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Enhancement of productivity through soil and foliar application of nutrients in summer Sesamum (*Sesamum indicum* L.)

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Abstract
Field experiment was conducted for two years during 2017-18 and 2018-19, to investigate the effect of soil and foliar nutrition on yield and productivity of summer sesame (*Sesamum indicum*. L). the experiment was laid out in randomized block design with nine treatments. Application of 50-50-0 kg NPK ha^{-1} + foliar spray of 19:19:19@2.0% mixture at flowering and pod formation stage during both the years recorded highest plant height (120.72, 110.17), number of branches per plant (6.78, 6.67), number of capsules per plant (75.66, 69.78) and highest yield of 2060.88, 1897.05 kg/ha respectively. Application of 50-50-0 kg NPK ha^{-1}+ foliar spray of 19:19:19 @2.0% mixture at flowering and pod formation also recorded highest net returns of Rs. 34763/-(B:C ratio 1.71) and Rs. 28801/- (B:C ratio 1.42) during 2017-18 and 2018-19 in summer sesame.

Keywords: Foliar nutrition, fertilizer management, productivity, sesame, summer

Introduction
Oil seed crops play an important role in Indian economy and also entitled the country as a chief producer of oil seeds in the world. Oil seeds constitute the second major agricultural crop in the country next to food grain in terms of tonnage and value. Sesame (*Sesamum indicum* L.) is one of the most ancient edible oil seed crop of India and is called as "Queen of oil seeds" because of its good oil quality. Sesamum oil is useful for dry cough, asthma diseases of lungs, burning sensation, diseases of the ear and eyes. Recently omega-6 fatty acid desaturase also derived from sesamum which is helpful for heart patients (Jin *et al*., 2001) [2].It is mainly cultivated during rainy season in poor fertile soils with less attention and less use of required agro-inputs particularly manures and fertilizers. Therefore its productivity is very low in the country. Sesamum responds very well to application of high doses of manures and fertilizers in almost all growing areas of the country. But adequate and effective nutrient management is not scientifically worked out for achieving higher productivity. In India it is grown in an area of 1.95 m ha with a production of 0.85 m tonnesand productivity of 436 kg/ha (Ministry of Agriculture & Farmers welfare, G.O.I, 2007) [5]. Cultivation of sesame faces certain physiological constraints like heavy flower drop, slow dry matter accumulation and poor partitioning of assimilates from source to sink. These problems can be overcome by foliar application of plant growth regulators and nutrients essential for plant growth and development. Foliar application of macro and micro nutrients at critical stages of crop growth facilitates for quick supply of nutrients, there by promoting photosynthesis and mobilization of assimilates to sink and ultimately the yield (Sharma *et al*., 2013) [10]. Further, soil application of nutrients is often not enough to meet the growing crop demand. Foliar application of essential nutrients along with soil application plays a vital role in sesamum production by stimulating root development, energy transformation, various metabolic processes, translocation activity in plant and increasing capsule setting and thereby increasing the yield. However proper and balanced fertilizer schedule is also important among the various technologies for high production of the crop especially nitrogen and other fertilizers. Keeping the above points in view, the present investigation was initiated to find out the best nutrient management schedule for summer crop for achieving higher yields apart from sustaining soil health.

Materials and Methods
Field experiment was conducted during summer season of 2017-18 &2018-19 at Agricultural Research Station, Jangamaheswara puram, Gurazala, Guntur district of Andhra Pradesh, India to assess the effect of soil and foliar nutrition on growth and yield of Sesame (*Sesamum indicum* L.).

The soil of the experimental site was low in organic carbon (0.49%), neutral in reaction (PH 7.5) with electrical conductivity 0.36 ds/m and low in available nitrogen (181.7 Kg/ha), medium in available P2O5 (25.7 Kg/ha) and high in available K2O (321.7 Kg/ha). The experiment was laid out in Randomized Block Design comprising of nine treatments which are replicated thrice. Each treatment net plot size is 3m × 3m with spacing of 30 X15 cm. The treatments details are T1-Absolute control, T2- 50-50-0 kg NPK ha-1 (soil application), T3- T2 + foliar spray of 2.0% DAP at flowering and pod formation stage, T4- T2 + foliar spray of 2.0% 19:19:19 mixture at flowering and pod formation stage, T5- T2 + foliar spray of 2.0% Urea at flowering and pod formation stage, T6- T2 + foliar spray of 1% K2SO4 at flowering and pod formation stage, T7- T2 + foliar spray of 0.5% ZnSO4at flowering and pod formation stage, T8- T2 + foliar spray of 0.02% Boric acid at flowering and pod formation stage and T9- T2 + foliar spray of 0.5% FeSO4 at flowering and pod formation stage. Observations on Plant height (cm), Branches plant-2, 1000 seed weight (gm), Number of capsules plant-1, Seed yield (kg ha-1), Straw yield (kg ha-1) and Harvest index (%) were recorded and the data obtained from the experiment on growth, physiological growth parameters, yield component and yield were statically analyzed.

