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Yield and economic returns of sesame as influenced by soil applied fertilizers and foliar nutrition

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Abstract
Field experiment was conducted during *Rabi*, 2016-17 on sandy loam soils of Agricultural College Farm, Naira to study the yield and economic returns of sesame as influenced by soil applied nutrients and foliar nutrition. The experiment was laid out in split-plot design with four levels of NPK applied to soil and four levels of foliar nutrition practices, each replicated thrice. Application of 125% RDF (M_3) along with foliar application of 19:19:19 @ 1.0 % at early budding stage followed by 1.0 % KNO_3 at early capsule formation stage (F_4) recorded the highest seed yield (923 kg ha^{-1}), stalk yield (2095 kg ha^{-1}) and economics. The lowest values for yield and economics were found with the lowest level (75% RDF) of NPK supplied to soil and non-supply of foliar nutrients (F_1).

Keywords: Economic returns, foliar nutrition, sesame, soil applied fertilizers, yield.

Introduction
Sesame (*Sesamum indicum* L.) is a crop highly valued for production of high quality oil. It is also grown in many parts of the world for its insecticidal and medicinal properties as well as for its cosmetic and ornamental values. Sesame can also be grown as a spice or as green manure. Oil contains antioxidants *viz*., *sesamin* and *sesamolin* which prevent the oxidative rancidity and increases shelf life. The importance of sesame lies in the oil content (46 to 52%), protein content (20 to 26%), minerals and vitamins.

In India, sesame is grown in 1784 lakh ha with an annual production of 850 M t and productivity of 486 kg ha^{-1} (*www.indiastat.com*, 2015-16) [7]. In Andhra Pradesh, it is grown in an area of 8.5 lakh ha with a production of 2.8 M tonnes and productivity of 329 kg ha^{-1} (Ministry of Agriculture, Government of India, 2014-15) [7].

Crop average productivity is very low in comparison to world as well as national average. The yields are low may be due to the reasons like cultivation of sesame on marginal and sub marginal lands of poor fertility under very poor agronomic practices and inadequate or even no use of fertilizers by the farmers.

Inorganic fertilizers play an important role to meet nutrient needs of sesame, but continuous use of chemical fertilizers shows adverse effects on soil physical and chemical conditions. Therefore, integrated use of organic and chemical nutrient sources improves the soil health and yield (Verma *et al*., 2014). Along with integrated fertilizers foliar spray helps in increase of chlorophyll production, cellular activity and regulates respiration. Hence, there is a need to evaluate the good recommended fertilizers for getting better yield and economic returns to farmers. So this experiment was carried out to provide better economic value with better yield.

Material and Methods
A field experiment was conducted during *Rabi* of 2016-17 at the Agricultural College Farm, Naira, Andhra Pradesh. The soil was sandy loam in texture with a pH of 7.04 and EC of 0.078 dSm^{-1}, low in organic carbon (0.61%), low in available nitrogen (252.5 kg ha^{-1}), medium in available phosphorus (29.5 kg ha^{-1}) and high in available potassium (352.5 kg ha^{-1}). Brown colored seed of sesame 'YLM-66' were line sown at a spacing of 30 cm x 10 cm at a seed rate of 4 kg ha^{-1} on 24th December, 2016. The plot size was 6 m × 5 m. The experiment was laid out in split-plot design, comprising of four NPK levels; 100% RDF (40:20:20 kg NPK ha^{-1}-M_1), 75% RDF (M_2), 125% RDF (M_3) and 75% RDF + 25% nitrogen through vermicompost (M_4) allotted to main plots and four foliar nutrition treatments *viz*., control (F_1),

foliar application of 19:19:19 @ 1.0% at early budding stage (F_2), foliar application of KNO_3 @ 1.0% at early capsule formation stage (F_3) and 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO_3 at early capsule formation stage (F_4) allotted to subplots and each treatment replicated thrice. The crop was harvested on 4th April, 2017.

Results and Discussion

Maximum seed yield (873 kg ha^{-1}) and stalk yield (2036 kg ha^{-1}) of sesame were realized with application of 125% RDF (M_3) and found significantly superior to rest of the nutrient levels. The seed yield (785 kg ha^{-1}) and stalk yield (1891 kg ha^{-1}) obtained with application of 100% RDF (M_1) were statistically comparable with M_4-75% RDF + 25% nitrogen through vermicompost (777, 1893 kg ha^{-1}). Seed yield (668 kg ha^{-1}) and stalk yield (1753 kg ha^{-1}) were found to be the lowest with application of 75% RDF (M_2) and found statistically inferior to rest of the treatments. The per cent gain in the seed yield due to application of the highest dose (M_3-125% RDF) over lowest dose (M_2-75 % RDF) was worked out to be 30.6% indicating the response of sesame to 66.6% hike in the recommended dose of NPK. While, the gain in seed yield due to 25% enhancement in fertilizer dose over the recommended dose of NPK applied to soil (100% RDF) was worked out to be 11.0%, clearly showing that the currently recommended dose of NPK (40:20:20 kg NPK ha^{-1}) was suboptimal. The results are in agreement with those reported by Gayatri Sahu *et al*. (2017) [3] and Mahajan *et al*. (2016) [5].

