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Effect of Water Soluble Fertilizers on Yield, Oil Content and Economics of Groundnut

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Authors' contributions

This work was carried out in collaboration among all authors. Authors VM, NSH and LHM designed the study and wrote the protocol. Author VM performed statistical analysis and wrote the first draft of the manuscript. Authors NSH and LHM managed the analyses of the study. Authors RG and BR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, to know the effect of water soluble fertilizers on growth, yield and oil content of groundnut (Cv TAG 24). The experiment was conducted in a Vertisol with ten treatment combinations consisting of FYM and different doses of recommended NPK as basal soil application and foliar spray of water soluble fertilizers at 30, 45 and 60 days after sowing in a Randomized complete block design with three replications. Application of FYM + 100% RDF + foliar spray of fertilizers at 30, 45 and 60 DAS showed higher pod yield (5615 kg/ha) which was 22% higher over application of 100% RDF alone (4601 kg/ha). But the crop was equally responsive in increasing the pod yield, when RDF was reduced by 15% along with foliar application of water soluble grade fertilizer. The yield components, kernel yield (3892 kg/ha), haulm yield (8916 kg/ha), total number of pods plant^{-1} (33.80), =sound mature kernels (88.67) and oil yield (1858 kg/ha) were highest in the treatment of FYM + 100% RDF + foliar spray of fertilizers over rest of the treatments. But the highest

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Benefit cost ratio (4.40) was found in the treatment of FYM + 85% RDF + foliar application of fertilizers followed by the treatment of FYM + 100% RDF + foliar application of fertilizers (4.36) whereas the lowest B: C ratio (3.91) was observed in control.

Keywords: Arachis hypogaea; foliar spray; dry pod yield; oil yield; benefit cost ratio.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the most important annual legume food crop in the world. Commercially, groundnut is the world's thirteenth most important food crop, fourth most important source of edible oil and third most important source of vegetable protein. About two thirds of world production is crushed for oil and one third is consumed as food [1]. Groundnut cake is a high protein animal feed. It contains about 50% oil, 25- 30% protein, 20% carbohydrates and 5% fiber and ash having a substantial contribution to human nutrition [2].

In Karnataka, it is grown over an area of 0.67 million ha with a production of 0.42 million tonnes and a productivity of 629 kg ha^{-1} which is significantly lower compared to 1398 Kg/ha in India [3]. In Dharwad district, it is grown over an area of 17,403 ha with a production of 10,480 tons and a productivity of 644 kg ha^{-1} [4]. The low productivity of groundnut in Karnataka as well as Dharwad district might be due to several production constraints, which include growing crop on low fertility lands and imbalanced nutrition to the crop.

Groundnut is very exhaustive crop compared to other legumes because a very little portion of the plant residue is left in the soil after harvest [5]. Therefore, cultivation of groundnut depletes the soil fertility rapidly unless the crop is adequately fertilized. So, balanced fertilization is essential for enhancing the groundnut production. The nutrient requirement of groundnut is higher especially at pegging and pod development stages. The requirement at these stages cannot be fulfilled merely by soil application alone and need to be supplemented through foliar application. Futher more, foliar application enhances the efficiency of applied nutrients which otherwise subjected to leaching losses, precipitation and fixation losses.

Groundnut being a leguminous crop, fixes substantial quantity of atmospheric nitrogen. So, the application of full dose of nitrogen may not be required. Usually phosphorus requirement is higher at initial stages for root development. Since the experimental site is medium in available phosphorus and high in available potassium, dosage of fertilizer application may be reduced. Application of recommended dose of FYM also supply all essential nutrients in minute quantities besides improving the soil physical properties. Further, foliar application ensures the supply of nutrients as and when they are required by crop. Keeping all these points in view, there is a possibility for saving the costly fertilizer input without yield penalty which also lessens the environmental pollution. In the light of the above, an experiment was conducted with combination of FYM, doses of NPK and foliar application of water soluble fertilizers.

2. MATERIALS AND METHODS

A field experiment was conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, India, during summer 2012. Dharwad is situated at 15^0 26′N latitude and 75^0 07′ E longitude and at an altitude of 678 m above mean sea level. The mean annual rainfall during the experimental year from January 2012 to December 2012 was 540.11 mm. The highest mean monthly maximum temperature (35.8^0 C) and lowest mean monthly minimum temperature (12 ^{0}C) were recorded in March 2012 and January 2012, respectively. Mean monthly maximum relative humidity was recorded during the month of July (84.6%).

