11% oil content. Although the sunflower performance in relation to its growth and yield contributing traits was better under wider planting densities i.e. 29526 plants ha$^{-1}$ (75 x 45 cm) and 36852 (60 x 45 cm), but due to improper plant population, their seed yield ha$^{-1}$ was significantly lower; while the sunflower crop sown in row x plant spacing of 60 x 30 cm (55278 plants ha$^{-1}$) + 3% N ha$^{-1}$ at seed development stage) proved to be most effective with maximum seed yield ha$^{-1}$.

**Key words:** Sunflower · Planting geometry · Foliar N · Crop Stages · Growth · Seed Yield

## INTRODUCTION

The factors constraining the high sunflower yield per unit area involve improper planting density and inefficient application of inputs and nutrient application by the average sunflower grower did not apply these nutrients efficiently [1]. Considerable research on planting density of sunflower has been conducted in different parts of the world. Dev and Sarawgi [2] reported that an increase in spacing increased the nutrient accumulation in sunflower plant and seed. Vijayakumar and. Ramesh [3] found that growth rates of sunflower was highest at the widest spacing (30 x 37.5 cm) at all stages of crop growth, while seed yield was highest at the closest spacing (30 x 25 cm). Jahangir *et al.* [4] observed that the highest sunflower yield was obtained under a plant spacing of 20 cm; while *Cruvinel et al.* [5] observed that row spacing of 50cm resulted in higher production of fresh and dry matter of the shoot and an increase of 57.7% in seed yield when compared to the spacing of 100 cm between sowing lines. The row spacing of 60cm and plant spacing of 30cm produced seed yield upto 1456.13 kg ha$^{-1}$ in sunflower

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[6]. A high sunflower seed yield and oil content was obtained from 75 cm row spacing [7]; while in another study, Johnson *et al*. [8] noted that effects of row spacing and plant population were evident, seed moisture differences caused by plant population. There were significant differences in plant height, number of leaves plant$^{-1}$, head diameter, number of achenes head$^{-1}$, 1000-achenes weight and achenes yield ha$^{-1}$ when sunflower was cultivated in different row and plant spacing [9]. The taller plants (178 cm) were observed in Hysun-33 with optimum row spacing of 75 cm followed by the same hybrid (177.5 cm) with narrow row spacing of 55 cm [10].

Efficient use of nitrogen fertilizer plays major role in successful crop production. Nitrogen is an essential element and important determinant in growth and development of crop plants. It has an important role in chlorophyll, protein, nucleic acid, hormones and vitamin synthesis and helps in cell division, cell elongation [11]. Similarly, foliar fertilization is very useful to fulfil the plant requirement for various macro and micronutrients. Foliar fertilizers immediately deliver nutrients to the tissues and organs of the crop. This is a practice of applying liquid fertilizers to leaves. The leaves are green factories where photosynthesis produces compounds needed for growth. These are absorbed right at the site they are used acting fast. For instance, 80 per cent of the phosphorus applied through conventional fertilizers may get fixed up in the soil but up to 80 per cent of the foliar-added phosphorus is directly absorbed. Reisdorph and Koster [12] reported foliar application of micronutrients along with straight soil applied NPK that maximized net returns to the growers; while Sharma and Chaudhary, [13] applied various concentrations of different organic and inorganic solutions in foliar form and reported enhanced crop growth and yield.

Foliar application of N in the form of urea has the advantages of low cost and rapid plant response and the disadvantage of possible foliar burn, incompatibility problems with other chemicals and limitations on the amount of nutrient that can be applied [14, 15] found that supplemental foliar N applications resulted varied response depended on the location due to differences in soil characteristics. Oosterhuis and Bondada, [16] found that the response of foliar fertilization is associated with the soil and environmental conditions. Once foliar applied urea is absorbed by the leaves, it is converted to ammonia, by the enzyme urease [17] and ammonia is incorporated into glutamate by the enzyme glutamine synthetase [18]. The foliar application urea can be an effective method to help study the fate of urea in plant leaves. Keeping in view the facts stated above, the present study was carried out to investigate the cumulative effect of planting density and foliar applied urea on the growth and yield of sunflower.

