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EFFECT OF SOWING ENVIRONMENTS AND NITROGEN LEVELS ON GROWTH AND YIELD OF SUNFLOWER

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ABSTRACT

A field experiment was carried out during *rabi*, 2023-24 at Agricultural Research Institute of Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad, to study the effect of sowing environments and nitrogen levels on growth and yield of Sunflower. Sowing of sunflower during 1st Fortnight of December recorded significantly higher growth parameters *viz.*, plant height (136 cm), leaf area index (1.96), drymatter production (7334 kg ha^{-1}) and yield attributes *viz.*, number of seeds head^{-1} (687), stalk yield (5091 kg ha^{-1}) and finally significantly higher sunflower seed yield (1993 kg ha^{-1}) and was comparable with crop sown during 2nd Fortnight of December and 1st Fortnight of January. Application of 125% RDN resulted in significantly higher growth parameters *viz.*, plant height (135 cm), leaf area index (1.81), drymatter production (6992 kg ha^{-1}), yield attributes *viz.*, number of seeds head^{-1} (629), stalk yield (4765 kg ha^{-1}) and sunflower seed yield (1934 kg ha^{1}) and was comparable with 150% RDN which realized 2095 kg ha^{-1} seed yield.

Key words*:* Sunflower, Sowing environment, Nitrogen

Introduction

Oilseeds occupy an important position in Indian agriculture being next to food grains as a farm commodity. Sunflower (*Helianthus annuus* L.) is one of the major oilseed crops of India has been described as "drenched with sun-vitality" because the head follows the sun, ending up facing the west "to absorb the few last rays for the dying sun" (Nagaraj, 1995) and also Surajmukhi in India (Nirakar and Mahalik, 2008). Globally, sunflower covers 27.4 M. ha having productivity of 2049 kg ha^{-1} whereas, India cultivates sunflower in 0.226 M. ha with productivity of 1011 kg ha^{-1} and in Telangana, it is cultivated 0.007 M. ha with a productivity of 2342 kg ha^{-1} in 2020-21 (Indiastat 2021). India imported about 15 million metric tons of edible oils in 2019 (sunflower makes up 16 percent of these, after palm and soy oils), totaling about Rs. 7,300 crores. This amount made up 40 percent of the country's agricultural import bill and 3 percent of its total import bill. Sunflower cultivation is therefore a highly desirable addition to the production of oilseeds.

Increased irrigation potential and continuous cultivation of rice crop under submerged conditions, soil health deteriorates, salinity problems increase, and rice procurement becomes more difficult, necessitating crop diversification during the *rabi* season rather than the Rice-Rice system in Telangana state. Sunflower was identified as one of the finest alternative oilseed crops because it was well adapted to both zero and conventional tillage practices, adding area during the *rabi* season. The estimates imply a considerable risk to agriculture in warmer environmental conditions; nevertheless, the temperate zone may profit from this climate change. The yield and yield characteristics of achenes are unique to hybrids; however, they are impacted by the growing environment and technological advancement.

Sunflower is a photo and thermo-insensitive, day-neutral plant and its oil has superior stability and quality under a variety of climatic situations. In India, if we can locate a good sowing date without sacrificing yield, sunflower can readily fit into the existing *rabi* cropping schedule.

The fertilizer requirements of sunflower cultivars vary depending on ecological circumstances, precipitation, irrigation regimes, and plant species. Higher nitrogen doses enhance photosynthesis, increase leaf area, and boost net digestion rates. However, excessive nitrogen application can lead to environmental degradation, uneven plant nutrition, lower quality, and higher production costs. Therefore, optimum nitrogen levels should be selected to improve yield and quality while avoiding detrimental effects on human and soil health.

Considering the above, a study was carried out to identify the influence of sowing time and nitrogen levels on sunflower growth and yield under changing climatic conditions in order to increase its area, production, and edible oil production during *rabi* season.

