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# Cumulative Impact of Crop Stand and Foliar Urea on Traits of Importance in Sunflower (*Helianthus Annus*L.)

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**Abstract:** In order to assess the cumulative impact of crop stand and foliar urea on sunflower, the experiment was conducted during 2016 (spring). Six treatments were formed with various ha$^{-1}$ plant populations such as: $T_1$=44289 ha$^{-1}$ (75×30cm=Control), $T_2$=29526 (75×45cm+foliar urea at development of leaves), $T_3$=36852 (60×45cm+foliar urea at development of flower bud), $T_4$=49284 (45×45cm+foliar urea at flowering completion), $T_5$=55278 (60×30cm+foliar ureaat seed initiation) and $T_6$=73926 (45×30cm+foliar ureaat seed development/maturity). The crop stand and foliar N (urea) application treatments showed remarkable (P<0.05) impact on traits contributing crop growth and yield. On the basis of seed yield ha$^{-1}$, sunflower sowing in row × plant distance of 60×30cm row× plant distance with 55278 plant population + foliar urea(at seed initiation) showed most promising results grew plants upto166.5cm height having 6.8cm thick stems with more leaves (15.6 plant$^{-1}$) and bigger seed heads (18.1cm) as well as more (1408.7) and heavier (60.5g) seeds head$^{-1}$.The seed index was also higher (53.0g) in this treatment leading maximum yields (2181.7kg ha$^{-1}$) and determined highest oil content (40.1%). Sunflower sown under $T_6$, $T_4$, $T_1$, $T_3$ and $T_2$ ranked 2nd, 3rd, 4th, 5th and 6th in overall yield performance. Generally the crop under wider plant distances with lower per ha$^{-1}$ populations of 29526 and 36852 showed better growth, but decrease in plant population caused reduction in seed yield; while 60×30cm row × plant distance providing ha$^{-1}$ plant population of 55278 produced economically higher seed yield when given foliar applied urea at seed initiation.

**Keywords:** Sunflower, Crop Stand, Planting Density, Foliar Urea, Crop Stages, Seed Yield

## 1. INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a potential crop to bridge-up the gap between domestic demand of edible oil and production in Pakistan (Ahmad *et al*., 2009). The efforts are being made to enhance sunflower yields in addition to other conventional oilseed crops to overcome the edible oil deficit, because at least two sunflower crops in a year can be obtained (spring and autumn); and it is well adapted to existing agro-ecological conditions. During the year 2016-17, the total area under sunflower cultivation was 216 thousand hectares with seed production of 109 thousand tons and oil production of 41 thousand tons. These figures show a tiny contribution of sunflower to huge domestic edible oil consumption due to poor seed yields per unit area (GOP, 2017).

The factors constraining potential sunflower yields involve improper planting density and inefficient application of inputs and growers do not apply essentially required nutrients efficiently (Ahmad and Jabeen, 2009). Considerable research on crop stand or plant population in sunflower has been conducted in different parts of the world. The increase in spacing increases the nutrient accumulation in sunflower plant and seed (Dev and Sarawgi, 2004); while growth rates of sunflower is increased under wider spacing regardless of stages of crop growth (Vijaya and Ramesh, 2005). The higher sunflower yield can be obtained under a plant spacing of 20 cm (Jahangir *et al.*, 2006); while Cruvinel *et al.* (2007) recommended row spacing of 50cm for achieving desired crop vigour and seed production in sunflower. Spacing rows at 60cm and plant sat 30cm produce sunflower seed yield upto1456.13kg ha$^{-1}$(FAO, 2008). Some studies show that 75cm spaced rows produced higher seed yields and seed oil contents (Kazemeini *et al.* 2009); while in another study (Johnson *et al.* 2010) effects of row spacing and plant population were evident, where differences in seed moisture resulted in significant variation in crop stand. The traits related to growth and seed yield of sunflower followed a remarkable change when cultivated in rows spaced at different distances (Ali *et al.* 2011). The sunflower plants grew taller (178 cm) in sunflower hybrid (Hysun-33)when the rows were spaced at 75cm; while the hybrid tallness slightly decreased (177.5 cm) when the rows were spaced at 55cmdistance (Khan *et al.* 2011).

