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Effect of foliar nutrients and growth regulator on the growth and yield of spring hybrid Sunflower (*Helianthus annuus* L. Var. GKSF-2002) in Gangetic alluvial soils of West Bengal

Ranjeet Singh Bochalya, Rambilash Mallick, Meghna Gogoi and Kamal Kant

Abstract
An experiment was conducted during the spring season of 2017 at the Agricultural Experimental Farm of Institute of Agricultural Science of Calcutta University, Baruipur, situated in the Gangetic region of West Bengal, India for making a comparative assessment to study the effect of foliar nutrients and growth regulator on the growth and yield of spring hybrid Sunflower (*Helianthus annuus L.* Var. GKSF-2002). A total of six foliar nutrients, including Water spray (T_1), KCl@ 0.5% (T_2), KNO_3 @ 0.5% (T_3), DAP @1.5% (T_4), N P K 10:26:26 @1.5% (T_5) and NaCl @0.25% + Turmeric @0.25% (T_6) and four levels of growth regulator including Cycocel @0.2% (T_7), Cycocel @0.25% (T_8), Cycocel @0.3% (T_9) and Cycocel @0.25% + N P K 10:26:26 @1.5% (T_{10}) were established. The treatments were arranged in a randomized block design with three replications. The plant height (cm), number of green leaves per plant, head diameter (cm), number of seeds per plant, test weight, seed weight per plant, total seed yield (tha^{-1}) and oil quality were superior in T_{10}, T_5 and T_8 compared to T_1, T_2, T_3, T_4, T_6, T_7 and T_9 According to the results for the growth, the order was $T_{10}>T_5>T_8>T_4$ respectively. According to the results for the yield, the order was $T_{10}>T_5>T_8>T_4$ respectively. The results showed that using a foliar application of Cycocel @0.25% + N P K 10:26:26 @1.5% increased the growth and yield of sunflower significantly, as compared to the other treatments.

Keywords: Sunflower, foliar nutrients, growth regulator, cycocel

Introduction
Sunflower (*Helianthus annuus* L.) has become an important oil seed crop worldwide with an average annual harvested area of more than 25 million ha in 2013 (FAOSTAT, 2014) [2]. It is a photo and thermo-insensitive, short-duration, deep rooted, drought resistant, wide adaptable crop, offers promise for its cultivation under varied agro-climatic conditions and diverse cropping systems and subsistence farming situations for boosting oilseed production.

Despite of high yielding potential and various advantages of sunflower, the yield per unit area of the crop is low (517 kg/ha) which indicates that there is great scope in improving the productivity potential by using suitable measures particularly, the use of plant growth regulators and foliar nutrients. Plant growth regulators so far have emerged as "magic chemicals" that could increase agricultural production at an unprecedented rate and help in removing and circumventing many of the barriers imposed by genetics and environment. Plant growth regulators (promoters, inhibitors or retardants) play key role in contributing internal mechanisms of plant growth by interacting with key metabolic processes such as, nucleic acid metabolism and protein synthesis. Growth retardants are known to reduce inter-nodal distance, thereby enhancing source-sink relationship and stimulate the translocation of photo-assimilates to the seeds (Luib *et al*., 1987) [4]. Growth regulators exert their influence on foliar transport in a number of ways. These could enhance the absorption by the leaf at the site of application, increase the migration within the leaf and/or stimulate the transport out of leaf in the acropetal and basipetal direction.

For increasing seed yield and quality in sunflower, several approaches like application of micro nutrients, plant growth regulators, and protection against moisture stress has been suggested. Nanja Reddy *et al*. (2003) [7] reported that in sunflower large amount of biomass is locked up in the vegetative plant parts, any practice to manipulate the mobilization of photosynthates from vegetative phase to head improve HI and seed yield. They noticed that foliar application of nutrients with application of growth regulators to the plant improved the translocation of photosynthates to the head and increased seed yield.

Prasad and Sastry, (1978) [9] reported that exogenous application of growth regulators to the developing head was shown to increase the transport of photosynthates from leaf to the developing head. However, Pankaj Kumar *et al*. (2006) [8] reported that growth retardants viz., TIBA, Cycocel and mepiquat chloride were more beneficial in terms of the translocation of photo-assimilates towards developing reproductive parts compared to growth promoter kinetin and the control. Plant growth regulators are known to change the growth and development pattern of crop plants by altering many physiological and biochemical processes and thereby increasing the yield of crops.