2.1 Soil Chemical Properties and Adopted Methods

The soil was texturally clay, neutral in pH (7.24), non saline (0.61 dSm^{-1}), medium in organic carbon (6.50 g kg^{-1}), low in available nitrogen (237 kg N ha^{-1}), medium in available phosphorus (34.6 kg P_2O_5 ha^{-1}) and rich in available potassium (470 kg K_2O ha^{-1}). The soil was sufficient in all available micro nutrients Viz., Fe (3.84 mg kg^{-1}), Cu (0.51 mg kg^{-1}), Mn (5.60 mg kg^{-1}) except zinc (0.58 mg kg^{-1}). Soil reaction, electrical conductivity and organic carbon were determined as described by Jackson [6]. Available nitrogen measured by modified alkaline permanganate method described by Sharawat and Burford [7], available phosphorus, potassium and sulfur were determined by following the procedures of Black [8], Available copper, zinc,

iron and manganese were measured by following procedures given by Lindsay and Norwell [9].

2.2 Treatment Details

The experiment was laid with ten treatment combinations consisting of FYM and various levels of recommended NPK Viz., 100%, 85%, 60% NPK through soil application at the time of sowing and foliar spray of fertilizers at 30, 45 and 60 days after sowing (DAS) of groundnut. Foliar application included starter dose of water soluble grade fertilizer (11:36:24 + trace elements) @ 2% at 30 days after sowing followed by booster dose of water soluble grade fertilizer (8:16:39+ trace elements) @ 2% at 45 DAS and 60 DAS. Trace elements in the foliar mixture were Fe - 800 ppm, Mn - 400 ppm, Zn - 200 ppm, Cu - 50 ppm and Mo – 50 ppm. Experiment was laid out in a randomised complete block design with three replications.

2.3 application of Fertilizers

The nitrogen, phosphorus and potassium were applied in the form of urea, SSP and muriate of potash, respectively. The entire quantity of fertilizer mixture containing nitrogen, phosphorus and potassium were applied as per the treatments to each plot at the time of sowing. FYM @ 7.5 t ha^{-1} was applied as per the treatment to each plot three weeks prior to sowing. Fertilizers were mixed thoroughly and covered with the soil. Foliar application of starter dose of water soluble grade fertilizer (11:36:24 + trace elements) @ 2% was applied at 30 days after sowing (DAS). Foliar application of booster dose of water soluble grade fertilizer (8:16:39 + trace elements) @ 2% were applied at 45 DAS and 60 DAS with knapsack sprayer in the morning hours as per the treatments. Eleven irrigations were given to the crop during entire growth period. One pre-sowing irrigation was given for land preparation.

2.3.1 Harvesting and plucking

The crop was harvested at physiological maturity. Immediately after uprooting, the plants were sun dried for one week. the pod yield and haulm yield $plot^{-1}$ were recorded.

2.3.2 Oil content and oil yield

Dried kernels of each treatment were used for estimation of per cent oil content using Nuclear Magnetic Resonance (NMR). Oil yield was calculated by multiplying the oil per cent with kernel yield.

2.4 Statistical Analysis and Interpretation of Data

The analysis and interpretation of data were done using the Fischer's method of analysis of variance technique as described by Gomez and Gomez [10]. The level of significance used in 'F' and 't' test was P = 0.05. Critical difference values were calculated wherever the 'F' test was significant.

2.5 Correlation Studies

Simple correlation analysis was done to understand the interrelationships between nutrient uptake by the whole plant with yield attributes *viz.*, dry pod yield, kernel yield, oil content and oil yield. Correlation coefficients (r) were calculated in SPSS package and tests of significance were applied as per the procedure outlined by Snedecor and Cochran [11].

2.6 Economic Analysis

Based on the prevailing price of inputs and produce, the net profit per hectare and benefit cost ratio were worked out by using the following formulae.