## MATERIALS AND METHODS

The experiment was laid out in a randomized complete block design in three replicates using a plot size of 5m x 3m (15m$^2$). Before onset of sunflower sowing season, the experimental land was well worked by using disc plough, followed by levelling. After soaking dose, the plots were given two ploughings. The clods were crushed followed by planking for uniform distribution of seed, fertilizer and irrigation water. The sowing of the crop was done by using single coulter hand drilling at different row and plant spacing on 20$^{th}$ September 2011 using commercial variety HO-1 at the seed rate of 10 kg ha$^{-1}$. Nitrogen was applied at the rate of 45 kg ha$^{-1}$ in three splits at the time of sowing, at 2$^{nd}$ irrigation and at 3$^{rd}$ irrigation in the form of Urea. All P (35 kg ha$^{-1}$) and K (15 kg ha$^{-1}$) along with 1/3$^{rd}$ of N were applied at the time of bed preparation. The sunflower being sensitive crop needs more care as compared to other field crops. The crop stages sensitive to irrigation and other management practices were pointed out and accordingly the earthing and irrigation scheduling was managed. All the necessary cultural operations were adopted throughout the growing period as per the set plan. Pest scouting was adopted to keep close eye on insect pest infestation. A periodical visit of Entomologist, Plant Pathologist and also Plant Physiologist was ensured to avoid any physiological disorder or unseen emergence of insect pests. The observations on various parameters were recorded on randomly selected four plants in each plot. These sample plants were labelled with certain coding and reading of the four plants was averaged for replication-wise data. The oil content was determined in the laboratory of Soil Science Chemistry Department University of Sindh Jamshoro. The data so collected on the certain growth and yield components were statistically analysed by deriving analysis of variance to examine the overall significance of differences among treatment means as well as compared to control; while LSD (Least Significant Difference) test was applied to compare and perceive superiority of treatment means and observe significance of differences, following statistical methods suggested by Gomez and Gomez [19]. All these tests were performed by using Statics 8.1 Micro-Computer Statistical Software (USA).

## RESULTS

The study was conducted to assess the interactive effect of planting geometry and foliar application of nitrogen at different crop stages in sunflower crop, the data has been taken from the field, interpreted and obtained results are presented as following.

**Plant Height (Cm):** The sunflower sown in row x plant spacing of 60 x 30 cm (55278 plants $ha^{-1}$) + foliar applied urea @ 3% at seed development stage resulted in highest plant height of 166.59 cm, closely followed by plant height of 160.34 cm observed in crop sown under row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage, while the sunflower plants reduced their height up to 159.74 cm, 158.00 cm and 153.67 cm when planted in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage, 75 x 30 cm (44289 plants $ha^{-1}$) + no foliar application of urea (control) and 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage, respectively. However, the lowest plant height of 149.74 cm was observed in plants sown in row x plant spacing of 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage.

**Stem Girth (Cm):** The sunflower crop planted in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage resulted in maximum stem girth of 8.35 cm, followed by stem girth of 7.78 cm observed in crop sown under row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage, while the stem girth reduced to 6.82 cm, 6.78 cm and 6.63 cm when planted in 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage, 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage and 75 x 30 cm (44289 plants $ha^{-1}$) + no foliar application of urea (control), respectively. The stem girth further decreased to its lowest (6.26 cm) when sunflower was planted in 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage.

**Number of Leaves $Plant^{-1}$:** The plants grown in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage had more number of leaves (19.00) $plant^{-1}$, followed 17.00, 16.00 and 16.00 leaves $plant^{-1}$ recorded in crop sown under row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage, 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage and 75 x 30 cm (44289 plants $ha^{-1}$) + no foliar application of urea (control), respectively. Number of leaves reduced to 15.67 $plant^{-1}$ when the crop was sown in 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage, while the lowest number of leaves (14.33) $plant^{-1}$ was recorded in crop sown in 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage.

