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Influence of foliar application of boron and TIBA on photosynthetic parameters vis-a-vis productivity of sunflower (*Helianthus annuus* L.) under variable sowing dates

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ABSTRACT

Field experiments were conducted during spring 2014 and 2015 at Punjab Agricultural University, Ludhiana, to study the effect of staggered sowing on photosynthetic parameters and the productivity of sunflower (*Helianthus annuus* L.) in relation to foliar application of boron (B) and TIBA (Tri iodo benzoic acid-TIBA). The experiment was laid out in split plot design with three sowing dates (January 20, February 10 and March2) in main plots and eight foliar spray treatments (Control, water spray, B @ 110, 220, 440 ppm, TIBA @ 100, 200 and 400 ppm) in sub plots replicated thrice. The results indicated that delay in sowing caused significant reduction in biological and seed yield of sunflower probably due to significant reduction in photosynthetic parameters coupled with reduction in crop duration from 119 to 92 days. Foliar application of boron and TIBA improved the dry matter accumulation by leaf and seed as well as total but dry matter accumulation by stem did not vary at 90 DAS. Marked improvement in photosynthetic parameters coupled with better growth indices due to TIBA- 100, 200 and 400 ppm and boron 220 and 440 ppm increased crop productivity over control and water spray by way of improved DM partitioning. Correlation studies indicated significant positive correlation of seed yield with PAR, chlorophyll content and stomatal conductance at 90 DAS, emphasizing the importance of higher growth and photosynthetic rate during reproductive period for best yield accrual from sunflower.

Key words: Chlorophylls, dry matter partitioning, Helianthus annuus, PAR,

Temperature is major environmental factor that determines the rate of plant development. Sowing time influences the crop by subjecting it to variable temperature during growth period by affecting various physiological processes. Sowing time is an important non-monetary input that can be manipulated to avail the congenial environment for best yield accrual (Dhillon *et al.,* 2017). Under Punjab conditions, month of January is recommended sowing time of sunflower, which is difficult to be followed as the crop succeeds potato/sugarcane/ peas which vacate the field mostly in end February. Hence, crop is subjected to much high temperatures, which are not congenial for growth and yield due to various reasons (Ahmed *et al.,* 2015).

Besides environmental and agronomic factors, several physiological factors are also responsible for low yields of sunflower (Ram and Davari, 2011). The photosynthetic rate in the leaves decline after the development of reproductive organs due to ageing of leaves coupled with onset of senescence of most of the middle leaves and few top leaves. A large amount of biomass is locked up in the vegetative parts of sunflower. Any practice which can enhance the remobilization of photosynthates from vegetative parts to head will increase harvest index and seed yield. Application of growth regulators and boron (B) may make it possible to regulate the remobilization of metabolites from stalk during the leaf senescence and thereby, increase productivity (Nanja Reddy *et al.,* 2003). Besides, plant growth regulators have the ability to modify phasic development of plant either by altering the endogenous hormonal level or by changing the capacity of plant to respond to its natural hormones (Dhillon *et al.,* 2017a). TIBA (2, 3, 5-Tri-iodobenzoic acid), an inhibitor of polar auxin transport, increases the sink capacity of the head and thus results in movement of metabolites from vegetative organs to the head (Ram and Davari, 2011). The main physiological roles of boron (B) in plants are translocation of sugars, synthesis of cellular walls, maintaining membrane integrity, IAA metabolism, accelerating flowering and fruit-bearing processes in head (Jabeen and Ahmad, 2011). Hence, application of B to sunflower has been observed to be beneficial. Information on growth dynamics and photosynthetic parameters under variable environmental conditions is essential for identification and overcoming the yield constraints to amplify the crop potential. However, so far little information is available on such aspects of sunflower under Punjab conditions. Although the sunûower is considered as photo and thermo insensitive crop but its growth and photosynthetic rate are affected by variation in temperature (Prasad, 2003). Hence, experiment was conducted to study the photosynthesis and growth dynamics of staggered sown spring sunflower in relation to foliar application of boron and TIBA.

