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Performance of spring hybrid Sunflower (*Helianthus annuus* L. Var. GKSF-2002) under different foliar nutrients and growth regulator in West Bengal

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Abstract
The influence of foliar nutrients and growth regulators on growth, yield, and quality of sunflower was investigated during summer season of 2017. The experiment was laid out with a randomized block design at agricultural experimental farm of Institute of Agricultural Science of Calcutta University, Baruipur, West Bengal. Treatments included six foliar nutrients, *viz*., 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 *viz*., 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}). Nutrients and growth regulators were applied as foliar sprays and data were recorded for leaf area (cm^2/plant), leaf area index, no. of filled seeds per head, no. of unfilled seeds per head, stover yield (t/ha), biological yield (t/ha), harvest index and oil yield (t/ha). The observations showed that superior and better results in growth, yield and oil were recorded in T_{10} followed by T_5 and T_8 compared to T_1, T_2, T_3, T_4, T_6, T_7 and T_9. 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, leaf area index (LAI), DAP, cycocel

Introduction
Among various management practices for sunflower production, generation of low-cost technology assumes great importance particularly for resource poor farmers under subsistence farming conditions. Since due to heavy rain fall receipts in West-Bengal during rainy season, after harvest of long duration traditional *aman* (photo periodically season bound) grown during June-July to November-December, in low lying Gangetic alluvial plains, sunflower offers great prospect for its introduction and cultivation after the harvest of main crop of rice in the state.

Sunflower is disadvantaged by its tall growth coupled with its relatively limited root system (Weiss, 2000) [10], and this disadvantage is often manifested insusceptibility to lodging. Short sunflower plants with increased resistance to lodging may have advantages under adverse growth conditions and are often preferred by farmers for reasons of ease of harvest (Fick & Miller, 1997) [1]. In addition, short sunflower plants would allow the utilization of a higher number of plants per area, which in turn would contribute to faster ground cover and better weed control.

There is a direct link between foliar feeding and the activities of the enzymatic systems of the plant. The timeliness and ready availability of nutrients provided by foliar feeding stimulate enzymatic cycles to greater efficiency and quicker response. Elements have been shown to translocate as much as one foot per hour from the leaves to the roots. This rapid movement may be explained by the triggering of auxins or the stimulation of the energy mechanisms within the plant. The “law of little bits” always applies to foliar feeding. It is better to spray small amounts of material more frequently than it is to drench the foliage with large amounts of material. Small quantities of key elements such as N “speed up” the physiological functions of the plant. If foliar feeding is done correctly, visual results may be seen within 48 hours.

Primarily, foliar feeding is intended to delay natural senescence processes shortly after the end of reproductive growth stages.

Foliar feeding targets the growth stages where declining rates of Photo synthesis and leveling off of root growth and nutrient absorption occur, in attempts to aid translocation of nutrients into seed, fruit, tuber or vegetative production. Secondarily, foliar feeding can be an effective management tool to favorably influence pre-reproductive growth stages by compensating for environmentally induced stresses of adverse growing conditions and/ or poor nutrient availability.

Foliar fertilization is an effective way of quickly supplying plant nutrients during critical periods of flowering and seed filling at which time soil or root conditions are often unfavorable for optimum root uptake and there is insufficient uptake to supply demand. Foliar applications can be targeted to a particular stage of crop development to achieve specific objectives and is an excellent way to "fine tune" a high fertility program.

Materials and Methods

The field experiment entitled "Performance of spring hybrid Sunflower (*Helianthus annuus* L. Var. GKSF-2002) under different foliar nutrients and growth regulator in West Bengal" was conducted during the spring season of 2017 for making a comparative assessment of foliar nutrient and growth regulator management on the performance of sunflower.

Experimental site

The experiment was conducted at the Agricultural Experimental Farm of Institute of Agricultural Science of Calcutta University, Baruipur, situated in the Gangetic region of West Bengal, India. The field had an even topography and good drainage system. 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).

Climate and weather

Table No 1: Metrological data of Agricultural Experimental Station, Baruipur, South 24- Parganas, West Bengal

Month	Temperature (^{0}C)		Relative Humidity (%)		Monthly Rainfall (mm)
	Max	Min	Max	Min	
January 2017	25.5	10.3	95	46	0
February 2017	29.6	15.3	96	41	0
March 2017	32.1	20.7	95	54	4
April 2017	34.8	25.6	90	55	2
May 2017	36.9	25.7	89	57	3

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

Result and Discussion

Influence of foliar nutrients and growth regulator on leaf area (cm^2/plant) and leaf area index at different stages in sunflower:

Leaf area increased continuously and the increase was more between 30 DAS to 60 DAS as compared to 90 DAS. It did not vary at 30 and 60 DAS but it was differed significantly at 90 DAS. At 90 DAS, the maximum leaf area (2385.15 cm^2/plant**)** was recorded in T_5**.** However, minimum leaf area **(**1895.06 cm^2/plant**)** was recorded with T_9.