Fertilizers are energy intensive to produce and are very expensive. The present price hike of fertilizers is one of the main constraints to increase the economic yield of crops. Thus efforts are needed to minimize its losses and to enhance its economic use. Foliar fertilization, that is nutrient supplementation through leaves, is an efficient technique of fertilization which enhances the availability of nutrients. It has been observed that utilization of fertilizers especially urea applied through soil is not as effective as when it is supplied to the plant through foliage along with soil application. N due to leaching and volatilization and P due to fixation may not be available adequately at flowering and seed development stages of crop resulting in shedding of flowers and less seed development due to transient nutrient deficiency. Inactivation of the roots activity may be additional cause for this deficiency.

Foliar fertilization can be used to improve the efficiency and rapidity of utilization of a nutrient urgently required by the plant for maximum growth and yield. In this way the foliar fertilization supplements soil application for a more efficient supply of nutrients to the sunflower plants for optimum yields and oil quality. Foliar applied fertilizers (acting as osmoprotectants under environmental stress) often show a better efficacy which may help to reduce the required dose. These osmoprotectants need further evaluation regarding their potential and economic feasibility. Most of the works are conducted on foliar application of chemicals other than sunflower crop. Therefore, this study was thought needful to work out a strategy involving the use of osmoprotectants to enhance the growth and productivity of sunflower under irrigated conditions of Lower Indo Gangetic Plain zone that is prone to terminal heat stress.

Materials and Methods

The field experiment entitled "Effect of foliar nutrients and growth regulator on spring hybrid sunflower in Gangetic alluvial soils of West Bengal" was conducted during spring season of 2017 for making a comparative assessment of foliar nutrient and growth regulator management of sunflower on the productivity in Gangetic plains. Kolkata is situated at 22°53`N latitude and 88° 26`E longitude at an altitude of about 6.4 m above mean sea level. It has a semi-arid and sub-tropical climate with hot humid summers and cold winters. The mean maximum temperature in June, which is the hottest month of the year, ranges from 40° to 45 °C, while the mean minimum temperature in the coldest month of January is as low as 12.9 ºC. The mean annual rainfall is about 1582 mm, of which nearly 80 per cent is received during the monsoon period from June to September and the rest during the period between October and May. The mean wind velocity varies from 11 km hr^{-1} during October to 15 km hr^{-1} during April. Mean relative humidity attains the maximum value (85 to 90% or even more) during the south-west monsoon and the minimum (30 to 45%) during the summer months. The soil of Agricultural Experimental Farm, Baruipur belongs to order Inceptisol, Mahauli series having clayey texture in upper 30 cm layer. Water table remained below 3.5 m deep from ground surface during crop growth period. A composite representative soil sample was collected from the experimental field prior to experimentation and analyzed. The soil was sandy loam in texture, poor in organic carbon (0.76%), available N (174.3 kg/ha) and medium in available P (29.7 kg/ha).

Foliar spray: At 50% flowering stage and seed filling stage

Treatment details

T_1 : Water spray
T_2 : KCl@ 0.5%
T_3 : KNO3 @ 0.5%
T_4 : DAP @1.5%
T_5 : N P K 10:26:26 @1.5%
T_6 : NaCl @0.25% + Turmeric @0.25%
T_7 : Cycocel @0.2%
T_8 : Cycocel @0.25%
T_9 : Cycocel @0.3%
T_{10} : Cycocel @0.25% + N P K 10:26:26 @1.5%

Recommended dose of fertilizers: N: P_2 O_5: K_2O=80:100: 100 kg/ha

After harvest of *Kharif* rice, the land was given preparatory tillage once at optimum moisture condition. Finally the land was prepared by giving two cross ploughings by power tiller followed by planking when the experimental field brought into appropriate tilth, the field was laid out in a randomized block design with three replications. All the treatments were allotted at random to each plot under each replication and there were as many plots as the number of treatments.