**Head Diameter (Cm):** The sunflower sown in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage produced highest head diameter of 22.46 cm, followed by head diameter of 21.06 cm observed in sunflower sown under row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage, while the head diameter reduced to 19.95 cm, 19.44 cm and 18.19 cm when the crop planted in 75 x 30 cm (44289 plants $ha^{-1}$) without foliar application of urea (control), 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage and 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage, respectively. However, the head diameter reduced to its lowest (17.75 cm) when sunflower was planted in 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage. This showed that the head diameter was adversely affected by increasing plant density; because under low density plantation, the sunflower head diameter was markedly higher than those under high density plantation. However, the effect of foliar application of urea in all treatments was almost similar. However, the differences amongst all the treatments were significant ($P<0.05$) statistically.

**Number of Seeds $Head^{-1}$:** Sunflower planted in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage produced highest number of seeds (1579.30) $head^{-1}$, followed by 1519.70 and 1468.70 average number of seeds $head^{-1}$ noted in crop sown in row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage and 75 x 30 cm (44289 plants $ha^{-1}$) without foliar application of urea (control), respectively. The number of seeds further decreased to 1418.70 and 1408.70 $head^{-1}$ when the crop was planted in 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage and 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage, respectively. However, the number of seeds $head^{-1}$ was minimum (1111.70) when the

crop was planted in 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage. It was observed that the number of seeds $head^{-1}$ was adversely affected by increasing plant density and under highest planting density, the number of seeds $head^{-1}$ were lowest among all the treatments. However, the differences in the number of seeds $head^{-1}$ between populations of 29526 and 36852 plants $ha^{-1}$ as well as amongst 44289, 49284 and 55278 plants $ha^{-1}$ were statistically non-significant ($P<0.01$) and significant when compared with rest of the treatments.

**Weight of Seeds $Head^{-1}$ (G):** The crop sown in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage resulted maximum weight of seeds (68.23 g) $head^{-1}$, followed by 65.24 g and 63.60 g average weight of seeds $head^{-1}$ noted in crop sown in row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage and 75 x 30 cm (44289 plants $ha^{-1}$) without foliar application of urea (control), respectively. The weight of seeds further reduced to 60.54 g and 60.25 g $head^{-1}$ when the crop was planted in 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage and 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage respectively. However, the lowest weight of seeds $head^{-1}$ (52.62 g) was noted in crop planted in 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage. The weight of seeds $head^{-1}$ was inversely influenced and with increasing planting density the weight of seeds $head^{-1}$ was simultaneously decreased. However, the differences in the weight of seeds $head^{-1}$ between populations of 36852 and 44289 plants $ha^{-1}$ or between 49284 and 55278 plants $ha^{-1}$ were statistically non-significant ($P<0.01$) and significant when compared with other treatments.

**Seed Index (1000 Seeds Weight G):** Crop sown in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage gave highest seed index (57.25 g), followed by seed index of 56.24 g and 54.60 g noted in row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage and 75 x 30 cm (44289 plants $ha^{-1}$) without foliar application of urea (control), respectively. The weight of seeds further reduced to 53.30 g and 53.05 g when the crop was planted in 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage and 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage, respectively. However, the lowest seed index (47.18 g) was noted in crop planted in 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage. The seed index was mainly associated with the planting density; while effect of foliar application of urea when applied at leaf development stage. The LSD test indicated that the differences in the seed index between populations of 49284 and 55278 plants $ha^{-1}$ were statistically non-significant ($P<0.01$) and significant when compared with rest of the treatments.