MATERIALS AND METHODS

The field experiment was conducted during spring 2014 and 2015 at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana (30°56' N latitude, 75°52' E longitude and an elevation of 247 metres above the mean sea level). The soil of location selected for conducting experiment was Typic Ustipsamment (Fatehpur sandy–loam) in texture, low in available N and soil organic carbon (SOC) status. However, high in available–P, medium in available–K and sufficient in B-status. The soil pH and electrical conductivity were within the normal range. The field experiments was laid out in split plot design with 24 treatment combinations consisting of three sowing dates (D_1-January 20, D_2-February 10 and D_3-March 2) in main plots and eight foliar spray treatments (Control (no spray)-S_1, water spray-S_2, boron 110, 220, 440 ppm, TIBA 100, 200 and 400 ppm) in sub plots. Each treatment was replicated thrice. Sunflower hybrid PSH 996 was sown at row to row and plant to plant spacing of 60 x 30 cm by dibbling 3 seeds per hill. Thinning was done at 3 weeks after sowing and one plant per hill was retained. Crop was fertilized with 30 kg ha^{-1} each of P_2O_5 and K_2O at the time of sowing. Nitrogen was applied @ 60 kg ha^{-1} through urea in two equal splits as basal and at thinning (3 weeks after planting). Crop was irrigated as per requirement. Two hoeings were done to control weeds. The crop was then earthed up at 6-7 weeks after sowing to protect it from lodging. Foliar application of boron (borax) and TIBA was done at ray floret opening stage of crop with knap sack sprayer discharging water @ 400 L ha^{-1}. Chlorpyriphos 20 EC @ 2.5 l ha^{-1} was sprayed at bud formation and 50 % flowering stages to control semi looper and head borer. Crop was protected from bird damage by erecting nylon net over the field at a height of 2.5 metre.

Observations on photosynthetically active radiations at 90 DAS were recorded at 1430 hours using line quantum facing sensor. The incoming, transmitted and reflected PAR were measured by keeping the sensor upward on the top of canopy, bottom of the canopy and by sensor facing inverted at about 10 cm above the soil surface, respectively. The intercepted PAR (%) was calculated by using following formula:

$$\text{PARI}\,(\%) = \frac{\text{PAR(I) - PAR(T) - PAR(R)}}{\text{PAR(I)}} \times 100$$

where,

PAR (I), PAR (T) and PAR (R) are the incident, transmitted and reflected photo-synthetically active radiations, respectively.

Chlorophyll content was determined as per the method described by Anderson and Boardman, (1964). Photosynthetic parameters viz. transpiration rate and stomatal conductance were measured at 90 DAS from fully expanded apical leaves, using portable LCi photosynthesis system (ADC Bio-Scientific Limited). The staggered sown crop experienced different temperatures, the details of which are given in Fig 1.The biological and seed yield was recorded as total weight and weight of threshed seeds obtained from net plot area of each experimental unit, respectively, which was adjusted to 9 per cent moisture level and expressed as kg ha^{-1}. Data were subjected to analysis of variance (ANOVA) using statistical analysis software (SAS 9.3.) to evaluate differences between treatments.

RESULTS AND DISCUSSION

Weather parameters and dry matter accumulation (DMA)

Rainfall, maximum and minimum temperatures were measured at agro–meteorological observatory of PAU, Ludhiana. Maximum air temperature varied from 17.5 to 40.6 °C and 15.6 to 39.6 °C, minimum from 7.0 to 27.1°C and 7.5 to 23.8°C with mean temperature variation from 12.2 to 33.8°C and 11.3 to 31.7 °C during spring 2014 and 2015, respectively (Fig 1). Total rainfall of 214.6 and 191.2 mm was received during respective crop seasons of 2014 and 2015. Overall, both the seasons were normal but rainfall pattern was more uniform during 2014.

Crop sown on March 2 experienced comparatively higher mean air temperature throughout the crop season, whereas, crop sown on January 20 experienced low temperature up to 60 days of sowing and near optimum temperature during later part of crop growth, thereby affecting the dry matter accumulation (Fig 1) during both the years. Due to availability of congenial temperature at early phase (up to 60 DAS) of March 2 sown crop, the increment in DM was higher. However, at later growth stages