Material and methods

The field experiment was carried out during *rabi*, 2023-24 at Agricultural Research Institute of Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad. The farm is geographically situated at 17º 19' 27" N latitude, 78º 23' 56''E longitude and at an altitude of 545 m above mean sea level (MSL) and falls under semi-arid tropic region (SAT).

The experiment was carried out using Hybrid GK-2002 on sandy loamy soils which was low in organic carbon, neutral pH, low in available nitrogen, medium in available phosphorous and high in available potassium.

The experiment was laid out in split plot design replicated thrice with six main plot treatments (S_1- 1st Fortnight of November; S_2- 2nd Fortnight of November; S_3- 1st Fortnight of December; S_4- 2nd Fortnight of December; S_5- 1st Fortnight of January; S_6- 2nd Fortnight of January) and four sub plot treatments (F_1: No Nitrogen (0 kg N ha^{-1}); F_2: 100% RDN (75 kg N ha^{-1}); F_3: 125% RDN (94 kg N ha^{-1}); F_4: 150% RDN (113 kg N ha^{-1}). Healthy seeds sown by dibbling method by adopting a spacing of 45 x 20 cm during *rabi* 2023-24. The crop was supplemented with 90 kg P_2O_5 and 30 kg K_2O ha^{-1} at the time of sowing. Nitrogen applied in 3 splits *i.e.*, 50% as basal, 25% each at 35 DAS and 55 DAS as top dressing.

Methodology

Plant height

Plant height was measured for ten tagged plants from the base of the stem at ground level to the apex of the stem axis with the help of ruler and mean of the ten plants was recorded in centimeters.

Leaf area index (LAI)

Leaf area was measured using the LI-COR model LI-300 portable leaf area meter with transparent belt conveyor (model LI-3050 A) and an electronic digital display. As the chopped leaves were put into the conveyor belt assembly, the area was calculated and presented in cm^2. The LAI was then computed by dividing the total leaf area by the corresponding land area, as suggested by Watson (1952).

$$LAI = \frac{\text{Leaf Area}}{\text{Ground Area}}$$

Dry matter production (kg ha^{-1})

From the destructive sampling rows, five plants were randomly removed and the root portion of plants was discarded. Then, the plants were separated into sections such as the stem, leaves, and head. Following a period of shade drying, the samples were then oven dried at 60°C until a constant weight was attained. The weight of dry matter was then quantified in kg ha^{-1}.

Number of seeds $head^{-1}$

The total number of seeds were counted from the heads which were tagged with the help of contador seed counter. In the seed counter, sunflower seeds are fed into the device, which uses optical sensors or mechanical components to count each seed as it passes through. The average of these ten head seeds was recorded as total number of seeds $head^{-1}$.

Seed yield (kg ha^{-1})

The heads were harvested from the net plot area and the seeds were separated by gently beating with sticks. Seeds were sundried for 2 to 3 days. After drying, the weight was recorded and the kg $plot^{-1}$ values were converted into kg ha^{-1}.

Stalk yield (kg ha^{-1})

Stalks were cut to the ground and sundried in the plots until constant weight was attained and then weighed and converted to kg ha^{-1}.

Results and discussion:

Plant height at Physiological Maturity

The plant height of sunflower was significantly influenced by different dates of sowing (Table 1). Sunflower crop sown on 1st Fortnight of December recorded significantly higher plant height (136 cm) at physiological maturity stage which was on par with the plant height observed at 2nd Fortnight of December (127 cm), 1st Fortnight of January (127 cm) and 2nd Fortnight

Table 1: Growth parameters, Yield attributes and yield of Sunflower under different dates of sowing and nitrogen levels