Net profit per hectare (in rupees) = Gross income per hectare (Rs) - Cost of cultivation (Rs)

$$\text{Benefit: Cost} = \frac{\text{Net profit ha}^{-1}\text{(Rs)}}{\text{Cost of cultivation ha}^{-1}\text{(Rs)}}$$

3. RESULTS AND DISCUSSION

Yield and yield parameters were significantly influenced by foliar application of water soluble fertilizers (Table 1). Total number of pods per plant was increased with increasing level of fertilizers. The highest number of pods per plant was recorded with the treatment receiving FYM + 100% RDF + foliar spray of fertilizers (33.80). Roy [12] reported that the foliar grade water soluble fertilizers application to groundnut had the positive response to increase the pod yield either alone or in combination with recommended fertilizer dose. Further, Application of FYM might have provided balanced nutrients in readily available from throughout the growth period resulting in greater production of

Table 1. Yield and yield components of groundnut as influenced by soil and foliar application of fertilizers

Treatment details	Total no. of pods plant^{-1}		Sound mature Kernels plant^{-1}		Dry pod weight (g plant^{-1})		Dry pod yield (kg ha^{-1})		Kernel yield (kg ha^{-1})		Haulm yield (kg ha^{-1})		Harvest index		Shelling per cent		Oil content (%)		Oil yield (kg/ha)	
T_1 : Absolute control	27.0	c	78.3	c	18.3	c	3801	f	2540	d	7829	b	0.22	c	66.8	a	46.2	b	1174	d
T_2 : 100% RDF	29.7	bc	81.6	a-c	19.6	bc	4601	cd	3140	b-d	8166	ab	0.25	ab	68.2	a	47.3	a	1486	bc
T_3 : Foliar application of water soluble grade fertilizers @ 2%	27.7	bc	80.0	bc	19.0	bc	4219	e	2860	cd	7846	ab	0.24	bc	67.7	a	46.5	b	1330	cd
T_4 : 100% RDF+ foliar spray	31.0	ab	84.3	a-c	21.6	a-c	5091	b	3495	ab	8576	ab	0.26	ab	68.6	a	47.6	a	1666	ab
T_5 : FYM + 100% RDF+ water spray	30.7	ab	83.0	a-c	21.3	a-c	5013	b	3439	a-c	8185	ab	0.26	ab	68.6	a	47.4	a	1630	ab
T_6 : FYM + 100% RDF+ foliar spray	33.8	a	88.6	a	24.2	a	5615	a	3892	a	8916	a	0.27	a	69.3	a	47.7	a	1858	a
T_7 : FYM + 85% RDF + water spray	30.6	ab	82.6	a-c	19.6	bc	4900	bc	3360	a-c	8175	ab	0.26	ab	68.5	a	47.3	a	1592	b
T_8 : FYM + 85% RDF+ foliar spray	31.0	ab	87.6	ab	22.8	ab	5567	a	3859	a	8580	ab	0.27	a	69.3	a	47.6	a	1840	a
T_9 : FYM + 60% RDF + water spray	27.6	bc	81.0	a-c	19.3	bc	4523	d	3078	b-d	8015	ab	0.25	ab	68.0	a	46.5	b	1431	bc
T_{10} : FYM + 60% RDF+ foliar spray	29.0	bc	81.6	a-c	19.5	bc	4956	b	3377	a-c	7890	ab	0.26	a	68.1	a	46.9	ab	1586	b
Mean	30		82.9		20.5		4828		3304		8218		0.25		68.4		47.1		1559	
S.Em +	1.09		2.45		1.68		102.02		187		363.06		0.011		0.93		0.25		73.03	

Note: Recommended dose of fertilizers: 25: 75:25 kg N, P_2O_5, K_2O/ha.
FYM: 7.5 t/ha.
Foliar application of starter dose of water soluble grade fertilizer (11:36:24 + Trace elements) @2.00% at 30 days after sowing (DAS) + Foliar application of booster dose of water soluble grade fertilizer (8:16:39+ Trace elements) @ 2.00% at 45 DAS and 60 DAS.
In a column mean values followed by the common letter are not significantly different at p=0.05 level (DMRT at 5% level)

metabolites and their translocation to productive structures which could have helped in increased number of pods per plant and overall plant growth [13].

Shelling percentage and hundred kernel weight of groundnut did not differ significantly due to foliar application of water soluble fertilizer along with or without application of 100%, 85% or 60% RDF.