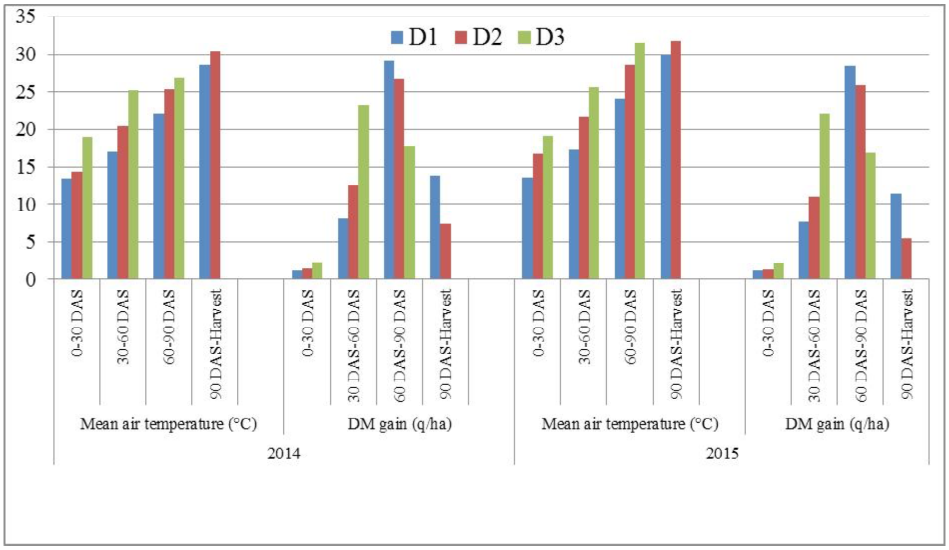

Fig 1: Mean air temperature (°C) and dry matter increment (q ha^{-1}) by staggered sown sunflower during different growth stages. (Note: The crop sown on March 2 was harvested 92 DAS, hence data for 90 DAS- harvest is not given)

i.e. 60-90 DAS and 90 DAS to harvest, the dry matter increment was higher under earlier sown crop, thereby indicating the importance of congenial temperature for higher DMA. Prasad (2003) opined that temperature of 15-20˚C during the vegetative period and 20-25˚C during reproductive period is considered ideal for sunflower production. Hence, availability of congenial temperature at juvenile phase of crop sown on March 2 favored better growth but very high temperature at later stages of March 2 sown crop limited its growth. However, the increase of temperature within optimum range between 60 DAS to harvest of early sown crop favoured higher DMA during the said period. These results are in line with the earlier work of Dhillon *et al.* (2017); Dhillon and Sharma (2016).

Photosynthetic parameters

Data in Table 1 reveals that PARI, chlorophyll content and transpiration rate decreased significantly and progressively with each delay in sowing. But stomatal conductance did not differ due to variation in sowing dates. Foliar applications also influenced the photosynthetically active radiation interception significantly. Application of B @ 440 ppm recorded the highest and the control (no spray) the lowest PARI. Control was statistically at par with water spray and boron 110 ppm spray, whereas rest all treatments were at par with boron @ 440 ppm, indicating their superiority over control, water spray and boron 110 ppm. Similarly, significant differences in chlorophyll content were also noted due to various foliar treatments; and application of TIBA @ 200 ppm resulted in significantly the highest and control, the least chlorophyll content. Control was at par with water spray. However, foliar application treatments did not exerted significant effect on transpiration rate and stomatal conductance. All interactions were found to be non-significant. The observed differences in photo-synthetically active radiation interception due to dates of sowing may be ascribed to the differences in the canopy cover. As leaves are associated with the capture of radiant energy. Crop sown on January 20 had higher total and leaf DM, which might have been beneficial in capturing more quanta of photosynthetically active radiation than the later sowing dates.

Dry mater partitioning

A perusal of data in Table 2 reveals that at 90 DAS, DMA by leaf and total DMA decreased significantly with each delay in sowing, but DMA by stem did not vary among different sowing dates. However, DMA by sink showed increasing trend in response to delay of sowing. Data in Table 2 further indicate that application of TIBA @ 200 ppm resulted in significantly higher DMA by leaf, sink as well as total, which was statistically at par with all foliar treatments except water spray. Control treatment registered the lowest DMA by all plant parts. However, dry matter accumulation by stem did not vary significantly due to foliar treatments.

Significantly poorer dry matter accumulation by later sown crop (March 2) may be due to the fact that high temperature caused leaf senescence, increased respiratory losses thereby inhibiting vegetative growth of crop and forced the crop to attain maturity quickly. The higher dry

Table 1: Photostynthetic parameters of sunflower at 90 DAS as influenced by sowing dates and foliar sprays of boron and TIBA (Mean of two years±S.D.)