**Seed Yield (Kg $Ha^{-1}$):** The sunflower planted in row x plant spacing of 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage produced highest seed yield (2181.70 kg $ha^{-1}$), followed by seed yield of 2056.30 kg and 1964.70 kg $ha^{-1}$ noted in row x plant spacing of 45 x 30 cm (73926 plants $ha^{-1}$) + foliar application of urea at seed maturity stage and 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage, respectively. The seed yield further decreased with decreasing planting density, where in row x plant spacing of 75 x 30 cm (44289 plants $ha^{-1}$) without foliar application of urea (control) the seed yield reduced to 1901.30 kg $ha^{-1}$ and 1823.00 kg $ha^{-1}$ in row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage. However, the lowest seed yield (1733.00 kg $ha^{-1}$) was observed in crop planted in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage. It was observed that regardless the performance of treatments under various growth and yield contributing traits of sunflower, the yield of higher where the 55278 $ha^{-1}$ plant population was maintained. However, the differences in seed yield $ha^{-1}$ was non-significant between plant populations of 73926 and 55278 plants $ha^{-1}$ or between 36852 and 29526 and even between 49284 and 44289 plants $ha^{-1}$ were non-significant ($P>0.05$) and significant ($P<0.05$) when these treatment groups were compared with each other.

**Oil Content (%):** The sunflower planted in row x plant spacing of 75 x 45 cm (29526 plants $ha^{-1}$) + foliar application of urea at leaf development stage resulted in highest oil content (41.25%), followed by 41.16% and 40.21% noted in crop sown in row x plant spacing of 60 x 45 cm (36852 plants $ha^{-1}$) + foliar application of urea at flower bud stage and 75 x 30 cm (44289 plants $ha^{-1}$) without foliar application of urea (control), respectively. The oil content further reduced to 40.11% and 40.04% when the crop was planted in 60 x 30 cm (55278 plants $ha^{-1}$) + foliar application of urea at seed development stage and 45 x 45 cm (49284 plants $ha^{-1}$) + foliar application of urea at flowering stage, respectively. However, the oil content was lowest (38.84%) when the

crop was planted in row x plant spacing of 45 x 30 cm (73926 plants ha$^{-1}$) + foliar application of urea at seed maturity stage.

## CONCLUSIONS

Although the sunflower performance in relation to its growth and yield contributing traits was better under wider planting densities i.e. 29526 plants ha$^{-1}$ (75 x 45 cm) and 36852 (60 x 45 cm), but due to improper plant population, their seed yield ha$^{-1}$ was significantly lower; while the sunflower crop sown in row x plant spacing of 60 x 30 cm (55278 plants ha$^{-1}$) + 3% N ha$^{-1}$ at seed development stage) proved to be most effective with maximum seed yield ha$^{-1}$.

It was further concluded that high density plantation in row x plant spacing of 60 x 30 cm (73926 plants ha$^{-1}$) + 3% N ha$^{-1}$ at seed maturity stage could not show optimistic performance due to most populous planting. Hence, it is concluded that for achieving optimum results in sunflower variety HO-1, the crop may be sown in row x plant spacing of 60 x 30 cm to achieve 55278 plants ha$^{-1}$. Moreover, foliar application of urea (3%) at seed development stage added beneficial effects to the crop performance.

Table 1: Plant height, stem girth, leaves plant$^{-1}$ and head diameter sunflower as affected by planting geometry and foliar N application at various crop stages

| Plant population (Row x plant spacing) | Plant height (cm) | Stem girth (cm) | Number of leaves plant$^{-1}$ | Head diameter (cm) |
|---|---|---|---|---|
| T1= 44289 plants ha$^{-1}$ (75 x 30 cm = Control) | 158.00 b | 6.63 c | 16.00 b | 19.95 c |
| T2= 29526 plants ha$^{-1}$ (75 x 45 cm + 3% N ha$^{-1}$ at leaf development stage) | 159.74 b | 8.35 a | 19.00 a | 22.46 a |
| T3= 36852 plants ha$^{-1}$ (60 x 45 cm + 3% N ha$^{-1}$ at flower bud stage) | 160.34 a | 7.78 b | 17.00 b | 21.06 b |
| T4= 49284 plants ha$^{-1}$ (45 x 45 cm + 3% N ha$^{-1}$ at flowering stage) | 153.67 b | 6.78 c | 16.00 b | 19.44 d |
| T5= 55278 plants ha$^{-1}$ (60 x 30 cm + 3% N ha$^{-1}$ at seed development stage) | 166.59 a | 6.82 c | 15.67 c | 18.19 e |
| T6= 73926 plants ha$^{-1}$ (60 x 30 cm + 3% N ha$^{-1}$ at seed maturity stage) | 149.74 c | 6.26 d | 14.33 c | 17.75 f |
| S.E..± | 2.9118 | 0.1701 | 0.7303 | 0.1114 |
| LSD 0.05 | 6.4879 | 0.3791 | 1.6272 | 0.2482 |
| LSD 0.01 | 9.2283 | 0.5392 | 2.3145 | 0.3531 |