The maximum dry pod yield was observed in the treatment of FYM + 100% RDF + foliar spray of fertilizers (5615 kg/ha). However, the crop was equally responsive in increasing the pod yield, when RDF was reduced by 15% (85% of RDF) along with foliar application of water soluble fertilizer (5567 kg/ha). Even the treatment of FYM + 60% RDF + foliar spray of fertilizers produced higher dry pod yield (4956 kg/ha) compared to 100% RDF (4601 kg/ha) indicating the effective utilization of foliar applied nutrients (Table 1). This might also be due to groundnut being a leguminous crop, able to fix the atmospheric nitrogen so, basal application of nitrogenous fertilizer requirement is less. In addition foliar application of water soluble fertilizer could improve the nutrient uptake and utilization. Increased production of dry matter and its efficient translocation to the economic parts resulted in higher final pod yield as reported by Shete [14]. Similar observations were reported by Balerao [15] who observed that mean dry pod yield was increased by 5.6 – 20% by foliar application of individual or combined trace elements, urea, phosphorus and plant growth regulators.

Kernel yield and haulm yields of groundnut were significantly influenced by soil and foliar application of fertilizers. The maximum kernel yield (3892 Kg/ha) and haulm yield (8916 Kg/ha) were observed in the treatment of FYM + 100% RDF + foliar spray of fertilizers (3892 kg/ha). However, the treatments $T_{8,}$ $T_{4,}$ $T_{5,}$ $T_{7,}$ and T_{10} were on par with T_6 for kernel yield. Treatment of FYM + 60% RDF + foliar spray of fertilizers produced higher kernel yield (3377 kg/ha) on par with T_6 (Table 1). In case of haulm yield all the treatments were found on par with T_6 except control. The growth of groundnut is intense from 30-70 Days after sowing [16]. Therefore, synchronization of nutrient supply at these stages through foliar application resulted in growth and higher yields. Efficient partitioning of metabolites, appropriate translocation and accumulation of photosynthates, vitamins, amino acids to developing reproductive structures through foliar application resulted in enhancement in yield attributing characters. Karthika and Ramanathan [17] found increased haulm yield of groundnut was mainly due to the higher production of dry matter, leaf area and all the yield attributing components of the crop. The improvement in the kernel yield might be due to the instant assimilation of nutrients supplied through the foliar application meeting the required nutrient demand of the crop during flowering period of groundnut. Improved pod weight under foliar treatments was mainly due to increased translocation of photosynthates from leaves and stem to developing pods resulting in sound mature kernels [18]. Foliar spray maintains the leaf area for longer duration which extends period of photosynthates translocation to developing pods resulting in bolder and well-shaped seeds [19].

The higher seed oil content (47.73%) and oil yield (1858 kg/ha) were observed in FYM + 100% RDF + foliar spray of fertilizers treatment. This might also be due to supply of iron with foliar spray which increased the oil content in kernels. The results of present investigation are in confirmity with the findings of Patil [20] and Krishnappa [21] in groundnut. Patil [20] observed that significant increase in protein and oil content of groundnut due to the foliar spray of ferrous sulphate at 30, 60 and 75 days after sowing. Moreover, Phosphorus is a major constituent of fatty acids, higher accumulation of phosphorus exhibited higher seed oil content. Higher kernel yield and higher oil content of the foliar sprayed treatments showed higher oil yields compared to their counter parts.

3.1 Economics

The acceptance of any generated technology is ultimately based on the cost of cultivation and net returns from it. In the present investigation, treatment with FYM + 100% RDF + foliar application of fertilizers showed highest gross income (Rs 213370.00 ha^{-1}) as well as net income (Rs 173590.00 ha^{-1}) followed by the treatment FYM + 85% RDF + foliar application of fertilizers (Rs 211546 and Rs 172351, gross income and net income, respectively). But the highest (4.40) benefit cost ratio was found in the treatment of FYM + 85% RDF + foliar application of fertilizers followed by the treatment (T_6) that received FYM + 100% RDF + foliar application of fertilizers (4.36) whereas the lowest B: C ratio

(3.91) was observed in control (Table 2). Even though the gross and net returns were higher in the treatment of FYM + 100% RDF + foliar application of fertilizers but the B: C ratio was lower because of higher input cost compared to T_8. Critical examination of the data revealed that all treatments with foliar spray of fertilizers recorded numerically higher B: C ratio compared to their corresponding treatments with water spray. Similar resulted were reported by Roy [12] who observed highest net return: cost ratio of 2.70 in the treatment FYM + 85% RDF + Foliar spray treatment.

