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INFLUENCE OF FOLIAR NUTRIENTS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF SPRING SUNFLOWER IN SOUTHERN PART OF WEST BENGAL

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ABSTRACT

A field experiment was conducted during spring season of 2016 and 2017 at the Agricultural Experimental Farm University of Calcutta, Baruipur, South 24-Parganas, West Bengal to evaluate the effects of foliar nutrients on spring hybrid sunflower (*Helianthus annuus* L.) variety 'SIRI-333'. The experiment was laid out in randomized block design, comprised of 3 replications with 9 different foliar nutrient treatments *viz.,* water spray, potassium sulphate (K_2SO_4) @ 0.5%, potassium chloride (KCl) @ 0.5%, sodium chloride (NaCl) @ 0.5%, potassium nitrate (KNO_3) @ 0.5%, N-P-K 19:19:19 @ 0.5%, N-P-K 10:26:26 @ 1.5%, diammonium phosphate (DAP) @ 1.5% and urea @ 1.5% along with recommended dose of fertilizer (RDF). These foliar treatments were applied twice (first at 50% flowering and second at seed development stage). From the pooled analysis of two successive years it was observed that among all the different foliar nutrient treatments, significantly ($P<0.05$) higher achene or seed yield was obtained by N-P-K 10:26:26 @ 1.5% (2.77 t ha^{-1}) followed by N-P-K 19:19:19 @ 1.5% (2.74 t ha^{-1}) while spraying of N-P-K 19:19:19 @ 0.5% had recorded highest stalk yield (7.05 t ha^{-1}) which remained at par with urea @ 1.5%. The results showed that the foliar nutrient treatments having three nutrients *i.e.* N-P-K 10:26:26 @ 1.5% and N-P-K 19:19:19 @ 0.5% sprayed during 50% flowering and seed development stages significantly improved yield attributes *viz*., capitulum diameter, number of seeds capitulum^{-1} and test weight over control (only water spray) and were capable of producing higher seed yield and stalk yield of sunflower. The highest (3.32) benefit : cost ratio was found in foliar nutrient treatments 10:26:26 @ 1.5% (3.32) followed by N-P-K 19:19:19 @ 1.5% (2.99). Hence, these two treatments can be recommended to enhance yield in sunflower.

(Key words: Sunflower, oilseed, foliar application, nutrient, yield, economics)

INTRODUCTION

Sunflower (*Helianthus annuus* L.) popularly known as "Surajmukhi" is the third most important oilseed crop in the world as well as one of the fastest growing important oilseed crop in India. Sunflower was cultivated in India over an area of about 1.91 m ha with a production of 1.46 m tonnes and productivity of 765 kg ha^{-1} (2007-08) which was remarkably decreased to only 0.24 m ha area with a production of 0.22 m tonnes, whereas the productivity was increased to 891 kg ha^{-1} in 2019-20 (Anonymous, 2020). The state West Bengal shares only 3.21% of area and 4.43% of total India's sunflower production *i.e.* only 0.01 m tonnes. Total sunflower oil production in the world in 2017 was 18.007 m tonnes (Anonymous, 2020a). The demand for vegetable oil in the country will rise at the rate of around 4-6% by 2030 (Anonymous, 2011), owing to the country's growing population. As a result, increasing the productivity of oilseed crops is essential to meet the existing demand (Reddy *et al.,* 2020). In the southern part of West Bengal there is a vast tract of fallow areas about 0.35 million hectares of Gangetic alluvial land. Due to late harvest of traditional *aman* rice as well as due to late receding of water from low lying rice fields, sowing of important winter crops like potato, wheat, rape-seed and mustard is not practically possible on such rice fallow land. Sunflower is a short duration, photo and thermo-insensitive and flexibility in sowing time may be grown on those lands to wipe out shortage of oilseeds in the state of West Bengal when most of the fields are lying vacant after harvest of traditional long duration *aman* rice and before the sowing of the next *kharif* season rice crop. Being an exhaustive crop sunflower responds well to nitrogen, phosphorus and potassium fertilizers. Sunflower has a high nutrient requirement that must be applied throughout its growth period. So without proper fertilizer application optimum yield could not be achieved. But loss of nitrogen due to leaching and volatilization, phosphorus due to fixation and potassium due to leaching and fixation, adequate nutrient may not be available at flowering and seed development stages of crop resulting in less number of flowers and poor seed development due to transient nutrient deficiency. Inactivation of the roots activity may be additional cause for this deficiency. So to provide plant nutrients at critical period, foliar application is very important. Foliar application gives the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and regulation on the uptake of nutrient by plants (Manonmani and Srimathi, 2009) and