Nitrogen has distinctive role in development of plant and its resourceful use is of primary importance. Nitrogen being essential element in growth and development of crop plants has not only its unique role but it also stimulates the utilization of other available macro and micronutrients (Silberbush, 2002). N application by foliar method instantaneously fulfils

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the plant nutrient requirement and delivering nutrients to plant tissues and organs by applying liquid fertilizers to leaves (Sharma *et al.*, 2007). Foliar applied N as urea has advantage of rapid plant response and coupled with monetary efficiency (Oosterhuis, 1999). However, Sadozai *et al.,* (2013) found that N supplemented in foliar form resulted in differential reaction but associated with ecological location and soil characteristics. The foliar application of urea also helps to study the urea fate in plant leaves (Ahmad, 2011; Khan *et al.,* 2011, Jabeen and Ahmad, 2012). This study was mainly aimed at investigating the cumulative impact of crop stand and foliar application of nitrogen (urea) at certain concentrations on sunflower growth and seed yield.

## 2. MATERIALS AND METHODS

The experiment was laid out in RCBD (replicated three times) using 5m × 3m ($15m^2$) plot size. The land was well worked before onset of sowing season by using recommended practices of sunflower production. The seed of HO-1 sunflower variety was obtained with the courtesy of oilseeds Botanist, Agriculture Research Institute, Tandojam and seeded by single coulter hand drill at varied densities at sowing rate of 10 kg $ha^{-1}$. 100 kg $ha^{-1}$N was applied in three splits at sowing, 2nd irrigation and at 3rd irrigation as Urea. All P (50 kg) and K (25 kg) in addition to 1/3rd of N were given at sowing by mixing in the soil while seedbed was prepared. For foliar application, urea solution (3%) was applied at different growth stages. The irrigation scheduling was associated with the earthing up timing and other cultural practices were followed as per the crop production technologies developed for sunflower crop. The insect pest infestation or occurrence of any disease problem was critically examined by the scientists of relevant disciplines. The crop was examined for various growth and yield traits on the basis of randomly selected five plants in each plot. The oil content was determined in the laboratory of Soil Science Chemistry Department University of Sindh Jamshoro. The data thus obtained were statistically analysed using ANOVA and LSD test following Gomez and Gomez (1984) using Statix 8.1 Micro-Computer Statistical Software (USA).

## 3. RESULTS AND DISCUSSION

### Plant height (cm)

The crop raised with plant population of 55278 $ha^{-1}$ (row×plant distance of 60×30cm and supplemented with foliar urea at seed formation produced plants with maximum height (166.59cm); while plants grew with reduced height (160.34cm) in crop raised with plant population of 36852 (60×45cm row×plant distance) supplemented with foliar urea at development of flower bud. The plants with decline in height (159.7, 158 and 153.6cm) were obtained in crop sown with 29526 (75×45cm row×plant distance)+foliar urea supplement when leaves are developed;44289 plant population $ha^{-1}$(75×30cm row×plant distance) without foliar urea (control) and 49284 plants $ha^{-1}$ (45×45cm row×plant distance) with foliar urea supplement, respectively. The sunflower plants with least height (149.7cm)were noted under highest plant population of 73926 $ha^{-1}$ (45×30cmrow×plant distance) with foliar ureaat seed development stage. The crop sown with 55278 plant population $ha^{-1}$showed apparently better response for plant height to applied inputs compared to rest of treatments. However, statistical similarity in height of plants was observed between plant populations of 55278-36852 or amongst 29526, 44289 and 49284 ($P>0.05$). Khan *et al.* (2011)found 178cmheight of sunflower plants in Hysun-33 hybrid in 75cm apart rows and intra row spacing of 55cm. Vijaya and Ramesh (2005) reported increased height of sunflower plants under wider spacing and at all phonological stages the crop growth under wider spacing was relatively better than those under narrow inter and intra row distances.