Variety: GKSF-2002- This variety is a medium tall, early maturing (100-120 days) and robust plant type with excellent uniformity of plant height and heads. Capitulum is fully convex, mono head, uniformly big size. Leaves are big dark green. Complete filling, light brown and bold seed and high yielding. It has large head diameter and bold seeds with yield potential up to 2500 kg/ha.

Seed Sowing: The sowing of spring sunflower was done by dibbling method with row to row spacing of 60 cm and plant to plant spacing of 30 cm with the seed rate used was 4 kg/ha.

Thinning and gap filling: Extra plants in the rows were thinned to maintain a plant to plant spacing of 30 cm on 15th day after sowing. The filling of gaps was also accomplished immediately after the completion of germination in order to maintain optimum plant population.

Intercultural operations: The weeds were controlled by two hand weedings with the interval of 15 days in Sunflower.

Irrigation: Four irrigations, i.e., one each as germination, budding, flowering and seed filling stages were given to the crop.

Plant protection measures: Spray of Metasystox @ 0.5% for control of leaf eating caterpillar in sunflower after 45 DAS was done.

Harvesting and Threshing: The net plots of sunflower were harvested on the maturity separately and dried before recording the biomass yield.

Result and discussion

Influence of foliar nutrients and growth regulator on plant height (cm) and number of leaves per plant at different stages in sunflower

Plant height increased continuously from 30 DAS to 90 DAS and the increase was more between 60 DAS to 90 DAS. At 90 DAS, the maximum plant height (174.05) was recorded in T_4. However, minimum (149.90) was recorded with T_9**.** Highest plant height was recorded under the foliar feeding with DAP and was closely followed by T_3. Supplementary foliar nutrient treatments were found to be significantly at par in case of improvement height of plant.

Number of green leaves plant^{-1} increased continuously from 30 DAS to 90 DAS. At 90 DAS, the maximum number of green leaves plant^{-1} (27.78) in T_5 was closely followed by T_6. However, minimum number (21.15) was recorded with T_1 which was at par with T_9 (22.19) and significantly lower with rest of the treatments.

Table 1: Influence of foliar nutrients and growth regulator on plant height (cm) and number of leaves per plant at different stages in sunflower

	Treatments	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	Control	20.45	122.52	165.96	9.00	18.48	21.15
T_2	KCl@0.5%	19.60	123.67	170.89	8.33	20.37	22.37
T_3	KNO_3@0.5%	20.15	123.97	173.33	8.33	20.54	24.66
T_4	DAP @1.5%	19.46	121.77	174.05	9.00	22.68	25.11
T_5	N P K 10:26:26 @1.5%	19.52	125.00	171.03	9.00	23.37	27.78
T_6	NaCl @0.25% + Turmeric@0.25%	19.84	124.78	173.99	8.66	20.60	26.11
T_7	Cycocel @0.2%	19.68	125.59	152.70	9.00	21.44	24.08
T_8	Cycocel @0.25%	20.20	125.85	150.11	9.00	21.92	24.24
T_9	Cycocel @0.3%	20.19	125.40	149.90	8.00	20.80	22.19
T_{10}	Cycocel @0.25% + N P K 10:26:26 @1.5%	19.18	120.96	159.35	9.00	22.14	24.51
	CD (p=0.05)	NS	NS	5.5	NS	NS	1.12

The maximum increase in height with spray of T_4 suggests its positive role on stem elongation. This could be due to the translocation of stored photo-assimilates towards the development of reproductive organs. This type of growth behaviour in plant height has also been reported by Kumar and Yadav (2007) [3].

Influence of foliar nutrients and growth regulator on yield parameters and yield in sunflower

Highest head diameter (23.73cm) (27.6% higher over control) and number of seeds per head (58.55% higher over T_1) was recorded under the foliar feeding with T_5 and was closely followed by T_6. These two treatments were better than other nutrients i.e. T_2 and T_3. Within the foliar application of growth retardants maximum head diameter (23.48cm) and number of seeds per head (49.77% higher over T_1) was observed in T_8. The minimum head diameter (20 cm) was observed in case of T_9. Among all the 10 treatments, the maximum number of seeds per head (908.86) was noticed in T_{10} which was significantly higher than the rest of the treatments. The lowest (554.81) was observed in T_1.