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thus it has become an effective way to increase the yield and quality of field crops (Talebbeigi *et al.,* 2018). Foliar application of nitrogen is more suitable than soil application because it promotes rapid and efficient transportation of nitrogen to the grains (Wagan *et al*., 2017). Potassium on the other hand is essential for enzyme activation, protein synthesis and photosynthesis. It has proven to be effective in improvement of the cellular as well as the metabolic function of plant (Suryavanshii *et al*., 2016). Hence, evolving a proper management strategy was felt to find out the effects of foliar nutrients on growth and seed yield during flowering and seed development stages under irrigated condition on spring hybrid sunflower in Gangetic alluvial soils of West Bengal.

MATERIALS AND METHODS

A field experiment was carried out during spring season of 2016 and 2017 at the Agricultural Experimental Farm, University of Calcutta, Baruipur, South 24-Parganas, West Bengal (88°26' E; 22°22' N; 9 m altitude). The soil of the experimental site was clay loam in texture having pH of 6.5, organic carbon 7.3 g kg^{-1}, available nitrogen 169.3 kg ha^{-1}, phosphorus 29.2 kg ha^{-1} and potassium 257.2 kg ha^{-1}. After harvest of *kharif* rice, the land was prepared by giving two cross ploughings followed by one planking with optimum moisture condition to bring the experimental field into appropriate tilth. The experiment was laid out in randomized block design (RBD) with 3 replications and 9 treatments *viz.,* water spray, potassium sulphate (K_2SO_4) @ 0.5%, potassium chloride (KCl) @ 0.5%, sodium chloride (NaCl) @ 0.5%, potassium nitrate (KNO_3) @ 0.5%, N-P-K 19:19:19 @ 0.5%, N-P-K 10:26:26 @ 1.5%, diammonium phosphate (DAP) @ 1.5% and Urea @ 1.5%. A hybrid sunflower variety 'SIRI-333' (medium height, early maturity (100-120 days), mono head and fully convex capitulum) was sown at the rate of 4 kg ha^{-1} by dibbling method with row to row spacing of 60 cm and plant to plant spacing of 30 cm at a depth of 5 cm. A recommended fertilizer dose (RDF) of 60 kg ha^{-1} nitrogen, 80 kg ha^{-1} phosphorus and 80 kg ha^{-1} potassium were applied. Half of the nitrogen, entire quantity of phosphorus and potassium were applied at the time of final land preparation and rest of the nitrogen was given at the time of first irrigation as top dressing. Four irrigations were done at 15 days interval from the time of sowing. For weed management pre-emergence application of pendimethalin 0.75 kg a.i. ha^{-1} was applied just after sowing of the crop and after 30 days of sowing a hand weeding was done. Nutrient solutions used as various treatments were applied at a spray volume of 750 l ha^{-1} as foliar spray twice *i.e.* first at 50% flowering and second at seed development stage. Other recommended package of practices was followed uniformly to raise the crop. Observations recorded on plant height, number of leaves $plant^{-1}$, number of seeds $capitulum^{-1}$, capitulum diameter, test weight, seed yield and oil content at the time of harvest in both the years. Collected data from two years were subjected to pooled analysis as per the procedures outlined by Gomez and Gomez (1984). The critical differences were calculated at 5% level of probability wherever F test was found significant for various parameters under study.