### Stem girth (cm)

The treatment comprised of plant population and spacing of 29526 (75×45cm+foliar ureaat development of leaves) produced plants with maximum stem thickness (8.3cm); while stem thickness decreased (7.7cm) in crop raised with plant population of 36852 (60× 45cm+foliar ureaat development of flower bud). The plants with decreased stem thickness (6.8, 6.7 and 6.6cm) were obtained in crop sown with 55278 plants $ha^{-1}$(60×30cm row×plant distance)+supplemented with foliar urea when leaves are developed; 49284 (45× 45cm+foliar ureaat flowering completion) and 44289 $ha^{-1}$ (75×30cm=Control), respectively. The sunflower plants with minimum stem thickness (6.2cm) were found noted under highest plant population of 73926 (45×30cm+foliar ureaat seed development/maturity). The crop sown with 29526 plant population $ha^{-1}$ showed healthiest plants in relation to stem thickness. However, statistical similarity in stem thickness was analysed between plant populations of 55278 and 49284 ($P>0.05$). These results are in line with those of Jahangir *et al.* (2006) who reported that under high density planting of sunflower, the crop vigour is decreased and stem thickness is slightly decreased. Vijayakumar and Ramesh (2005) reported increased stem thickness of sunflower plants under wider spacing. This increased thickness under wider spacing is mainly associated with sharing more nutrients, moisture, light and increased aeration under lower plant population.

### Leaves $plant^{-1}$

The plant population and row×plant spacing of 29526 (75×45cm+foliar ureaat development of leaves) resulted more leaves $plant^{-1}$ (19.0); while leaves $plant^{-1}$ decreased to 17, 16 and 16 in crop raised with plant

population of 36852 (60× 45cm+foliar ureaat development of flower bud), 49284 (45×45cm+foliar ureaat flowering completion) and 44289ha$^{-1}$ (75×30cm=Control), respectively. The crop with 55278 plants ha$^{-1}$ (60×30cm row×plant distance) +supplemented with foliar urea when leaves are developed resulted in 15.6 leaves on average; while minimum leaves plant$^{-1}$ (14.3) were found noted under highest plant population of 73926 (45×30cm+foliar ureaat seed development/maturity). It was observed that the cropsown with 29526 plant population ha$^{-1}$ produced

**Table1: Effect of planting density and foliar application of urea on plant height, stem girth and leaves plant$^{-1}$ of sunflower**

| Plant population (Row × plant distance) | Plant height (cm) | Stem girth (cm) | Leaves plant$^{-1}$ |
|---|---|---|---|
| $T_1$= 44289 ha$^{-1}$ (75×30cm=Control) | **158.0$^{B}$** | **6.6$^{C}$** | **16.0$^{B}$** |
| $T_2$= 29526 ha$^{-1}$(75×45cm+foliar ureaat development of leaves) | **159.7$^{B}$** | **8.3$^{A}$** | **19.0$^{A}$** |
| $T_3$= 36852 ha$^{-1}$(60×45cm+foliar ureaat development of flower bud) | **160.3$^{A}$** | **7.7$^{B}$** | **17.0$^{B}$** |
| $T_4$= 49284 ha$^{-1}$(45×45cm+foliar ureaat flowering completion) | **153.6$^{B}$** | **6.7$^{C}$** | **16.0$^{B}$** |
| $T_5$= 55278 ha$^{-1}$(60×30cm+foliar ureaat seed initiation) | **166.5$^{A}$** | **6.8$^{C}$** | **15.6$^{C}$** |
| $T_6$= 73926ha$^{-1}$(45×30cm+foliar ureaat seed development/maturity). | **149.7$^{C}$** | **6.2$^{D}$** | **14.3$^{C}$** |
| *S.E.*± | ***2.9*** | ***0.1*** | ***0.7*** |
| *LSD 0.05* | ***6.4*** | ***0.3*** | ***1.6*** |