Treatments	Plant height (cm)	Leaf area Index	Dry matter production (kg ha^{-1})	Number of seeds head^{-1}	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
Sowing Dates						
S_1- 1st Fortnight of November	114	1.21	5718	488	1404	3785
S_2- 2nd Fortnight of November	125	1.22	5837	523	1576	4042
S_3- 1st Fortnight of December	136	1.96	7334	687	1993	5091
S_4- 2nd Fortnight of December	127	1.72	6792	670	1852	4994
S_5- 1st Fortnight of January	127	1.67	6663	641	1796	4730
S_6- 2nd Fortnight of January	121	1.18	5515	472	1377	3782
SEm(±)	3.39	0.14	363	21.16	80	213
CD (P=0.05)	10.81	0.31	809	67.54	255	680
Nitrogen (N) (kg ha-1)						
F_1: No Nitrogen (0 kg N ha^{-1})	96	0.63	4835	447	774	3427
F_2: 100% RDN (75 kg N ha^{-1})	130	1.55	6541	541	1807	4336
F_3: 125% RDN (94 kg N ha^{-1})	135	1.81	6992	629	1934	4765
F_4: 150% RDN (113 kg N ha^{-1}	138	1.98	7363	705	2095	5089
SEm(±)	2.55	0.12	188	28.12	40	147
CD (P=0.05)	7.34	0.25	380	80.98	115	425
Interaction						
DxN						
SEm(±)	6.38	0.30	459	63.29	138	378
CD (P=0.05)	NS	NS	NS	NS	NS	NS
NxD						
SEm(±)	6.77	0.20	473	42.32	144	426
CD (P=0.05)	NS	NS	NS	NS	NS	NS

of November (125 cm) sowings. However significantly the lowest plant height (114 cm) was noticed in the crop sown during 1st Fortnight of November over the later dates of sowing except plant height (119 cm) recorded with 2nd Fortnight of January sown crop. The findings were also supported by Ahmed *et al*. (2015) and Baghdadi *et al*. (2014), who reported increased sunflower plant heights with the early sowings and a significant decline in plant height was observed in later dates of sowing.

Graded levels of nitrogen had significant impact on plant height at all the growth stages of the crop. At physiological maturity stage, higher plant height was recorded with 150% (138 cm) and was on par with application of 125% RDN (135 cm) which was intern on par with 100% RDN (130 cm). Significantly, inferior plant height (96 cm) was observed with control *i.e.*, no nitrogen application which highlights the necessity of adequate nitrogen supply for sunflower growth. Increased nitrogen levels significantly improved plant height at all the stages as nitrogen is a crucial nutrient for sunflower growth, especially for vegetative development and flowering, where it plays a key role in promoting cell division, leaf expansion, and overall plant vigour (Arvin 2019).

The interaction effect of sowing dates and nitrogen levels on plant height in sunflower crop was found non-significant.

Leaf area index (LAI)

Leaf area index of sunflower was significantly influenced by different dates of sowing and nitrogen levels. Sunflower crop sown on the 1st fortnight of December (S_3) exhibited the highest LAI at physiological maturity stage (1.96) and which was on par with each other as LAI recorded in sunflower sown during 2nd Fortnight of December (1.72) and 1st Fortnight of January (1.67) and followed by rest of the sowing dates where LAI was found on par with each other during all growth stages. December and first fortnight of January sown crops have higher leaf area index as it might have experienced optimal environmental conditions such as temperature, photoperiod, and moisture resulting in superior growth. Similar results were reported by Gomez-Macpherson and Richards (1995).

Application of 150% RDN resulted in significantly higher LAI (1.98) at physiological maturity stage and which was at par with 125% RDN application (1.81) and followed by 100% RDN application (1.55).

Significantly lowest LAI (0.63) was recorded in sunflower where no nitrogen was applied to the crop. The trend of higher nitrogen rates improving LAI aligns with the understanding that nitrogen enhances crop productivity by boosting photosynthesis and leaf development (Fayyaz-ul-Hassan *et al.,* 2005). Increased nitrogen likely promotes cell division and leaf expansion, resulting in a stronger canopy structure (Steer *et al.,* 1986).

The interaction between sowing dates (DxN) and nitrogen treatments (NxD) did not show a significant effect on LAI.