Treatments	PAR interception (%)	Chlorophyll content (mg g^{-1} fresh weight)	Transpiration rate (m mol m^{-2} sec^{-1})	Stomatal conductance (mol m^{-2} sec^{-1})
Sowing date				
Jan., 20 (D_1)	77.7±2.2	2.11±0.05	4.76±0.03	0.37±0.00
Feb., 10 (D_2)	74.2±2.4	1.95±0.07	4.55±0.04	0.35±0.01
March,2 (D_3)	63.0±3.0	1.71±0.12	4.26±0.06	0.34±0.01
CD (p=0.05)	3.4	0.11	0.18	NS
Foliar spray (ppm)				
Control	68.4±4.9	1.77±0.08	4.42±0.03	0.34±0.01
Water spray	68.4±4.5	1.78±0.08	4.42±0.01	0.34±0.00
Boron 110	71.9±3.5	1.90±0.16	4.52±0.02	0.35±0.00
Boron 220	73.2±4.3	1.98±0.08	4.55±0.01	0.36±0.01
Boron 440	73.0±5.3	1.97±0.08	4.56±0.03	0.36±0.01
TIBA 100	72.4±4.5	1.97±0.09	4.56±0.01	0.37±0.01
TIBA 200	72.7±4.2	1.99±0.06	4.61±0.03	0.36±0.00
TIBA 400	73.2±4.7	1.98±0.08	4.56±0.02	0.36±0.01
CD (p=0.05)	3.6	0.15	NS	NS

Table 2: Dry matter partitioning (kg ha^{-1}) of sunflower at 90 DAS as influenced by sowing dates and foliar sprays of boron and TIBA (Mean of two years±S.D.)

Treatments	Leaf	Stem	Sink	Total
Sowing date				
Jan., 20 (D_1)	1224±14	1278±15	1279±109	3782±73
Feb., 10 (D_2)	1100±7	1346±10	1478±105	3947±163
March,2 (D_3)	948±6	1309±12	1889±108	4145±163
CD (p=0.05)	91	NS	111	124
Foliar spray (ppm)				
Control	987±21	1312±11	1458±100	3757±110
Water spray	977±6	1313±5	1459±93	3749±103
Boron 110	1109±26	1306±7	1570±106	3985±124
Boron 220	1126±13	1323±13	1603±121	4052±148
Boron 440	1146±9	1329±18	1606±120	4081±129
TIBA 100	1113±5	1290±25	1572±111	3974±135
TIBA 200	1145±4	1316±13	1616±129	4077±146
TIBA 400	1125±5	1313±23	1505±77	3942±101
CD (p=0.05)	85	NS	NS	183

matter accumulation by sink under later sown crop (at 90 DAS) may be ascribed to the fact that duration of earlier sown crop was118 days whereas, that of late sown crop was 92 days only (Dhillon *et al.,* 2017). These results are in line with the earlier findings of Jabeen and Ahmad (2011). Likewise, the favourable effect of TIBA on dry matter

Table 3: Effect of sowing dates and foliar application of boron and TIBA on biological and seed yield of sunflower (Mean of two years±S.D.)

Treatments	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})
Sowing date		
Jan., 20 (D_1)	5040±245	2010±226
Feb., 10 (D_2)	4590±308	1820±223
March,2 (D_3)	4217±173	1487±122
CD(p=0.05)	123	79
Foliar spray (ppm)		
Control	4207±229	1578±167
Water spray	4235±257	1603±172
Boron 110	4615±257	1754±214
Boron 220	4752±255	1824±214
Boron 440	4768±250	1832±213
TIBA 100	4766±248	1875±212
TIBA 200	4872±240	1917±212
TIBA 400	4709±197	1796±141
CD (p=0.05)	201	130

accumulation and partitioning into sink is reported by Hunje *et al*., (1996) in cow peas.

Seed and biological yield

Delay in sowing caused progressive reduction in biological and seed yield of sunflower (Table 3). The highest biological yield produced under January 20 was 9.8 % higher than February 10 and 18.9 % higher than March 2 sowing date. Similarly, crop sown on January 20 out yielded the February 10 and March 2 sown crop by a margin of 10.4 and 34.9 %, respectively in seed yield. Under late sowing, higher night temperature reduces DMA by increasing the rate of respiration occurring in absence of photosynthesis. The higher photosynthetic efficiency of early sown crop can be related to higher photosynthetically active radiations interception, total chlorophylls and transpiration rate (Table 1) coupled with better dry matter partitioning (Table 2) due to availability of congenial temperature (Fig 1). All the physiological processes are temperature dependent and hence hike in temperature within the optimum range has favorable effect on photosynthesis, thus resulting in higher dry matter accumulation in seeds of early sown crop. The studies of Dhillon and Sharma (2016) also reveals that that early sowing improved crop growth rate, increased duration of seed filling and reproductive phase, which ultimately helped the crop to utilize the thermal energy more efficiently leading to enhanced heat use efficiency. Ahmed *et al.,* (2015) also reported that early sown sunflower gave higher Biological and Seed yield.