foliage compared to rest of the treatments; which was mainly linked with availability of more inputs for average plants due to lower plant population. However, statistical similarity in leaves plant$^{-1}$ was analysed between plant populations of 44289, 36852 and 49284 or between 55278 and 73926 ha$^{-1}$(P>0.05). (Cruvinel *et al*. 2007) suggested 50cm row spacing managing around 50000 plants ha$^{-1}$ for achieving desired results for vigorous plant growth.Jahangir *et al.* (2006) reported that the crop vigour is decreased under high density planting of sunflower.

**Head diameter(cm)**

The results (Table 2) show that the plant population and row×plantspacing of 29526 (75×45cm+foliar ureaat development of leaves) produced greater head diameter (22.4cm); while the head diameterdeclined to 21.0, 19.9 and 19.4cm in crop raised with plant population of 36852 (60×45cm+foliar ureaat development of flower bud), 44289 ha$^{-1}$ (75×30cm=Control) and 49284 (45×45cm+foliar ureaat flowering completion), respectively. The plantation with 55278 plants ha$^{-1}$ (60×30cm row×plant distance) and supplemented with foliar urea when leaves are developed resulted in 18.1cm head diameter on average; while least head diameter (17.7cm) was measured in highest plant population of 73926 (45×30cm+foliar urea at seed development/maturity). This greater head size under lower plant population was associated with enhanced share of inputs as compared to high population where per plant share is substantially decreased. So far the head size is concerned, plant population of 29526 ha$^{-1}$was effective to produce bigger heads in sunflower. These results are further confirmed by Johnson *et al.* (2010) who reported that 60 cm×30cm row×plant distance is recommendable that would produce slightly decreased head size but increased population would enhance the seed yield. However, Jahangir *et al.* (2006) reported that under high density planting of sunflower the head size was decreased but the overall yield was increased.

**Seeds head$^{-1}$**

It is apparent from the data **(Table 2)** that the plant population and row×plant spacing of 29526 (75×45cm)+foliar ureaat development of leaves produced heads with maximum number of seeds (1579.3); followed by 1519.7, 1468.7 and 1418.7 seeds head$^{-1}$counted in crop raised with plant population of 36852 (60×45cm)+foliar ureaat development of flower bud, 44289 ha$^{-1}$ (75×30cm=Control) and 49284 (45×45cm+foliar ureaat flowering completion), respectively. The crop stand comprised of with 55278 plants ha$^{-1}$ (60×30cm row×plant distance) +supplemented with foliar urea when leaves are developed produced heads with 1408.7 seeds on average; while minimum seeds head$^{-1}$ (1111.7) were counted under highest plant population of 73926 (45×30cm+foliar ureaat seed development/maturity). This greater number of seeds head$^{-1}$ under wider spacing was mainly associated with head diameter and increase head diameter enhanced the seed rows on head and hence more seeds head$^{-1}$ were achieved. Statistically seeds head$^{-1}$showed similarity between plant populations of 29526 and 36852 or 49284 and 55278 ha$^{-1}$ (P>0.05). Kazemeini *et al.* (2009) reported that number of seeds is dependent of head size and foliar applied N could enhance the head size and seeds number on sunflower head. Moreover, they found higher seed number under wider row spacing of 75 cm. Similarly, Cruvinel, *et al.* (2007) reported that 50cm row spacing may provide an economical and optimum plant population.