Dry matter production (kg ha^{-1})

The dry matter production of sunflower was significantly influenced by the prevailing weather conditions under different dates of sowing of sunflower. Significantly higher drymatter production (7334 kg ha^{-1}) was found at physiological maturity stage in sunflower sown during 1st Fortnight of December and it was at par with dry matter production obtained in crop sown at 2nd Fortnight of December (6792 kg ha^{-1}) and 1st Fortnight of January (6663 kg ha^{-1}). Significantly lower drymatter production (5515 kg ha^{-1}) was recorded with crop sown during 2nd Fortnight of January which was comparable with dry matter production obtained in other sunflower sowings during 1st Fortnight of November (5718 kg ha^{-1}) and 2nd Fortnight of November (5837 kg ha^{-1}). The early and late sown crop entered in to reproductive phase at an early date compared to crop sown in December and competition between vegetative and reproductive parts restricted its growth and development resulted in less drymatter production. The longer period to reach anthesis might have enabled to accumulate more photosynthates in December sown crop and poor drymatter accumulation in late sown crop may be attributed to early leaf senescence and inhibited vegetative growth compared to December sown crop (Sofield *et al*., 1977).

Among sub plots at Physiological Maturity application of 150% RDN to sunflower found significantly higher dry matter production (7363 kg ha^{-1}) at physiological maturity stage over 100% RDN and no nitrogen application and it was comparable with dry matter production obtained with 125% RDN (6992 kg ha^{-1}). Significantly lowest drymatter production (4345 kg ha^{-1}) was obtained when no nitrogen was applied to sunflower. Application of 100% RDN produced 6541 kg ha^{-1} drymatter at physiological maturity stage was superior over no nitrogen application and inferior to higher levels of nitrogen application. The maximum drymatter production with 150% RDN or 125% RDN might have resulted due to higher net photosynthesizing area, LAI which facilitated higher rate of photosynthesis resulting in higher amount of drymatter production. Positive effect of N fertilizer on drymatter production has earlier been demonstrated by Nasim *et al.,* (2011). The enhancement of drymatter production with increasing rate of nitrogen was due to better crop growth rate that gave more photosynthates, LAI, and ultimately produced more biological yield. This is in accordance with the study by Dordas and Sioulas (2009).

No significant interaction was observed between sowing dates and nitrogen levels at any growth stage for dry matter production.

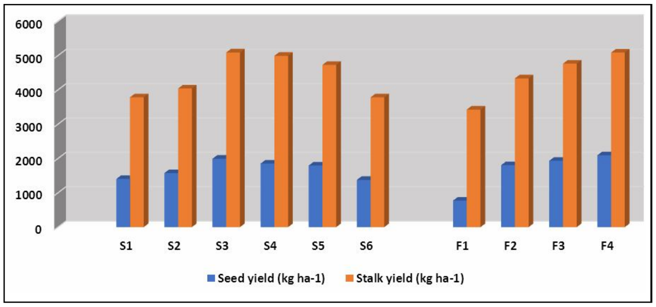
Yield Parameters and Yield

Number of seeds head^{-1}

The number of seeds head^{-1} were statistically significant due to different dates of sowing and varied nitrogen levels.

The 1st Fortnight of December sown sunflower produced significantly higher number of seeds head^{-1} (687) and in turn, which was at par with the number of seeds obtained in 2nd Fortnight of December (670) and 1st Fortnight of January (641) sown crop. December sowing clearly enhances seed production compared to earlier or later sowing periods. The 2nd Fortnight of January sown crop had significantly fewest seeds head^{-1} (472) showing the adverse effects of delayed sowing. However, it was observed at par seeds head^{-1} in crop sown during 1st Fortnight of November (488) and 2nd Fortnight of November (523) with crop 2nd Fortnight of January sown crop. Early sowing in November may expose sunflower to lower temperatures during their initial development, which can impede vegetative growth and delay flowering, ultimately reducing seed set per head (Reddy and Giri, 1997; Lawal *et al.,* 2011). Conversely, sowing in January may subject the plants to excessive heat during the flowering and seed development stages, potentially diminishing pollination efficiency and seed viability (Tomar *et al.,* 1997).