Table 2: Mean squares corresponding to various growth traits of sunflower

| Source of variation | D.F. | Plant height (cm) | Stem girth (cm) | Number of leaves plant$^{-1}$ | Head diameter (cm) |
|---|---|---|---|---|---|
| Replications | 2 | 23.178 | 0.04011 | 0.66667 | 0.00202 |
| Treatments | 5 | 101.554** | 1.88395** | 7.33333** | 9.38188** |
| Error | 10 | 12.718 | 0.04343 | 0.8000 | 0.01862 |
| Total | 17 | - | - | - | |

Table 3: Seeds head$^{-1}$, weight of seeds head$^{-1}$, seed index, seed yield ha$^{-1}$ and oil content of sunflower as affected by planting geometry and foliar applied N at various crop stages

| Plant population (Row x plant spacing) | Seeds head$^{-1}$ | Seed weight head$^{-1}$(g) | Seed index (g) | Seed yield ha$^{-1}$(kg) | Oil content (%) |
|---|---|---|---|---|---|
| T1=44289 plants ha$^{-1}$ (75 x 30 cm = Control) | 1468.70 b | 63.60 b | 54.60 c | 1901.30 b | 40.21 b |
| T2=29526 plants ha$^{-1}$ (75 x 45 cm + 3% N ha$^{-1}$ at leaf development stage) | 1579.30 a | 68.23 a | 57.25 a | 1733.00 c | 41.25 a |
| T3=36852 plants ha$^{-1}$ (60 x 45 cm + 3% N ha$^{-1}$ at flower bud stage) | 1519.70 a | 65.24 b | 56.24 b | 1823.00 c | 41.16 a |
| T4=49284 plants ha$^{-1}$ (45 x 45 cm + 3% N ha$^{-1}$ at flowering stage) | 1418.70 b | 60.25 c | 53.30 d | 1964.70 b | 40.04 b |
| T5=55278 plants ha$^{-1}$ (60 x 30 cm + 3% N ha$^{-1}$ at seed development stage) | 1408.70 b | 60.54 c | 53.05 d | 2181.70 a | 40.11 b |
| T6=73926 plants ha$^{-1}$ (60 x 30 cm + 3% N ha$^{-1}$ at seed maturity stage) | 1111.70 c | 52.62 d | 47.18 e | 2056.30 a | 38.84 c |
| S.E..± | 51.791 | 1.2553 | 0.4504 | 80.291 | 0.1202 |
| LSD 0.05 | 104.52 | 2.7970 | 1.0036 | 178.90 | 0.2677 |
| LSD 0.01 | 150.91 | 3.9784 | 1.4276 | 254.46 | 0.3808 |

Table 4: Mean squares corresponding to various seed yield traits and oil content of sunflower

| Source of variation | d.f | Seeds head$^{-1}$ | Weight of seeds head$^{-1}$ | Seed index | Seed yield ha$^{-1}$ | Oil content |
|---|---|---|---|---|---|---|
| Replications | 2 | 2926.4 | 0.0006 | 0.5729 | 896.0 | 0.00201 |
| Treatments | 5 | 79715.4** | 86.3235** | 37.7768** | 78306.7** | 2.31474** |
| Error | 10 | 12638.3 | 2.3637 | 0.3043 | 9669.9 | 0.02166 |
| Total | 17 | - | - | - | - | - |