3.2 Correlation Studies

3.2.1 Nutrient uptake by whole plant vs. yield and quality attributes

Yield attributes Viz., total number of pods, dry pod yield and kernel yield were positively and significantly influenced by leaf area, total dry matter production, number of nodules and chlorophyll content (Table 3). Both Major and micro nutrient uptake was positively correlated with dry pod yield, kernel yield, oil content and oil yield. Foliar application resulted in greater absorption, assimilation and translocation of

Table 2. Economics of groundnut cultivation as influenced by soil and foliar application of fertilizers

Treatment details	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B : C ratio
T_1 : Absolute control	29400	144438	115038	3.91
T_2 : 100% RDF	34030	174838	140808	4.14
T_3 : Foliar application of water soluble grade fertilizers @ 2%	32400	160322	127922	3.95
T_4 : 100% RDF+ foliar spray	37030	193458	156428	4.22
T_5 : FYM + 100% RDF+ water spray	36780	190494	153714	4.18
T_6 : FYM + 100% RDF+ foliar spray	39780	213370	173590	4.36
T_7 : FYM + 85% RDF + water spray	36195	186200	150005	4.14
T_8 : FYM + 85% RDF+ foliar spray	39195	211546	172351	4.40
T_9 : FYM + 60% RDF + water spray	34377	171874	137497	4.00
T_{10} : FYM + 60% RDF+ foliar spray	37377	188328	150951	4.04

Note: Recommended dose of fertilizers: 25: 75:25 kg N, P_2O_5, K_2O/ha.
FYM: 7.5 t/ha.
Foliar application of starter dose of water soluble grade fertilizer (11:36:24 + Trace elements) @2.00% at 30 days after sowing (DAS) + Foliar application of booster dose of water soluble grade fertilizer (8:16:39+ Trace elements) @ 2.00% at 45 DAS and 60 DAS.
In a column mean values followed by the common letter are not significantly different at p=0.05 level (DMRT at 5% level)

Table 3. Relationship between Growth parameters and nutrient uptake with yield attributes of groundnut

Nutrient Uptake	'r' value			
	Total number of pods	Dry Pod Yield	Kernel Yield	Oil yield
Leaf area	0.96**	0.93**	0.93**	0.94**
Chlorophyll content	0.85**	0.89**	0.89**	0.89**
Total dry matter production	0.96**	0.93**	0.94**	0.95**
Number of nodules	0.95**	0.94**	0.95**	0.95**
N uptake	0.94**	0.92**	0.92**	0.93**
P uptake	0.96**	0.94**	0.95**	0.95**
K uptake	0.93**	0.87**	0.88**	0.89**
S uptake	0.93**	0.95**	0.95**	0.96**

***significant at 1%*

nutrients for increased photosynthesis. Therefore, better availability and uptake of nutrients could be assigned as the proper reason behind the significant increase in dry matter production and its accumulation ultimately reflected in yield parameters. Similar results were reported by Shivakumar [22] and Dalei [23]. Sulphur uptake was positively correlated with oil yield (0.96 **). Since sulphur is an integral part of oil, the increased availability of sulphur might have favorably influenced the synthesis of essential metabolism for higher oil content. Similar results were reported by Jat and ahlawat [24] and Yadav [25].