RESULTS AND DISCUSSION

Effects on plant height and number of leaves $plant^{-1}$

All the foliar nutrient treatments had significant influence on different growth and yield attributing parameters. The results (Table 1) revealed that the only significant plant height (149.64 cm) at the time of harvest was recorded in foliar application of urea. Higher level of nitrogen helps in excessive vegetative growth and development of the plant as nitrogen effects cell elongation as well as brought the principal component of protein, enzymes, hormones, vitamins, chlorophyll and it accelerated the meristamatic activity of plant which promoted to increase in internode length, protein synthesis and photosynthetic area leading to higher plant height and dry matter production. Oad *el al*. (2018) also found the similar kind of result. They observed maximum plant height (179.76 cm) in sunflower crop by the foliar application of urea (1%) after 35 days of sowing. Ram *et al*. (2020) recorded the highest plant height in maize through application of 180 kg N ha^{-1} compared to other lower dosage of nitrogen application. The lowest (93.53 cm) plant height was recorded with water spray. The results also revealed that among the different treatments significantly highest number of leaves (27.50) $plant^{-1}$ at harvest was also from application of urea, which was closely followed by NPK 19:19:19 and NPK 10:26:26. Application of nitrogen which has durable consequence on the improvement and increase of leaf area might be the reason behind this result**.** Application of these nitrogenous foliar nutrients at later stages of crop growth assumes greater importance as the technique hastened the availability of nutrients to the plant systems, delayed the synthesis of abscisic acids and promotes cytokinin activities and causes high chlorophyll retention and thereby higher photosynthetic activities in effective leaves for supply of current photosynthates. Ahmad *et al*. (2018) also suggested that increasing the nitrogen level have positive effect sunflower growth parameter like plant height, number of leaves $plant^{-1}$ and leaf area index etc.

Effects on yield attributes

The supplementary foliar nutrient treatments significantly influenced the yield attributing parameters like number of seeds $capitulum^{-1}$, capitulum diameter and test weight. The highest capitulum diameter (17.98 cm) was recorded under the treatment NPK 10:26:26 which was at par with NPK 19:19:19 (17.91 cm) and DAP (17.72 cm). Similarly maximum number of seeds $capitulum^{-1}$ (952.21) was recorded in NPK 10:26:26 which was found at par with NPK 19:19:19. Both the number of seeds $capitulum^{-1}$ and capitulum diameter were lowest where no foliar treatment was applied (control). Among the nine treatments, NPK 10:26:26 recorded

the highest test weight (63.66 g) which was closely followed by NPK 19:19:19, DAP and KNO_3. The probable reason of highest yield attributing characters of sunflower plants might be due to increasing levels of three primary nutrients (N, P and K) through foliar application met nutrient requirement of the crop during flowering and seed development periods resulting in greater availability, absorption of nutrient and efficient translocation of assimilates to reproductive parts which eventually contributed to the high yield attributes. Also increased yield attributes might be due to enhanced partitioning efficiency and correction of transient nutrient deficiency during flowering and seed filling stages when nutrient demand is at peak but supply from root may not be sufficient to meet the demand.

Effects on yield and economics

As revealed from data (Table 1), significantly the highest levels of achene (seed) yield (2.77 t ha^{-1}) was recorded under foliar application of NPK 10:26:26 (42.05 % higher yield over control), followed by NPK 19:19:19 (40.51% higher than control plot). Increased yield with spray of NPK 10:26:26 and NPK 19:19:19 @ 1.5% might be due to adequate nutrient availability of three primary plant nutrients *e.g.* nitrogen, phosphorus and potassium at critical growth stages and thus enhanced photosynthetic efficiency followed by partitioning efficiency. Spraying of these supplementary foliar nutrients at 50% flowering and seed filling stages might have helped the plants better absorption and consequent assimilation of nutrients supplied through foliar application resulting in optimum growth and development which led to higher dry matter and consequently improved yield attributes and subsequently higher seed yield in sunflower. All the foliar nutrient treatments recorded significantly higher yield over control. Increased yield in these treatments might be attributed to the beneficial effects of these foliar nutrients (acted as osmoprotectants) on photosynthesis, increased in sink strength and later on, assimilate translocation to developing seeds.

Haseeb and Maqbool (2015) found that the increase in yield with 1% urea spray was recorded up to 1.37 t ha^{-1} in comparison to water spray. Patel *et al*. (2020) reported that soil application of 50% RDF + 2% foliar spray of soluble NPK 19:19:19 at 30, 45 and 60 DAS in wheat gave significant grain (4405 kg ha^{-1}) and straw (5383 kg ha^{-1}) yield. Positive effect of foliar applications of nutrients has also been reported in Punjab by Suryavanshii *et al*. (2016). Where they had shown that foliar application of either SNP (Sodium nitroprusside) 400 µg ml^{-1} or 2% KNO_3 after anthesis were found most suitable for achieving better growth and increased productivity of wheat.