## DISCUSSION

Proper plant stand is the primary factor that influences the sunflower productivity; while the efficient use of nutrients has also been proved markedly beneficial to the crop yields. Under water stress conditions, the foliar application of nutrients sustains the crop growth due to prompt availability of required nutrients for the plant leaves. The study was carried out to investigate the cumulative effect of planting density and foliar applied urea on the growth and yield of sunflower. The present study suggested significant ($P<0.05$) influence of planting density and foliar applied urea on growth and seed yield of sunflower. Taking into consideration the seed yield $ha^{-1}$ in sunflower, the sown in row x plant spacing of 60 x 30 cm plant x row spacing maintaining population of 55278 plants $ha^{-1}$ along with foliar applied urea (3%) at seed development stage showed most promising results with 166.59 cm plant height, 6.82 cm stem girth, 15.67 leaves $plant^{-1}$, 18.19 cm head diameter, 1408.70 seeds $head^{-1}$, 60.54 g weight of seeds $head^{-1}$, 53.05 g seed index, 2181.70 kg seed yield $ha^{-1}$ and 40.11% oil content. Although the sunflower performance in relation to its growth and yield contributing traits was better under wider planting densities i.e. 29526 plants $ha^{-1}$ (75 x 45 cm) and 36852 (60 x 45 cm), but due to improper plant population, their seed yield $ha^{-1}$ was significantly lower; while the sunflower crop sown in row x plant spacing of 60 x 30 cm (55278 plants $ha^{-1}$) + 3% N $ha^{-1}$ at seed development stage) proved to be most effective with maximum seed yield $ha^{-1}$. It was concluded that high density plantation in row x plant spacing of 60 x 30 cm (73926 plants $ha^{-1}$) + 3% N $ha^{-1}$ at seed maturity stage could not show optimistic performance due to most populous planting. Hence, for achieving optimum results in sunflower variety HO-1, the crop may be sown in row x plant spacing of 60 x 30 cm to achieve 55278 plants $ha^{-1}$. These results are in concurrence with those of Vijayakumar and Ramesh [3] who found improved crop growth in sunflower under wider spacing at all stages of crop growth; while Jahangir *et al.* [4] observed highest sunflower yield under high density planting. Similarly, *Cruvinel et al.* [5] suggested 50 cm row spacing for sunflower; while in another study, FAO [6], it was observed that the crop had sown in row and plant spacing of 60 x 30 cm produced seed yield up to 1456.13 kg $ha^{-1}$. In contrast, a high sunflower seed yield and oil content was obtained from 75 cm row spacing by Kazemeini *et al.* [7]; while Johnson *et al*. [8] reported 60 cm x 30 cm row x plant spacing as an optimum spacing arrangement for sunflower and effects were significant on plant height, number of leaves $plant^{-1}$, head diameter, number of seeds $head^{-1}$, 1000-seed weight and seed yield $ha^{-1}$ when sunflower was cultivated in different row and plant spacing [9]. However, Khan *et al.* [10] reported taller plants up to 178 cm in sunflower hybrid Hysun-33 with row spacing of 75cm followed by the same hybrid (177.5 cm) with narrow row spacing of 55 cm.

The other aspect of the study assessing the effect of foliar application of N in the form of urea indicated that foliar application of urea (3%) at seed development stage added more beneficial effects to the crop performance as compared to its application an other phenological stages. These findings are in line with those of Sharma and Chaudhary [13] who applied urea as foliar application and reported beneficial effect when application at seed development stage. Foliar application of N in the form of urea has the advantages of low cost and rapid plant response [14]. The comparative analysis of the findings of present research and the results reported by past workers concludes that the proper plant population with more effective row and plant spacing is the key factor to influence the sunflower performance. However, the plant population of around 55000 plants $ha^{-1}$ are optimally needed to maintain a good crop stand. Moreover, foliar application of nutrients particularly at seed development stage stimulates the crop to sustain its development even under drought and water stress conditions.

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