Leaf area Index (LAI) increased continuously from 30 DAS to 90 DAS and the rate of increment was more at 60 DAS. LAI did not vary significantly at any stages of plant growth.

Table 2: Influence of foliar nutrients and growth regulator on leaf area (cm^2/plant) and leaf area index at different stages in sunflower

	Treatments	Leaf Area (cm^2/plant)			Leaf Area Index		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	Control	934.66	2946.66	1961.66	0.518	1.63	1.08
T_2	KCl@0.5%	933.66	2920.03	1961.33	0.518	1.62	0.757
T_3	KNO_3@0.5%	935.01	3151.33	2267.33	0.519	1.64	1.25
T_4	DAP @1.5%	935.20	2982.66	2077.45	0.519	1.65	1.15
T_5	N P K 10:26:26 @1.5%	933.33	3021.33	2385.15	0.518	1.67	1.32
T_6	NaCl @0.25% + Turmeric@0.25%	938.13	3017.66	2249.35	0.520	1.67	1.24
T_7	Cycocel @0.2%	936.66	2941.33	1974.66	0.520	1.63	1.09
T_8	Cycocel @0.25%	935.33	2977.66	1974.33	0.519	1.65	1.09
T_9	Cycocel @0.3%	937.23	2980.12	1895.06	0.520	1.65	1.05
T_{10}	Cycocel @0.25% + N P K 10:26:26 @1.5%	936.34	3088.33	2223.33	0.526	1.66	1.06
	CD (p=0.05)	NS	NS	317	NS	NS	NS

By applying a foliar fertilizer directly to the leaf, it increases the activity in the leaf, at the same time increasing chlorophyll and thus photosynthesis. Because of this increased activity, it increases the need for water by the leaf. In turn this increases water uptake by the plants vascular system, which in turn increases the uptake of nutrients from the soil. The essential role of chlorine lies in its biochemical inertness, which enables it to fill osmotic and cation neutralization roles which have biochemical and/or biophysical consequence of importance. Also, Chlorine increases the efficiency of chloroplast, provides oxygen in photosystem-II in the process of photosynthesis. It thus, regulates osmotic pressure, turgor

pressure, plant-water potential, osmotic potential, which facilitates the water availability to plants.

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

Higher number of filled seeds/head was recorded under the foliar feeding with T_5 (58.55% higher over control). Within the foliar application of different doses of Cycocel, maximum number of filled seeds per head (49.77% higher over control) was observed in T_8 and the minimum (800.03) was recorded in 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 number of seeds per head (554.81) was observed in T_1.

Foliar nutrient treatments significantly reduced number of un-filled seeds per head over control. Lowest number (175.60) was recorded under T_5. Within the foliar application of plant growth retardant (Cycocel), lower number of un-filled seeds per head (174.75) was observed in T_7. Overall, the lowest number of un-filled seeds per head (163.03) was noticed in T_{10} and the highest in T_1.

Among all the foliar nutrient treatments, highest stover yield (7.56t /ha) was recorded under the foliar feeding with T_5 and was closely followed by T4. Within foliar application of plant growth retardant (Cycocel), the maximum stover yield was observed in T_8 and the minimum was observed in T_9.

Foliar nutrient treatments significantly improved biological yield. Highest biological yield (10.34 t/ha) was recorded under the foliar feeding with T_5 which was closely followed by T_4 (9.91 t/ha). These two treatments were better than T_2 and T_3. Within the application of Cycocel, maximum biological yield (9.01 t/ha) was observed in T_8 and minimum (7.94 t/ha) was observed in T_9. T_8 and T_7 were statistically at par.

Among the foliar feeding treatments, higher harvest index (HI) (26.8%) was recorded under the foliar feeding with T_5 (23.50% higher over control) and was closely followed by T_4 (21.65% higher over control). These two application treatments showed better results than T_2 and T_3. Within Cycocel application the maximum HI (31.33% higher over control) was observed in T_8 and minimum (21.2%) was observed in T_9. The overall maximum HI (29.9%) was however noticed in T_{10}.

Table 3: Influence of foliar nutrients and growth regulator on yield parameters in sunflower

	Treatments	No. of filled seeds per head	No. of unfilled seeds per head	Stover Yield (t/ha)	Biological Yield (t/ha)	Harvest Index
T_1	Control	554.81	206.91	6.71	7.90	21.7
T_2	KCl@0.5%	719.36	177.37	7.13	9.41	24.3
T_3	KNO_3@0.5%	738.13	181.05	7.17	9.54	24.8
T_4	DAP @1.5%	774.44	180.17	7.29	9.91	26.4
T_5	N P K 10:26:26 @1.5%	879.67	175.60	7.56	10.34	26.8
T_6	NaCl @0.25% + Turmeric@0.25%	807.93	181.55	7.41	9.93	25.3
T_7	Cycocel @0.2%	812.80	174.75	6.26	8.69	27.4
T_8	Cycocel @0.25%	830.98	178.98	6.41	9.01	28.5
T_9	Cycocel @0.3%	800.03	182.78	6.27	7.94	21.2
T_{10}	Cycocel @0.25% + N P K 10:26:26 @1.5%	908.86	163.03	6.75	9.59	29.9
	CD (p=0.05)	30.66	9.91	1.55	1.40	4.29

T_{10} was superior over other foliar applied treatments due to prolonged assimilation activity of leaves as nutrients were effectively absorbed as cations and anions by the plants, in the presence of three primary nutrients in adequate amount and suitable proportion (Mallick and Mallick, 2014) [3] at appropriate growth stage of the crop. This favored higher photosynthesis for efficient seed filling.