Highest test weight (60.26g) was recorded with T_5 and was followed by T_6 and T_4. These three foliar application treatments were found to be better than T_2 and T_3. Lowest was observed in T_2. Within different doses of plant growth retardant, the highest test weight (60.66g) was observed in T_8. The minimum (56.84) was observed in T_9. Maximum test weight among all the 10 treatments was noticed in T_{10} (62.72g) and was closely followed by T_5, T_6, T_7 and T_8.

Seed weight/ head (50.16g) was recorded highest under the foliar feeding with T_5 (49.28% higher over T_1) and was closely followed by T_4 (40.35% higher over T_1). Within the different doses of plant growth retardant, the maximum seed weight/ head (39.31% higher over T_1) was observed in T_8. The minimum (30.14g) was observed in T_9. Among the all the 10 treatments, the maximum seed weight/head (51.45 g) was noticed in T_{10} which was significantly higher than the rest of the treatments except T_5, T_4 and T_8.

Highest seed yield (2.78 tonnes/ha) was recorded with T_5 (49.46% higher over T_1) and was closely followed by T_4 (40.86% higher over T_1). Within the plant growth retardant, the maximum yield/ha (2.60/ha; 39.78% higher over T_1) was observed in T_8. The minimum yield/ha (1.68 tonnes/ha) was observed in case of T_9. Among the all ten treatments, maximum seed yield/ha (2.84t) was noticed in T_{10} which was significantly higher than the rest of the treatments except T_5 and T_4.

Table 2: Influence of foliar nutrients and growth regulator on yield parameters and yield in sunflower

	Treatments	Head diameter (cm)	No. of seeds/ head	Test weight (g)	Seed weight/ head (g)	Seed yield (t/ha)
T_1	Control	18.36	554.81	50.07	33.6	1.86
T_2	KCl@0.5%	19.79	719.36	54.59	40.98	2.27
T_3	KNO_3@0.5%	19.99	738.13	56.46	42.72	2.37
T_4	DAP @1.5%	20.56	774.44	58.48	47.16	2.62
T_5	N P K 10:26:26 @1.5%	23.33	879.67	60.26	50.16	2.78
T_6	NaCl @0.25% + Turmeric@0.25%	22.73	807.93	59.91	45.28	2.52
T_7	Cycocel @0.2%	23.26	812.80	59.95	43.49	2.43
T_8	Cycocel @0.25%	23.48	830.98	60.66	46.8	2.60
T_9	Cycocel @0.3%	20.00	800.03	56.84	30.14	1.68
T_{10}	Cycocel @0.25% + N P K 10:26:26 @1.5%	24.43	908.86	62.72	51.45	2.84
	CD (P=0.05)	2.89	30.66	3.22	4.84	0.22

Spraying of N P K 10:26:26 @1.5% (T_5) and DAP @1.5% (T_4) has given corresponding higher head diameter, number of seeds/head and 1000-seed weight. The probable reason of highest yield attributing characters may be due to the foliar application of two/three salts met the N-P-K requirement of the crop during flowering periods resulting in greater availability, absorption of nutrient and efficient translocation of assimilates to reproductive parts which eventually contribute to the high yield attributes. These results are in line with the findings of Reddy *et al.* (2005) [10]. They also reported that improved nutritional management as a result of foliar nutrients were found to increase nutrients supply might have favorable effect led to increase transformation of photosynthesis towards yield attributing characters and finally yield of the crop compared to water spray plots. Similar results were also obtained by Sarkar *et al.* (2007) [12] and Mallick and Sarkar, (2009) [6] in sunflower.

Similar trend was observed in case of seed yield i.e. higher yields were recorded under foliar nutrient application with T_5 and T_4 than other two nutrients. T_5 recorded better result than T_4 due to presence of extra potassium ion in it and this potassium might be responsible to reduced flower and immature seed drop, prevention of formation of abscission layer which resulted in formation of more seed and their retention on head of sunflower plants. Similar findings were also reported by Bundy and Andraski (2004) [1]. The reason could be that potassium at optimum level enhanced production of seed by maintaining cell turgor, reducing water loss and providing favorable environment to the plants. Besides potassium is essential for enzyme activation, protein synthesis and photosynthesis, it may act as osmoregulator during stress for increased active update of K+ by the guard cells and stomatal regulation. Its application extensively improved the cellular as well as metabolic function of plants. It has proved to be very effective in improvement of relative water contents, photosynthesis, oxidant and antioxidants status, gas exchange characteristics and many other processes needed for osmotic stress mitigation in sunflower.