**Weight of seeds head$^{-1}$ (g)**

The treatment based on plant population (29526 ha$^{-1}$) and row×plantspacing of 75×45cm+foliar ureaat development of leaves produced bolder and heavier

seeds (68.2g head$^{-1}$); followed by 65.2, 63.6 and 60.5 and 60.2g seeds weight head$^{-1}$noted in crop raised with plant population of 36852 (60×45cm)+foliar ureaat development of flower bud, 44289 ha$^{-1}$ (75×30cm =Control), 55278 (60×30cm+foliar ureaat seed initiation) and 49284 (45×45cm+foliar ureaat flowering completion), respectively; while minimum weight of seeds head$^{-1}$ (52.6g) were counted under highest plant population of 73926 (45×30cm+foliar ureaat seed development/maturity). This increased weight of seeds head$^{-1}$ under wider spacing was mainly associated with head diameter and more seeds head$^{-1}$ which in turn resulted in increased seed weight head$^{-1}$. Statistically seeds weight head$^{-1}$ showed similarity between plant populations of 44289 and 29526 or 49284 and 55278 ha$^{-1}$ (P>0.05). Kazemeini *et al.* (2009) reported that number and weight of seeds is dependent of head size and foliar applied N could enhance the head size, seeds number and weight of seeds head$^{-1}$ in sunflower. Oosterhuis, 1999) reported that foliar application of urea on sunflower showed beneficial effect on seed weight, particularly under water stress conditions, the crop sustained the conditions and maintained the yield as under normal irrigation conditions.

**Table 2: Effect of planting density and foliar application of urea on head diameter, seeds head$^{-1}$ and weight of seeds head$^{-1}$of sunflower**

| Plant population (Row × plant distance) | Head diameter (cm) | No. of Seeds head$^{-1}$ | Weight of seeds head$^{-1}$ (g) |
|---|---|---|---|
| $T_1$= 44289 ha$^{-1}$ (75×30cm=Control) | **19.9$^{C}$** | **1468.7$^{B}$** | **63.6$^{B}$** |
| $T_2$= 29526 ha$^{-1}$ (75×45cm+foliar ureaat development of leaves) | **22.4$^{A}$** | **1579.3$^{A}$** | **68.2$^{A}$** |
| $T_3$= 36852 ha$^{-1}$ (60×45cm+foliar ureaat development of flower bud) | **21.0$^{B}$** | **1519.7$^{A}$** | **65.2$^{B}$** |
| $T_4$= 49284 ha$^{-1}$ (45×45cm+foliar ureaat flowering completion) | **19.4$^{D}$** | **1418.7$^{B}$** | **60.2$^{C}$** |
| $T_5$= 55278 ha$^{-1}$ (60×30cm+foliar ureaat seed initiation) | **18.1$^{E}$** | **1408.7$^{B}$** | **60.5$^{C}$** |
| $T_6$= 73926 ha$^{-1}$ (45×30cm+foliar ureaat seed development/maturity). | **17.7$^{F}$** | **1111.7$^{C}$** | **52.6$^{D}$** |
| *S.E.*± | ***0.1*** | ***51.7*** | ***1.2*** |
| *LSD 0.05* | ***0.2*** | ***104.5*** | ***2.7*** |

## Seed yield (kg ha$^{-1}$)

The experimental data **(Table 3)** show that the treatment consisted of plant population and row×plantspacing of 55278 (60×30cm+foliar urea at seed initiation) produced maximum seed yield ha$^{-1}$ (2181.7kg); followed by 2056.3, 1964.7,1901.3 and 1823kg ha$^{-1}$ realized from sunflower plant population of 73926 (60×30cm+foliar urea at seed development/ maturity), 49284 (45×45cm+foliar ureaat flowering completion), 44289 ha$^{-1}$ (75×30cm=Control), 36852 (60×45cm+foliar urea at development of flower bud), respectively; while minimum seed yield ha$^{-1}$ (17.33kg) was obtained in plantation with plant population of 29526 (75×45cm+foliar urea at development of leaves). The seed yield ha$^{-1}$ showed a different trend from the other traits studied. This contradicting response was mainly associated with the plant population; because optimum plant population ensures to achieve desired yields; while under lower plant population regardless of other treatments the potential yields cannot be achieved. Statistically the seed yield showed similarity between plant populations of 55278 and 73926or 29526 and 36852 ha$^{-1}$(P>0.05). Similar results have been reported by Vijaya and Ramesh (2005) who concluded that wider spacing showed improved individual plant performance but overall yield was higher under dense planting. Jahangir *et al.* (2006) found that under high density planting the yield was higher compared to lower planting density. FAO (2008) suggested row and plant spacing of 60×30cm for achieving higher seed yields; while Kazemeini *et al.* (2009) suggested 75 cm row spacing in sunflower. Johnson *et al.* (2010) reported 60 cm x 30 cm row×plant distance for achieving higher crop yields; while Ali *et al.* (2011), Sharma and Chaudhary (2007) found that foliar applied N at seed initiation was highly beneficial in increasing crop yield in sunflower.