Results and Discussion

Significant difference was recorded on plant height between different treatments and maximum plant height (120.72 cm) was recorded in treatment T4-T2 + foliar spray of 2.0% 19:19:19 mixture at flowering and pod formation stage and was on par with T8- T2 + foliar spray of 2% KNO3and T5- T2 + foliar spray of 2.0% Urea which recorded plant height of 112.29 and 112.27 respectively during the first year of study and similar results were observed during the consecutive year. Untreated control recorded the least height of 89.50 cm and 75.28 cm in 2017-18 and in 2018-19, respectively (Table 1&2).The observed improvement in plant height might be due to cell enlargement, cell division and multiplication which ultimately led to better plant height of Sesame and boosted plant growth. Similar findings were also reported by Choudhary *et al*. (2010) [1] in Sunflower and Murthy *et al*. (2007) [6] in Sesame. The vegetative growth in height of many crop plants is characterized by a sigmoid pattern. At initial stage of growth, there is no vast difference in plant vigour is influenced through effective absorption of nutrients at critical stage, resulting in enhanced physiological activity and increased plant height (Sarkar *et al*., 1999) [9]. This type of growth behavior in plant height has also been reported by Kumar and Yadav (2007) [3].

Number of branches in different treatments of soil and foliar application was highest in T4-T2 + foliar spray of 2.0% 19:19:19 mixture (6.78 branches/plant in 2017-18 and 6.67 branches/plant in 2018-19) and was on par with T6, T5, T8, T9 and T10 treatments (Table 1&2).

Number of capsules decides the seed yield directly in the crop. There was significant difference observed in the number of capsules and seed yield among the treatments. Highest number of capsules per plant (75.56 capsules) and seed yield (688.26 kg/ha) was recorded in T4-T2 + foliar spray of 2.0% 19:19:19 mixture and was on par with next best treatment T6-T2 + foliar spray of 2.0% MAP (72.22 capsules per plant and seed yield of 675.65 kg/ha) during the first year of study and similar results were obtained during 2018-19 with highest number of capsules and yield in treatment T4(Table 1&2 and Graph 1). Promoting vegetative growth by influencing cell division and elongation in meristematic cell, thereby increasing the sink in terms in number of capsules/plant were reported by Yadav *et al*. (2007) [13], Shekh *et al*. (2014) [11] and Patel (2012) [7]. Thus, an increase in nitrogen supply might have increased all the growth parameters, yield attributing characters which ultimately contributed to increase in yields. The results are in accordance with Sarkar and Saha (2006) [8]. Significantly higher number of capsules (153.2), seeds per capsule (58.4) and thousand seed weight (3.12 g) was recorded by combined nutrient spray @ 2% at 30 and 45 DAS. This was followed by foliar spray of 19:19:19 @ 1% at 30 and 45 DAS as reported by Teresa Alex *et al*. (2017) [12].

Dry matter in terms of straw yield was recorded, among the different treatments during both years (2017-18 and 2018-19) highest was recorded in T4-T2 + foliar spray of 2.0% 19:19:19 mixture at flowering and pod formation stage with 2060.88 and 1897.05 kg/ha respectively (Table 1&2). Dry matter accumulation in plants has followed a sigmoid pattern under different foliar sprays which is characterized by all growth parameters described.

Cost economics worked for different treatments revealed that the highest net returns with rupee per investment during both the years was observed in the treatment T4-T2 + foliar spray of 2.0% 19:19:19 mixture with Rs.34763/- (2017-18) and Rs.28801/- (2018-19) respectively. Rupee per investment was also found highest in the treatment T4 during both the years 1.71 (2017-18) and 1.42 (2018-19) (Table 1&2).

The results thus evidently indicate that application of 50-50-0 kg NPK ha-1 + foliar spray of 2.0% 19:19:19 mixture at flowering and pod formation stage appears to be most suitable agronomic practices for optimum growth development and it is best management option to get higher growth and yield in summer sesame.