Table 4: Correlation between photosynthetic parameters and yield of sunflower

Parameters	Seed yield	Biological yield
Stomatal conductance 90 DAS	0.91	0.94
PAR 90 DAS	0.94	0.88
Total chlorophylls 90 DAS	0.98	0.97

Biological yield and seed yield also varied significantly under the influence of different foliar application treatments (Table 3). The least biological and seed yield obtained under control was statistically at par with water spray. Significantly the highest biological and seed yield obtained with 200 ppm TIBA was statistically at par with all other treatments except water spray and control. The least seed yield recorded under control was statistically at par with water spray but significantly higher than all boron and TIBA treatments. Boron, an essential element for sunflower is playing an important role in flowering, pollen germination, fruiting processes and seed setting. Besides improving pollen viability, spray of boron might have improved the cell wall structure, with transitory increase in elasticity module followed by reduced secondary thickening and increase in the incidence of plasma membrane bound reductase activity for better partitioning to sink, leading to higher DM partitioning to seed (Yu *et al.,*. 2002). The enhancement of total chlorophyll, total sugars and yield by application TIBA has also been reported by Kashid *et al,*. (2010).

Correlation studies

Simple pearsons correlation ® between seed and biological yield (Table 4) with various photosynthetic parameters of sunflower reveal positive correlation of seed and biological yield with PARI, Chlorophyll content and Stomatal conductance at 90 DAS.

REFERENCES

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

Dhillon, B. S. and Sharma, P. K.(2016). Emergence and growth dynamics of *spring* sunflower (*Helianthus annuus* L.) in relation to sowing dates, densities and nitrogen rates. *Curr. Adv. Agric. Sci.*8(1): 69-75.

Dhillon, B. S., Sharma, P. K. and Kingra, P. K. (2017). Agronomic measures to improve thermal energy utilization by *spring* sunflower. *J. Agrometeorol*. 19 (1): 34-38.

Dhillon, B. S., Sharma, P. K. and Kingra, P. K. (2017a). Effect of foliar application of boron and TIBA on crop phenology and solar energy utilization efficiency of *spring* sunflower under staggered sowing. *Agric Res J.,* 54 (2): 202-207.

Hunje, R. V., Kulkarni, G. V., Vyakaranhal, B. S. & Shashidhara, S. D. (1996). Effect of growth regulators on growth and yield in cowpea. *Karnataka J. Agric. Sci.,* 8: 429-31.

Jabeen, N. and Ahmad, R. (2011). Effect of foliar applied boron and manganese on growth and biochemical activities in sunflower under saline conditions. *Pakistan J. Bot.,* 43: 1271-82.

Kashid, D. A., Chetti, M. B., Hiremath, S. M. & Arvindkumar, B. N. (2010). Effect of growth retardants on morpho-physiological traits and yield in sunflower. *Karnataka J. Agric. Sci.,* 23: 347-349.

Nanja Reddy, Y. A., Uma Shankar, R., Prasad, T. G. and Kumar, U. (2003). Physiological approaches for improving harvest index and productivity in sunflower. *Helia.,* 26: 81-90.

Prasad, R. (2003). "Textbook of Field Crops Production". ICAR, New Delhi publication, pp: 473-74.

Qadir, G., Cheema, M. A., Hassan, F.U., Ashraf, M. and Wahid, M. A. (2007). Relationship of heat units accumulation and fatty acid composition in sunflower. *Pakistan J. Agric. Sci.,* 44(1): 24-29.

Ram, M. and Davari, M. R. (2011).Seed setting and filling problem in sunflower and its management – A review. *Int. J. Agron. & Pl. Prod.,* 2(2): 33-56.

Sheoran, P., Sardana, V. and Singh, R. (2014). Evaluating productivity potential of *spring* sown Sunflower (*Helianthus annuus* L.) hybrids in response to sowing dates under changing climate scenario. *Indian J. Agron.,* 59: 124-32.

Yu, Q., Hlavacka, A., Matoh, T., Volkmamn, D., Nanzel, D. & Baluska, F. (2002). Short term deprivation inhibits endo-cytosis of cell wall pectins in meristematic cells of maize and wheat root apices. *Pl. Physiol.,* 130: 415-21.

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