It appears that foliage supplied nutrients through N P K: 10:26:26, DAP and other important foliar nutrients at appropriate growth stage of the crop, nutrients were effectively absorbed as cations and anions by the plants, causing prolonged retention of leaves and more production of chlorophylls which favoured higher photosynthesis for efficient seed filling and thus enhanced yield. It is worth to note that even soil grade fertilizer like N P K: 10:26:26 and DAP (which is easily available to the farmers) when applied as foliar nutrient, enhanced seed yield of sunflower considerably. These results corroborate the findings of Mallick and Mallick, 2014 in green gram.

Among the all ten treatments, maximum head diameter, number of seeds/ head, seed

weight /head and ultimately seed yield /ha was noticed in T_{10} i.e. Cycocel @0.25% + N P K

10:26:26@1.5% which was significantly higher than the rest of the treatments. The reason for these may be due to better translocation of photosynthates by shortening the plant height and efficiently translocation of photosynthates to the reproductive part (source –sink). This result corroborates the findings of Nanja Reddy *et al.* (2003) [7]. They reported that in sunflower large amount of biomass is locked up in the vegetative plant parts, any practice to manipulate the mobilization of photosynthates from vegetative phase to head improves seed yield. They also observed that foliar application of nutrients along with application of growth regulators to the plant improved the translocation of photosynthates to the head and increased seed yield.

The growth retardants significantly increased the seed yield. The increased seed yield could be attributed to the higher dry matter production and it's translocation and accumulation in reproductive parts, higher number of filled seeds, head diameter, least number of unfilled seeds, high seed filling percentage, 1000 seed weight, seed yield per plant and seed yield/ha.

Influence of foliar nutrients and growth regulator on quality parameters in sunflower

Highest oil percentage (43.29%) was recorded under the foliar feeding with T_5 (6.25% higher over T_1) which was followed by T_4 (2.99% higher over T_1). Within different doses of plant growth retardant, the maximum oil percentage (19% higher over T_1) was observed in T_7. The minimum (40.59%) was observed in case of T_9. The maximum oil percentage (43.71%) was noticed in T_{10} which was significantly higher than the rest of the treatments except T_5 and T_4. The lowest oil percentage (40.59%) was observed in control treatment.

Table 3: Table of quality parameters as influenced by different treatments

	Treatments	Oil percentage
T_1	Control	40.59
T_2	KCl@0.5%	40.66
T_3	KNO_3@0.5%	40.7
T_4	DAP @1.5%	41.96
T_5	N P K 10:26:26 @1.5%	43.29
T_6	NaCl @0.25% + Turmeric@0.25%	42.47
T_7	Cycocel @0.2%	40.82
T_8	Cycocel @0.25%	40.74
T_9	Cycocel @0.3%	40.74
T_{10}	Cycocel @0.25% + N P K 10:26:26 @1.5%	43.71
	CD (P=0.05)	3.23

Conclusion

Among all the foliar nutrient treatments, significantly higher growth and yield attributes as well as yield was obtained by NPK 10:26:26 @1.5% (T_5) followed by DAP @1.5% (T_4). It is worth to note that even spraying of NaCl @0.25% + Turmeric @0.25% (T_{10}) significantly improved all the yield attributes as well as yield of this crop. Growth retardants considerably decreases the height of plant and in case of different doses of Cycocel, it was observed that T_8 (Cycocel @0.25%) is the optimum dose of Cycocel to be applied for getting optimum (also highest among all the applied doses of Cycocel) head diameter, seeds/plant, seed weight/plant, 1000 seed weight, yield/ha, and oil content. Increasing the dosage beyond this point was found to be detrimental to this crop.

The superiority of T_5 over other foliar applied treatments was attributed towards prolonged assimilation activity of leaves, as reflected on growth parameters due to the presence of three primary nutrients in adequate amount and suitable proportion

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