Significantly highest seed count (705 seeds per head) was achieved with 150% RDN (113 kg N ha^{1}) fertilization over lower nitrogen levels and was comparable with 125% RDN (629 seeds per head). Application of 100% RDN resulted in 541 seeds per head, which was significantly inferior over higher levels of RDN and superior over no nitrogen application (447 seeds per head). Nitrogen is essential for optimal seed development, and higher nitrogen doses further enhance reproductive success by improving nutrient allocation during the flowering and seed-setting stages (Killi *et al.,* 2004).



Sowing dates: S_1- 1st Fortnight of November, S_2- 2nd Fortnight of November, S_3- 1st Fortnight of December, S_4- 2nd Fortnight of December, S_5- 1st Fortnight of January, S_6- 2nd Fortnight of January

Fertility levels: F_1: No Nitrogen (0 kg N ha^{-1}), F_2: 100% RDN (75 kg N ha^{-1}), F_3: 125% RDN (94 kg N ha^{-1}), F_4: 150% RDN (113 kg N ha^{-1})

Fig. 1: Seed yield and stalk yield of Sunflower during *rabi* 2023-24 under different dates of sowing and nitrogen levels.

The interaction effects between sowing dates and nitrogen levels on the number of seeds $head^{-1}$ were not statistically significant, indicating that each factor independently affects seed production.

Seed yield (kg ha^{-1})

The seed yield of sunflower crop was markedly influenced by various sowing dates and varied nitrogen levels which was depicted in the Fig 1. The sunflower crop sown during the 1st Fortnight of December recorded the significantly higher seed yield (1993 kg ha^{-1}) and which was comparable with seed yield obtained when crop sown during 2nd Fortnight of December (1852 kg ha^{-1}) and 1st Fortnight of January (1796 kg ha^{-1}) which might have experienced the favourable environment for maximizing sunflower production. The seed yield recorded during 1st Fortnight of January was intern on par with seed yield recorded from the crop sown during 2nd Fortnight of November (1576 kg ha^{-1}) which was comparable at par with the seed yield obtained from sunflower crop sown during 1st Fortnight of November (1404 kg ha^{-1}) and 2nd Fortnight of January (1377 kg ha^{-1}). The observed reduction in yield can be attributed due to suboptimal conditions and abbreviated growth periods during the crop's vegetative and reproductive phases, which adversely affected seed development. Similar findings were documented by Sarker *et al.*, (2015), who noted that late sowing exposes crops to elevated temperatures and shorter photoperiods during the flowering stage, resulting in diminished pollination efficiency and grain filling. This invariably leads to reduced seed size and lower oil content, which further impacts overall yield.

Significantly highest sunflower seed yield (2095 kg ha^{-1}) was achieved with 150% RDN (113 kg N ha^{-1}), over lower levels of nitrogen application but it was at par with the seed yield (1934 kg ha^{-1}) obtained with 125% RDN (94 kg N ha^{-1}). Significantly lowest seed yield (774 kg ha^{-1}) was recorded under no nitrogen application. However, application of 100% RDN (75 kg N ha^{-1}) resulted in producing of 1807 kg ha^{-1} sunflower seed yield which was superior to the yield obtained with no nitrogen application, and inferior to the incremental increase of 25% nitrogen application up to 150 % RDN. The comparable yields of F_3 and F_4 imply that while an increase in nitrogen from 125% to 150% RDN yields incremental improvements, the maximum benefit was attained with the 150% RDN level, suggesting the existence of a nitrogen saturation threshold for sunflower under the studied conditions. Similar results were reported by Elfadl *et al.* (2009), who indicated that nitrogen rates exceeding the standard recommended dosage markedly enhance sunflower seed yield, particularly under intensive cultivation conditions.

The interaction effects between sowing dates and nitrogen levels were found to be statistically non-significant, suggesting that sowing date and nitrogen level independently impacted seed yield.