As regards the response of sesame in terms of seed yield and stalk yield due to foliar feeding of nutrients, significantly highest values for seed yield (838 kg ha^{-1}) and stalk yield (1947 kg ha^{-1}) were noticed with F_4 (foliar application of 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO_3 at early capsule formation stage). While, non application of foliar nutrients to sesame (F_1) resulted in the lowest seed yield (697 kg ha^{-1}) and stalk yield (1841 kg ha^{-1}). There was an enhancement in the seed yield of sesame to the tune of 20.2% due to application of F_4 (foliar application of 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO_3 at early capsule formation stage) over non application of foliar nutrients (F_1- control). Similar views were also expressed by Bhosale *et al*. (2011) [1].

Harvest index, the ratio between seed yield to that of biological yield was not markedly altered either due to of varied levels of NPK to soil or due to foliar feeding of nutrients. The interaction effect between these two factors was also not statistically measurable.

Gross Returns

Maximum gross returns of (Rs. 96,585 ha^{-1}) were obtained with application of the highest dose of NPK to soil (M_3-125% RDF) while, it was minimum (Rs. 73,919 ha^{-1}) with the lowest level of NPK tried (M_2-75% RDF) and found significantly lower to rest of the nutrient doses applied to soil (Table 2 and Figure 1).

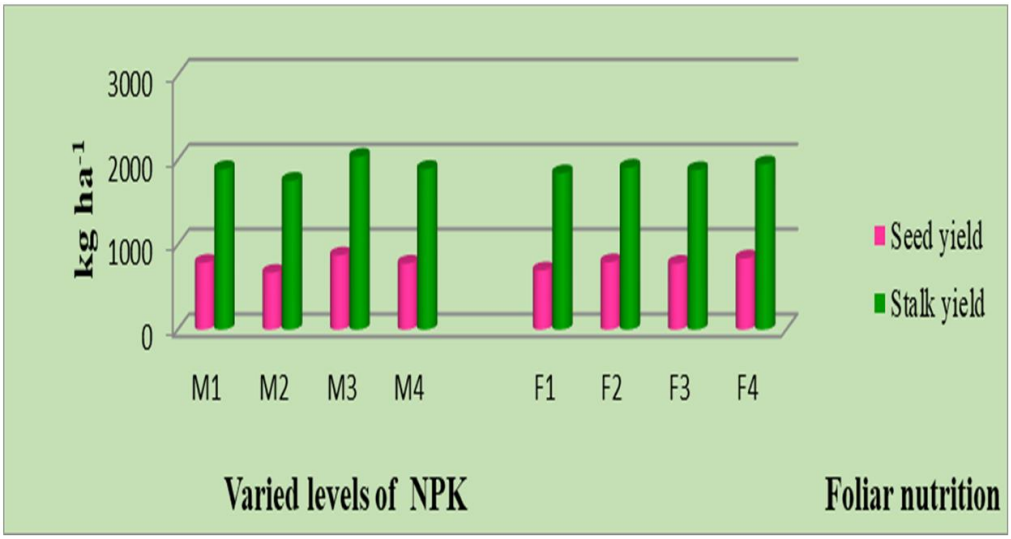
Table 1: Seed and stalk yield (kg ha^{-1}) of sesame as influenced by varied levels of NPK application to soil and foliar application of nutrients

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest Index (%)
Varied levels of NPK application to soil			
M_1**:** 100% RDF (40:20:20 kg NPK ha^{-1})	786	1891	29.32
M_2**:** 75% RDF	668	1753	27.55
M_3**:** 125% RDF	873	2036	30.03
M_4**:** 75% RDF + nitrogen through vermicompost	777	1893	29.07
SEm (±)	38.38	74.95	1.40
C.D (P=0.05)	66	130	NS
CV%	8.57	6.86	8.40
Foliar application of nutrients			
F_1**:** Control	697	1841	27.35
F_2**:** Foliar application of 19:19:19 @ 1.0 % at early budding stage	793	1908	29.24
F_3**:** Foliar application of KNO_3 @ 1.0 % at early budding stage	776	1878	29.28
F_4**:** Foliar application of 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO_3 at early capsule formation stage	838	1947	30.10
SEm (±)	13.07	23.99	1.46
C.D (P=0.05)	19	35	NS
CV%	2.92	2.20	8.78

Table 2: Economics of sesame as influenced by varied levels of NPK application to soil and foliar nutrition.