Sunflower and other crops of summer and spring season encounters high temperature stress and face both soil and atmospheric drought during the months April and May at their reproductive stages (*e.g.*- flowering and seed development). The beneficial effect of foliar nutrient treatments might be due to osmoprotectants actions under environmental stress and water stress (intermittent drought condition) by osmolyte accumulation in plant cells, decreases cell osmotic potential and maintains water absorption and cell turgor pressure, which might resulted in sustaining physiological processes, such as stomatal, photosynthesis and growth. Other nitrogenous fertilizer like Urea gave higher vegetative growth (plant height and number of leaves $plant^{-1}$) but failed to achieve significant achene yield. Interestingly it was observed from the investigation that even application of NaCl @ 0.5% significantly increased seed yield over foliar treatments K_2SO_4, KCl and control plot. Mallick and Chakraborty (2017) reported that NaCl @ 0.3% with turmeric @ 0.3% recorded significantly and appreciably highest seed yield (2950 kg ha^{-1}) in wheat.

The higher benefit : cost ratio (BCR) (3.32) was recorded with foliar spray of NPK 10:26:26 followed by NPK 19:19:19 (2.99). NaCl, DAP and Urea also gave higher BCR over control (2.11). However, oil content percentage of achene was not significantly affected by any treatments. However highest (41.34%) oil percentage was found in NPK 10:26:26 followed by the other treatments in descending order were DAP, K_2SO_4, NPK 19:19:19, KCl, KNO_3, Urea, NaCl and control plot. It was observed that beside NPK fertilizer treatments oil content was also increased by foliar application of K_2SO_4. This might be due to the beneficial effect of sulphur that highly influenced oil synthesis in sunflower plant.

On the basis of results of two years experiments it can be concluded that the N-P-K balanced foliar nutrient treatments significantly improved yield attributes *viz.,* capitulum diameter, number of seeds $capitulum^{-1}$ and test weight over control (only water spray). The increased yield attributes enhanced partitioning efficiency and correction of transient nutrient deficiency during flowering and seed filling stages when nutrient demand was at its peak but supply from root may not be sufficient to meet the demand. Also these foliar applied treatments might have acted as an osmoprotactant to mitigate terminal heat stress during the peak summer season and kept the plant healthy at vegetative to reproductive stages. Thus, the experimental finding suggest that NPK 10:26:26 @ 1.5% or NPK 19:19:19 @ 0.5% the foliar nutrients spray during 50 % flowering and seed filling/ development stages were capable of producing higher seed yield of sunflower. These treatments are also economically profitable.

Table 1. Effect of foliar nutrients on yield attributes and yields of sunflower (pooled data of 2016 and 2017)

Treatments	Plant height (cm) at harvest	No. of leaves plant^{-1} at harvest	No. of seeds capitulum^{-1}	Capitulum Diameter (cm)	Test weight (g)	Seed yield (t ha^{-1})	Oil content (%)	Benefit : Cost Ratio (BCR)
Water spray (Control)	91.39	20.00	680.33	15.77	55.82	1.95	40.53	2.11
Potassium sulphate (K_2SO_4) @0.5%	106.99	21.50	768.50	16.76	56.91	2.21	41.09	1.70
Potassium chloride (KCl) @0.5%	100.72	21.33	814.17	16.93	59.25	2.39	40.97	1.87
Sodium chloride (NaCl) @0.5%	124.95	21.17	811.67	16.49	60.04	2.43	40.70	2.76
Potassium nitrate (KNO_3) @0.5%	131.26	23.33	843.67	17.41	61.73	2.52	40.89	1.83
N-P-K 19:19:19 @0.5%	136.41	26.50	934.00	17.93	62.66	2.74	41.04	2.99
N-P-K 10:26:26 @1.5%	117.37	25.67	953.50	17.98	63.66	2.77	41.34	3.32
Diammonium phosphate @1.5%	123.19	23.50	866.33	17.74	62.21	2.58	41.26	2.51
Urea @1.5%	149.64	27.50	831.00	17.48	60.46	2.44	40.70	2.32
SEm± (0.05)	1.29	1.15	13.44	0.10	0.91	0.04	0.18	-
CD at 5%	3.85	3.43	40.31	0.29	2.71	0.12	-	-

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