Stalk yield (kg ha^{-1})

The stalk yield of sunflower crop was markedly influenced by various sowing dates and varied nitrogen

Fig. 2: Sowing operation in the experimental field

Fig. 3: Overall view of the experimental field

levels which was depicted in the Fig. 1. The sunflower crop sown during the 1st Fortnight of December recorded the significantly higher stalk yield (5091 kg ha^{-1}) which was comparable with the stalk yield obtained from crop sown during 2nd Fortnight of December (4994 kg ha^{-1}) and 1st Fortnight of January (4730 kg ha^{-1}). Significantly lowest stalk yield (3782 kg ha^{-1}) was recorded with crop sown during 2nd Fortnight of January was comparable with stalk yield obtained with crop sown during 1st Fortnight November (3785 kg ha^{-1}) and 2nd Fortnight of November (4042 kg ha^{-1}). Early sowing may subject crops to suboptimal temperatures, thereby inhibiting growth. Conversely, late sowing tends to extend crop development into unfavourable late-season conditions, which impedes the growth and biomass potential of sunflower (Sur and Sharma, 2013). Furthermore, very late sowing can prolong crop development under elevated temperatures, potentially leading to water stress and diminished biomass accumulation (Paul *et al.,* 2021).

Significantly higher stalk yield (5089 kg ha^{-1}) was achieved with 150% RDN (113 kg N ha^{-1}), over lower levels of nitrogen application but it was at par with the stalk yield (4765 kg ha^{-1}) obtained with 125% RDN. Significantly lowest stalk yield of 3427 kg ha^{-1} was recorded under no nitrogen application. However, application of 100% RDN resulted in producing of 4336 kg ha^{-1} stalk yield which was inferior to the incremental increase of 25% nitrogen application up to 150 % RDN and superior to the stalk yield obtained with no nitrogen application. This observed pattern suggests the existence of a nitrogen saturation threshold, beyond which the application of additional nitrogen does not lead to further yield enhancements. These results are consistent with earlier research conducted by Pavani *et al.,* (2013) and Sumathi and Rao (2007), which indicated that sunflower biomass substantially improves with nitrogen applications that exceed the recommended levels, particularly in nutrient-demanding conditions. Furthermore, similar conclusions have been drawn by Paul *et al.,* (2021), who reported that elevated nitrogen availability enhances leaf area, chlorophyll content, and the rate of photosynthesis, thereby contributing to greater biomass production.

The interaction effect of sowing dates and nitrogen levels on stalk yield in sunflower crop was found non-significant.

Conclusion

On the basis of experimental findings, it can be concluded that 1st Fortnight of December was found to be best sowing date for higher crop growth and yield of sunflower. Application of 125 % RDN (94 kg N ha^{-1}) can be recommended for sunflower as it had shown increased growth parameters and yield which was comparable with the crop applied with 150% RDN (113 kg N ha^{-1}).

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References

Ahmed, B., Sultana, M., Zaman, J., Paul, S.K., Rahman, M.M., Islam, M.R and Majumdar, F. (2015). Effect of sowing dates on the yield of sunflower. *Bangladesh Agronomy Journal*, **18(1):** 1-5.

Arvin, P. (2019). Study of Different Levels of Nitrogen, Phosphorus and Potassium on Physiological and Morphological Parameters and Essential Oils in Savory Plant (*Satureja hortensis* L.). *Journal of Plant Research (Iranian Journal of Biology),* **32(2):** 260–279.

Baghdadi, A., Halim, R.A., Nasiri, A., Ahmad, I and Aslani, F. (2014). Influence of plant spacing and sowing time on yield of sunflower (*Helianthus annuus* L.). *Journal of Food, Agriculture & Environment,* **12(2):** 688-691.

Dordas, C.A and Sioulas, C. (2009). Dry matter and nitrogen accumulation, partitioning, and retranslocation in safflower (*Carthamus tinctorius* L.) as affected by nitrogen fertilization. *Field Crops Research,* **110(1):**35-43.

Elfadl, E., Reinbrecht, C., Frick, C and Claupein, W. (2009). Optimization of nitrogen rate and seed density for safflower (*Carthamus tinctorius* L.) production under low-input farming conditions in temperate climate. *Field Crops Research,* **114(1):** 2-13.