Excessive vegetative growth, lack of photosynthetic activity at the time of seed filling and improper translocation of photosynthates (Patil and Dhomne, 1997) [6] also moisture stress and lack of growth regulators during seed development may have resulted in the occurrence of chaffy seeds in T_1. T_6 treatment significantly improved all the yield attributes as well as yield of this crop and recorded even higher yield attributes as compared to T_2 and T_3. This might be due beneficial effect of NaCl on the growth of sunflower mainly associated with the alleviation of the adverse effect of moisture stress, including low atmospheric humidity. Gale *et al.* (1970) [2] have also demonstrated such beneficial effect of NaC1 on the growth of *Atriplex halimus*. Turmeric is still a mystical element, whose proper role in growth, development, yield and yield attributes in plants is yet to be found. Assumable that, turmeric, just like chlorine, also helps in providing assistance in plants against pest-disease-insect, facilitating greater plant health and thus greater yield and other yield attributes.

The foliar application of N-P-K requirement of the crop with fertilizers and growth retardants during flowering periods resulted 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) and Sakal *et al*. (1991) [7, 8].

Improved nutritional management by application of foliar nutrients increased the nutrients supply to the plants. This might have a favorable effect leading to increase transformation of photosynthesis towards yield attributing characters and finally yield of the crop as compared to control (water spray plots). Similar such results in sunflower were also reported by Sarkar *et al. (*2007) and Mallick and Sarkar, (2009) [9, 4].

Large amount of biomass is locked up in the vegetative plant parts of sunflower and HI is improved by any practice to manipulate the mobilization of photosynthates from vegetative phase to head. These result are in line with the findings of Nanja Reddy *et al.* (2003) [5].

Influence of foliar nutrients and growth regulator on oil yield (t/ha) in sunflower

Higher oil yield (1.20 t/ha) was recorded under the foliar feeding T_5 (60% higher over control) and which was followed by T_4 (45.33% higher over control). These two foliar application treatments were found to be better than T_1 and T_2.

With the foliar application of Cycocel, the maximum oil yield (40% higher over control) was observed in T_8. The overall maximum oil yield (1.24 t/ha) was noticed in T_{10} which was significantly higher than the rest of the treatments except T_5 and T_4. The lowest oil yield (0.68 t/ha) was observed in T_9. Except T_9 all the other treatments had significantly higher oil yield over control.

Table 4: Table of oil yield (t/ha) in sunflower as influenced by different treatments

	Treatments	Oil Yield (t/ha)
T_1	Control	0.75
T_2	KCl@0.5%	0.92
T_3	KNO_3@0.5%	0.96
T_4	DAP @1.5%	1.09
T_5	N P K 10:26:26 @1.5%	1.20
T_6	NaCl @0.25% + Turmeric@0.25%	1.07
T_7	Cycocel @0.2%	0.9
T_8	Cycocel @0.25%	1.05
T_9	Cycocel @0.3%	0.68
T_{10}	Cycocel @0.25% + N P K 10:26:26 @1.5%	1.24
	CD (p=0.05)	0.48

Oil yields may be increased if nutrients are applied directly to the foliage during this critical growth stage. This makes foliar fertilization an inexpensive insurance to maximize crop yields, provided the application can be combined with some other field operation. The most critical times to apply are during periods of plant stress, which are during periods of great growth activity or when the plant is changing from a vegetative to a reproductive state. The functional nutrient Na improves the water availability in proximity of roots and thus plants. Na plays an important role in different photosynthetic pathways. It helps in more carbon assimilation by facilitating stomatal opening. Sodium helps in regulating nitrate reductase, which in a consequence improves protein content and oil yield.

Conclusion

Among all the foliar treatments, T_{10} (Cycocel @ 0.25% + N P K 10:26:26 @1.5%) recorded the highest growth (leaf area and LAI) and yield attributes (no. of filled seeds per head, no. of unfilled seeds per head, stover yield, biological yield, HI) as well as oil yield followed by T_5 (N P K 10:26:26 @1.5%), T_4 (DAP @1.5%) and T_8 (Cycocel @0.25%). It is worth to note that even spraying of NaCl @0.25% + Turmeric @0.25% (T_6) significantly improved all the yield attributes as well as yield of this crop. The increase in the seed yield could also be attributed higher LAI, total area of green leaves, total number of seeds per plant. All these parameters showed a significant difference as compared to water sprayed treatment.

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