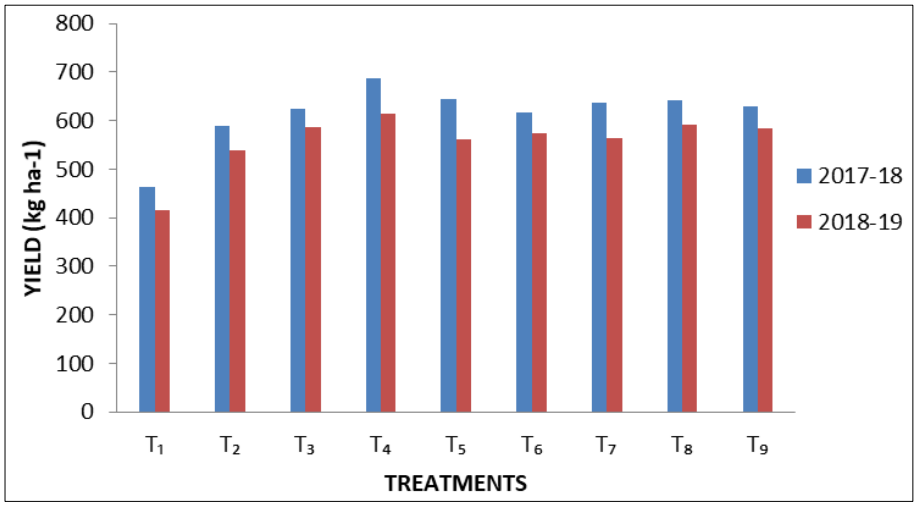
Table 1: Growth, yield and yield attributing characters as influenced by soil and foliar application of nutrients in Sesame during summer, 2017-2018

Treatments	Plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Returns per rupee investment
T_1) Absolute control	89.50	4.22	45.11	463.88	1431.59	37111	18523	1.00
T_2) 50-50-0 kg NPK ha^{-1} (soil application)	102.47	5.78	59.89	588.12	1152.09	47049	27049	1.35
T_3) T_2 + foliar spray of 2.0% DAP at flowering and pod formation stage	105.80	5.89	63.44	624.71	1884.20	49977	29929	1.49
T_4) T_2 + foliar spray of 2.0% 19:19:19 mixture at flowering and pod formation stage	120.72	6.78	75.56	688.26	2060.88	55061	34763	1.71
T_5) T_2 + foliar spray of 2.0% Urea at flowering and pod formation stage	112.27	6.34	69.11	643.12	1875.45	51450	31434	1.57
T_6) T_2 + foliar spray of 1% K_2SO_4 at flowering and pod formation stage	110.66	5.89	62.00	616.98	1992.41	49358	29058	1.43

T_7) T_2 + foliar spray of 0.5% $ZnSO_4$at flowering and pod formation stage	107.25	6.34	62.67	637.63	1910.05	51011	30641	1.50
T_8) T_2 + foliar spray of 0.02% Boric acid at flowering and pod formation stage	110.37	6.33	66.89	641.16	1949.10	51293	31133	1.54
T_9) T_2 + foliar spray of 0.5% $FeSO_4$ at flowering and pod formation stage	112.07	6.22	63.67	630.17	1753.29	50413	30147	1.49
S.Em	2.87	0.33	1.18	41.59	180.32			
CD 5%	8.92	0.99	3.56	122.70	531.96			
CV (%)	13.74	11.56	11.17	11.53	17.19			

Table 2: Growth, yield and yield attributing characters as influenced by soil and foliar application of nutrients in Sesame during summer, 2018-2019

Treatments	Plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Returns per rupee investment
T_1) Absolute control	75.28	4.00	42.22	415.18	1174.67	33215	14627	0.79
T_2) 50-50-0 kg NPK ha^{-1} (soil application)	88.43	5.22	52.67	537.67	1604.88	43014	23014	1.15
T_3) T_2 + foliar spray of 2.0% DAP at flowering and pod formation stage	107.25	6.11	65.56	586.36	1827.36	46909	26861	1.34
T_4) T_2 + foliar spray of 2.0% 19:19:19 mixture at flowering and pod formation stage	110.17	6.67	69.78	613.74	1897.05	49099	28801	1.42
T_5) T_2 + foliar spray of 2.0% Urea at flowering and pod formation stage	91.75	5.56	57.56	561.79	1794.87	44943	24927	1.25
T_6) T_2 + foliar spray of 1% K_2SO_4 at flowering and pod formation stage	99.93	6.00	62.22	574.26	1689.23	45941	25641	1.26
T_7) T_2 + foliar spray of 0.5% $ZnSO_4$at flowering and pod formation stage	94.55	5.67	59.89	565.04	1693.16	45203	24833	1.22
T_8) T_2 + foliar spray of 0.02% Boric acid at flowering and pod formation stage	109.98	6.22	66.33	591.24	1709.49	47299	27139	1.35
T_9) T_2 + foliar spray of 0.5% $FeSO_4$ at flowering and pod formation stage	104.18	6.00	64.33	583.45	1736.83	46676	26410	1.30
S.Em	6.25	0.30	2.98	33.93	112.91			
CD 5%	18.73	0.89	8.93	101.73	338.51			
CV (%)	11.05	8.97	8.59	10.52	11.64			



Graph 1: Growth, yield and yield attributing characters as influenced by soil and foliar application of nutrients in Sesame during summer, 2017-2019

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