Treatments	Gross Returns (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	B:C
Varied levels of NPK application to soil			
M_1**:** 100% RDF (40:20:20 kg NPK ha^{-1})	86878	57333	1.93
M_2**:** 75% RDF	73919	44374	1.49
M_3**:** 125% RDF	96585	67032	2.27
M_4**:** 75% RDF + 25 % N through vermicompost	85907	56362	1.90
SEm (±)	4215.19	4216.29	0.14
C.D (P=0.05)	7295	7297	0.24
CV%	8.51	12.98	13.05
Foliar application of nutrients			
F_1**:** Control	77176	47632	1.61
F_2**:** Foliar application of 19:19:19 @ 1.0% at early budding stage	87652	58107	1.96

F_3: Foliar application of KNO_3 @ 1.0% at early budding stage	85793	56248	1.90
F_4: Foliar application of 19:19:19 @ 1.0% at early budding stage followed by 1.0 % KNO_3 at early capsule formation stage	92667	63114	2.13
SEm (±)	1437.39	1436.66	0.04
C.D (P=0.05)	2098	2097	0.07
CV%	2.90	4.42	4.41



Main plot treatments
M_1 - 100 % RDF (40: 20: 20 kg NPK ha^{-1})
M_2 - 75 % RDF
M_3 - 125 % RDF
M_4 - 75 % RDF + 25 % N through VC
Sub plot treatments
F_1 - Control
F_2 - Foliar application of 19: 19: 19 @ 1.0 % at early budding stage
F_3 - Foliar application of KNO_3 @ 1.0 % at early budding stage
F_4 - Foliar application of 19: 19: 19 @ 1.0 % at early budding stage followed by 1.0 % KNO_3 at early capsule formation stage

Fig 1: Gross returns vs. net returns of sesame as influenced by varied levels of NPK application to soil and foliar nutrition

As regards foliar feeding of nutrients to rabi sesame, significantly higher gross returns (Rs. 92,667 ha^{-1}) were obtained with application of 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO_3 at early capsule formation stage (F_4) while it was minimum with F_1 (control).

Net returns
Significantly higher net returns (Rs. 67,032 ha^{-1}) were realized with application of the highest dose of NPK applied to soil (M_3- 125% RDF) along with foliar application of 19:19:19 @ 1.0 % at early budding stage followed by 1.0% KNO_3 at early capsule formation stage (F_4) of about (Rs. 63,114 ha^{-1}) found statistically superior to rest of the treatments. While, the net returns were found to be minimum (Rs. 44,374 ha^{-1}) with application of the lowest level of NPK applied to soil (75% RDF-M_2). The net returns realized due to application of 100% RDF (M_1) were comparable with M_4 (75% RDF + 25% nitrogen through vermicompost).

Benefit cost ratio
B: C ratio (2.27) was recorded significantly higher with M_3 (125% RDF) while, the lowest B: C ratio (1.50) was found to be associated with the lowest level of NPK applied to soil (75% RDF).
As regards the foliar application of major nutrients to sesame, the B: C ratio was found to be the highest (2.14) when sesame received foliar nutrition twice (F_4) and found significantly superior over other foliar feeding treatments. The B: C ratio was minimum (1.61) when sesame did not receive foliar nutrition (F_1-control) and found significantly inferior to rest of the foliar nutrition treatments.
The highest gross returns, net returns as well as B: C ratio realized with the highest level of NPK (125% RDF) applied to soil (M_3) over the other level tried might be due to the highest economic yield (seed and stalk) realized without proportionate increase in the cost of cultivation. Application of major nutrients through foliage twice (F_4-foliar application of 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO_3 at early capsule formation stage) registered significantly higher gross returns, net returns as well as B: C ratio. Supplementing major nutrients at crucial juncture during the reproductive phase, one at early budding stage with 19:19:19 followed by KNO_3 at capsule formation stage might have enabled to meet the nutritional demand efficiently in tune with the physiological needs to ultimately translocate into higher seed and stalk yield which in turn inflated B: C ratio compared to other foliar nutrition treatments. These results were in agreement with those reported by Kalpana Jamdhade *et al*. (2017) [4], Tulasi Lakshmi *et al*. (2014) [8], Bikram Singh *et al*. (2013) [2] and Mian *et al*. (2011) [6].

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