## Oil content (%)

The treatment effect on oil content of sunflower was investigated and the data **(Table 3)** indicated that oil content was highest (41.2%) was determined in treatment comprised of plant population and row×plant spacing of 29526 (75×45cm) +foliar urea at development of leaves, followed by average oil content of 41.1, 40.2, 40.1 and 40.0% determined in treatments comprised of plant population of 36852 (60×45cm+foliar urea at development of flower bud); 44289 ha$^{-1}$ (75×30cm=Control); 55278 (60×30cm +foliar ureaat seed initiation) and 49284 (45×45cm +foliar urea at flowering completion), respectively; while the minimum oil content (38.8%) was determined in crop with plant population of 73926 (45×30cm+foliar ureaat seed development/maturity). The oil content was relatively higher in sunflower planted in wider spacing; while in dense planting the oil content was considerably reduced. Vijaya and Ramesh (2005) reported that oil content was significantly affected by sources of N application as well as head and seed size of sunflower. Kazemeini *et al.* (2009) reported that the crop spaced at 75 cm row apart produced relatively higher oil contents compared to crop under narrow row spacing

**Table 3: Effect of planting density and foliar application of urea on seed index, seeds head$^{-1}$ and weight of seeds head$^{-1}$of sunflower**

| Plant population (Row × plant distance) | Seed index (g) | Seed yield (kg ha$^{-1}$) | Oil content (%) |
|---|---|---|---|
| $T_1$= 44289 ha$^{-1}$ (75×30cm=Control) | **54.6$^{C}$** | **1901.3$^{B}$** | **40.2$^{B}$** |
| $T_2$= 29526 ha$^{-1}$ (75×45cm+foliar ureaat development of leaves) | **57.2$^{A}$** | **1733.0$^{C}$** | **41.2$^{A}$** |
| $T_3$= 36852 ha$^{-1}$ (60×45cm+foliar ureaat development of flower bud) | **56.2$^{B}$** | **1823.0$^{C}$** | **41.1$^{A}$** |
| $T_4$= 49284 ha$^{-1}$ (45×45cm+foliar ureaat flowering completion) | **53.3$^{D}$** | **1964.7$^{B}$** | **40.0$^{B}$** |
| $T_5$= 55278 ha$^{-1}$ (60×30cm+foliar ureaat seed initiation) | **53.0$^{D}$** | **2181.7$^{A}$** | **40.1$^{B}$** |
| $T_6$= 73926 ha$^{-1}$ (45×30cm+foliar ureaat seed development/maturity). | **47.1$^{E}$** | **2056.3$^{A}$** | **38.8$^{C}$** |
| *S.E.*(±) | ***0.4*** | ***80.2*** | ***0.1*** |
| *LSD 0.05* | ***1.0*** | ***178.9*** | ***0.2*** |

## 4. CONCLUSIONS

- The single plant study showed that growth and yield contributing traits showed better overall crop performance under plant population of 29526 (75×45cm) and 36852 ha$^{-1}$ (60×45cm), but the ha$^{-1}$ yield was lower as compared to high density plantation due to inappropriate plant population.
- The treatment comprised of row×plant distance of 60×30cm (55278 plants ha$^{-1}$)+ foliar applied ureaat seed initiation was most effective to achieve maximum seed yield ha$^{-1}$.
- In HO-1 sunflower, the plant population of 55278 ha$^{-1}$ (row×plant distance of 60×30cm) is recommended.
- The foliar applied urea at 3% concentration at seed initiation was effective to supplement the crop for improved crop performance.