Fayyaz-ul-Hassan G., Qadir and Cheema, M.A. (2005). Growth and development of sunflower in response to seasonal variations. *Pakistan Journal of Botany,* **37:** 859-864.

Gomez-Macpherson, H. and Richards, R.A. (1995). Effect of sowing time on yield and agronomic characteristics of wheat in south-eastern Australia. *Australian Journal of Agricultural Research*, **46(7):** 1381-1399.

India Statistics. 2021. (www.indiastat.com, 2021-22).

Killi and Faith (2004). Influence of different nitrogen levels on productivity of oilseed and confection sunflowers (*Helianthus annuus* L.) under varying plant populations. *International Journal of Agriculture and Biology,* **4:** 594-598.

Lawal, B.A., Obigbesan, G.O., Akanbi, W.B and Kolawole, G.O. (2011). Effect of planting time on sunflower (*Helianthus annuus* L.) productivity in Ibadan, Nigeria. *African Journal of Agricultural Research,* **6(13):** 3049-3054.

Nagaraj, G. (1995). Quality and utility of oilseeds. Directorate of Oilseeds Research, Indian Council of Agricultural

Research, Hyderabad, India.

Nasim, W.A.J.I.D., Ahmad, A., Wajid, A., Akhtar, J and Muhammad, D. (2011). Nitrogen effects on growth and development of sunflower hybrids under agro-climatic conditions of Multan. *Pakistan Journal of Botany,* **43(4):** 2083-2092.

Nirakar Ranasingh, N.R. and Mahalik, J.K. (2008). Insect pests management in sunflower. *Orissa Review,* 51-53.

Paul, P.L.C., Bell, R.W., Barrett-Lennard, E.G., Kabir, E and Gaydon, D.S. (2021). Opportunities and risks with early sowing of sunflower in a salt-affected coastal region of the Ganges Delta. *Agronomy for Sustainable Development,* **41(3):** 39.

Pavani, S., Rekha, K.B., Babu, S.N and Moguloju, M. (2013). Effect of nitrogen and sulphur on growth, yield and quality of sunflower (*Helianthus annuus* L.). *Crop Research,* **45(1-3):** 152-154.

Reddy, G. P and Giri, G. (1997). Influence of time of seedling, pollination and nitrogen on yield of sunflower (*Helianthus annuus* L.). *Indian Journal of Agronomy,* **42:** 506-11.

Sarker, B.C., Nasreen, M., Quddus, K.G and Nurani, F.J. (2015). Growth and yield performance of sunflower (*Helianthus annuus* L.) at different dates of sowing under different tillage Conditions in Batiaghata Upazilla under Khulna District. *South Asian journal of Agriculture,* **6(1):** 97-110.

Sofield, K., Evans, L.T., Cook M.G., and Wardlaw, F. (1977). Factors influencing the rate and duration of grain filling in wheat. *Australian Journal of Plant Physiology,* **4:** 785-797

Steer, B.T, Coalitrake, P.D.C., Pearson, J and Canty, C.P. (1986). Effect of nitrogen supply and population density on plant development and yield components of irrigated sunflower (*Helianthus annuus* L.). *Field crops Research,* **13(2):** 99-115.

Sumathi, V. and Rao, D.K. (2007). Effect of organic and inorganic sources of nitrogen with different irrigation schedules on growth and yield of sunflower (*Helianthus annuus* L.). *Indian Journal of Agronomy,* **52(1):** 77-79.

Sur, H and Sharma, A. (2013). Response to sowing dates and performance of different sunflower (*Helianthus annuus* L.) hybrids during rainy season in high-intensity cropping systems. *The Indian Journal of Agricultural Sciences,* **69(10):** 45-49.

Tomar, H. P. S., Dadhwal, K. S and Singh, H. P. (1997). Root characteristics and moisture use pattern of spring sunflower (*Helianthus annuus* L.) as influenced by irrigation, nitrogen and phosphorus. *Indian Journal of Agronomy,* **42:** 515-519