4. CONCLUSION

From the above study, it can be concluded that the application of inorganic fertilizers can be reduced upto 15% with application of foliar grade water soluble fertilizer starter dose of water soluble grade fertilizer (11:36:24 + trace elements) @ 2% at 30 days after sowing (DAS) + Foliar application of booster dose of water soluble grade fertilizer (8:16:39+ trace elements) @2% at 45 DAS and 60 DAS to achieve optimum yield, yield parameters as well as highest benefit: cost ratio. Thus, the practice of foliar nutrition as a supplement for standard soil fertilization was beneficial for summer groundnut.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mekki. Yield and yield components of groundnut (*Arachis hypogaea* L.) in response to soil and foliar application of potassium. American-Eurasian J. Agric. & Environ. Sci., 2015;15(10):1907-1913.
2. Fageria NK, Baligar VC, Jones, C. Growth and mineral nutrition of field crops. 2 Ed. and Marcel Dekker, Inc, New York, 1997;494 .
3. Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India; 2018.
4. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India; 2013.
5. Varade PA, Urkude DK. Response of groundnut to sources and levels of potassium. Indian Potash J. 1982;7(1):2-5.
6. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. 1967;498.
7. Sharawat KL, Burford JR. Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. Soil. Sci. 1982;133:53-57.
8. Black CA. Methods of soil analysis part – ii, agronomy monograph. American. Soc. Agron., Madison, Wisconsin, USA. 1965;9: 375-377.
9. Lindsay WL, Norwell WA. Development of DTPA test zinc, iron, manganese and copper. Soil Sci. Soc. American J. 1978; 42:421-428.
10. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, An international Rice Research Institute Book, Wiley- Inter Science Publication, New York, USA. 1984;680.
11. Snedecor GW, Cochran WG. Statistical methods. Iowa State College Press, Ames, Iowa, USA; 1956.
12. Roy S, Gunri SK, Puste AM, Sengupta A, Saha D. Growth and yield of summer groundnut (*Arachis hypogaea* L.) as influenced by foliar application of water soluble fertilizer. Journal of Applied and Natural Science. 2016;8(1):245-250 .
13. Nagaraj R, Hanumanthappa M, Kamath S. Growth parameters and yield of groundnut as influenced by integrated nutrient management at coastal zone of Karnataka. Journal of Pharmacognosy and Phyto-chemistry. 2018;7(5):2725-2729.
14. Shete SA, Bulbule AV, Patil DS, Pawar RB. Effect of foliar nutrition on growth and uptake of macro and micronutrients of kharif groundnut (*Arachis hypogaea* L.). Int.J. Curr. Microbiolo. App.Sci. 2018; 7(10):1193-1200.
15. Balerao PD, Jadhao PN, Fulzele GR. Response of groundnut to foliar application of nutrients and growth stimulant. Journal of Maharashtra Agricul-tural-Universities. 1994;19(1):94-96.
16. Bewali IS, Shola GR, Shinde VM. Growth and development studies in groundnut. J. Maharastra Agril. Univ. 1980;5:76-77.
17. Karthika N, Ramanathan SP, Influence of drip fertigation on the physiological and yield parameters of groundnut (*Arachis hypogaea* L.) in light textured soils of Cauvery command in Tamil Nadu.

International Journal of chemical studies. 2019;7(3):3088-3011.
18. Shwetha BN, Anupama C, Sowmya TM, Yaligar R. Effect of foliar nutrition on productivity of groundnut crop. Journal of Pharmacognosy and Phytochemistry. 2018;SP1:2357-2360.
19. Kumar VHM, Salakinakop SR, Angadi SS. Enhancing groundnut (*Arachis hypogaea* L.) productivity through foliar nutrition. J Farm Sci. 2016;29(2):190-193.
20. Patil VC, Radder GD, Kudasomannavar BT. Effect of zinc, iron and calcium under varying levels of phosphorus on groundnut. Mysore J. Agric. Sci. 1979; 13(4):395-399.
21. Krishnappa M, Srinivas CN, Santhy P. Effect of macro and micronutrients on growth and yield in groundnut. Curr Res. 1994;23(1-2):7-9.
22. Shivakumar M. Effect of amonification with fly ash, fertilizer levels and foliar nutrition on NPK on growth and yield of groundnut and soil properties. M.Sc. (Agri.) Thesis, University of Agricultural Science, Dharwad, Karnataka; 2005.
23. Dalei BB, Kheroar S, Mohapatra PM, Panda S, Deshmukh MR. Effect of foliar sprays on seed yield and economics of Niger (*Guizotia abyssinica* L.). Journal of Agricultural Science. 2014;6:143-147.
24. Jat RA, Ahlawat IPS Effect of farmyard manure, source and level of sulphur on growth attributes, yield, quality and total nutrient uptake in pigeonpea (*Cajanus cajan*) and groundnut (*Arachis hypogaea*) intercropping system. Indian Journal of Agricultural Science. 2009;79(12):1016-1019.
25. Yadav N, Yadav SS, Yadav N, Yadav MR, Kumar RLR, Yadav VK, Yadav, Yadav A. Sulphur management in groundnut for higher productivity and profitability under Semi-Arid condition of Rajasthan. India Legume Research. 2019;42(4)2019:512-517.

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