## REFERENCES:


Ahmad, R. and N. Jabeen. (2009). Demonstration of growth improvement in sunflower (*Helianthus annuus*L.) by the use of organic fertilizers under saline conditions. Pak. J. Bot., 41(3): 1373-1384.

Ali, C. K., M.A. Nadeem and M.A. Javid. (2011). Effect of nitrogen levels and P application strategy on sunflower. Fertilizer News, 42 (3): 43-47.

Cruvinel, E. C., A. Perin, and P. H. C. Martins. (2007). Doses of nitrogen and reduced spacing in the culture of the sunflower.Documentos-Embrapa Soja, 292: 156-159.

Dev, C. M. and S. K. Sarawgi. (2004). Balance sheet of nitrogen, phosphorus and potassium as influenced by spacing and nutrient management in sunflower, (*Helianthus annuus* L).Journal of Oilseeds Research. 21(1):187-188.

FAO, (2008).Effect of row to row and plant to plant spacing on the growth and yield of sunflower. http://agris.fao.org/aos/records

GOP, (2017).monetary Surv4ey of Pakistan, 2016-2017. Government of Pakistan, Ministry of Food, Agriculture and Livestock, Agriculture & Livestock Division (Monetary Wing), Islamabad.

Jabeen, N. and R. Ahmad. (2011). Foliar Application of Potassium Nitrate Affects the Growth and Nitrate Reductase Activity in Sunflower and Safflower Leaves under Salinity. Not. Bot. Horti. Agrobo., 39(2):172-178.

Jahangir, A. A., R. K. Mondal, N. Afroze, and M. A. Hakim. (2006). Response of nitrogen and phosphorus fertilizer and plant spacing on growth and yield contributing character of sunflower. Bangladesh Journal of Scientific and Industrial Research, 41(1/2):33-40.

Johnson, B. L., M. E. Zarnstorff and J. F. Miller .(2010). Effect of Row Spacing and Plant Population on Oil Seed Sunflower. Proceedings of 21st Sunflower Research Workshop 183-192.

Kazemeini, S. A., M. Edalat and A. Shekoofa. (2009). Interaction effects of deficit irrigation and row spacing on sunflower *Helianthus annuus* L. growth, seed yield, and oil yield. African Journal of Agricultural Research, 4 (11) : 1165-1170.

Khan, M.M., A.R. Khilji and S.A. Taran. (2011). Effects of Row Spacing on the Growth and Yield of Sunflower Varieties. LAP Lambert Academic Publishing Co. 88-90

Oosterhuis, D. M. (1999).Foliar fertilization. Proc. Beltwide Cotton Conf., Orlando, Fla., 3-7, National Cotton Council, Memphis, Tenn., 26-29.

Sadozai, G. M. Farhad, M. A. Khan, E. A. Khan, M. Niamatullah, M. S. Baloch, A. A. Khakwani, and K. Wasim. (2013). Effect of different phosphorous levels on growth, yield and quality of spring planted sunflower. Pak. J. Nut., 12(12): 1070-1074.

Sharma, K. R., P. C. Srivastava, D. Ghosh, and M. S. Gangwar. (2007). Effect of boron and farmyard manure application on growth, yields, and boron nutrition of sunflower .Journal of Plant Nutrition. 22 (4/5): 633-640.

Silberbush, L. F. (2002). Response of maize to foliar vs. soil application of nitrogen-phosphorus-potassium fertilizers. J. Plant Nutrition. 25 (11): 2333-2342.

Vijayakumar, M. and S. Ramesh (2005). Effect of crop geometry and nitrogen management on growth analysis and yield of rain-fed sunflower (*Helianthus Annus*). Journal of Environmental Monitoring,15 (4): 371-376.