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AGRONOMY

Impact of Zinc and Iron Ferti-Fortification on Leaf Area Index, Kernel Yield, Shelling Percentage and Iron Uptake of Groundnut (*Arachis hypogaea* L.) Genotypes

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ABSTRACT

Results of the field experiment entitled "Studies on zinc and iron enrichment through ferti-fortification in groundnut (*Arachis hypogaea* L.) genotypes" was conducted during *rabi* season of 2014-15 at Agronomy field unit, College of Agriculture, UAS, Raichur are discussed in this paper. The soil of the experimental site was deep black, clay in texture with pH 8.4, deficient in DTPA extractable zinc and iron. Three groundnut genotypes in main plots and seven micronutrient treatments comprising of one control and three each of zinc and iron as soil, foliar and both were assigned in the sub-plot in a split-plot design replicated thrice. Results revealed that the groundnut genotype ICGV-00351 recorded significantly higher leaf area index (1.79 at harvest), kernel yield and shelling percentage (1934 kg ha^{-1} and 72.77%) and Fe uptake by kernels, haulm and their total uptake (357.12, 517.71 and 874.83 g ha^{-1}, respectively) as compared to other genotypes. Among the micronutrients, soil (25 kg ha^{-1}) and foliar (0.5%) application of $ZnSO_4$ recorded significantly higher leaf area index (2.10 at harvest), kernel yield (2051 kg ha^{-1}) and shelling percentage (73.21 %) as compared to the other treatments. Whereas, uptake of Fe in kernels, haulm and their total uptake. Significantly higher uptake of Fe in kernels, haulm and total uptake of Fe in groundnut was recorded with soil (25 kg ha^{-1}) and foliar (0.5 %) application of $FeSO_4$ (427.56, 701.62 and 1129.18 g ha^{-1}, respectively) over other treatments.

Highlights

- ICGV-00351 gave best response to zinc and iron application through soil (25 kg ha^{-1}) and foliar (0.5%) application of $ZnSO_4$ at 30 and 45 DAS as compared to TMV-2 and it was comparable with K-9.
- Soil (25 kg ha^{-1}) and foliar (0.5%) application of $ZnSO_4$ at 30 and 45 DAS was found to be more effective in increasing LAI, kernel yield and shelling percentage.
- Uptake of Fe in kernels, haulm and their total uptake. Significantly higher uptake of Fe in kernels, haulm and total uptake of Fe in groundnut was recorded with soil (25 kg ha^{-1}) and foliar (0.5%) application of $FeSO_4$ (427.56, 701.62 and 1129.18 g ha^{-1}, respectively) over other treatments.

Keywords: Groundnut genotypes, Leaf area index, Kernel yield, Shelling percentage, Zinc and Iron fortification

Groundnut is the world's fourth most important source of edible oil and third most important source of vegetable protein. The cultivated form of groundnut has been classified into two major groups *viz.*, valentia group (*Arachis hypogaea* sub spp. *fastigata)* and spanish group (*Arachis hypogaea* sub spp. *procumbens*).

It is a unique crop, combining the attributes of both oilseed and legume crop in the farming system of Indian agriculture. It is a valuable crop planted in dry areas of Asia, Africa, Central and South America, Australia and Caribbean in view of its economic, food and nutritional value. It contains about 50% oil, 25-30% protein, 20% carbohydrate and 5 % fiber and ash which make a substantial contribution to human nutrition and also a valuable source of vitamins E, K and B. The high-energy value protein content and minerals make groundnut a rich source of nutrition at a comparatively low price. About two third of world production is crushed for oil and remaining one third is consumed as food. It also fetches higher price in the international commodity market. It is a richest plant source of thiamine and niacin, which is low in cereals. The plant, kernels, oil and cake are economically used in one or the other way.

Among micronutrients, Fe was the first nutrient element discovered as essential for plant life. In the plant system, Fe plays an important role in a series of metabolic activities involving respiratory enzymes and various photosynthetic reactions. Iron also plays an important role in legumes for nodulation and nitrogen fixation. It is not only essential element required by legume host plants but also the rhizobium. Failure of the infecting rhizobia to obtain adequate amounts of Fe from the plant results in arrested nodule development and failure of the host plant to fix nitrogen in adequate amounts. Fe application also found to improve the protein content in groundnut kernels. Gris (1844) corrected the chlorosis in grapevine by foliar application of ferrous sulphate thus, establishing the essentiality of Fe for growth and development of higher plants. Iron has been considered to be associated with chlorophyll formation because any of its deficiency in the plant system results in foliar chlorosis.

The extent of Fe deficiency in India is next to that of zinc and seems to be one fourth as extensive as that of zinc (Malewar and Ismail 1995). Iron deficiency is responsible for many severe health complications, including anemia, reduced cognitive ability, childbirth complications, reduced physical capacity and productivity.

Among the several management practices, nutrient supply is one of the most important practices that determine the growth of the crops and ultimately the productivity. The practice of continuous addition of large amount of high analysis fertilizers with much decreased use of organic manures, little recycling of crop residues depletes organic matter in top soil. These affect the physico-chemical properties of soil which leads to micronutrient hunger in crops. The need of the micronutrient has been essentially and entirely met through its native reserve of the soil and thereby decreases the crop yield. Presently, the deficiency of zinc followed by iron has become wide spread and ranks next to N, P and K.

Hence, the present investigation was carried out to assess the performance of groundnut genotypes with respect to leaf area index, kernel yield, shelling percentage and iron uptake as influenced by ferti-fortification.

MATERIALS AND METHODS

Experimental Details and Treatments

Experimental Details: The research experiment was undertaken in 2014-15 at Agronomy field unit, College of Agriculture, Univerity of Agricultural Sciences (UAS), Raichur. The soil of the experimental site was deep black soil, clay in texture (sand 23.5%, silt 27.5% and clay 49.2%) with a bulk density of 1.30 Mg m^{-3} having pH 8.4. The soil was low in available N (231 kg ha^{-1}), medium in available P_2O_5 (27.3 kg ha^{-1}) high in available K_2O (345 kg ha^{-1}) and deficient in zinc and iron with DTPA extractable value of 0.45 and 3.72 ppm, respectively. An amount of 48.7 mm rainfall was received during crop growth period (November 2014 to March 2015).

Treatments: The experiment was conducted in split plot design having three replications with three groundnut genotypes (ICGV-00351, K-9 and TMV-2) in the main plots and seven micronutrient treatments *viz.*, control (no micronutrient- only recommended dose of fertilizer + FYM @ 10 tones ha^{-1}), soil application of $ZnSO_4$ @ 25 kg ha^{-1}, foliar application of $ZnSO_4$ @ 0.5% at 30 and 45 DAS, soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar application of $ZnSO_4$ @ 0.5% at 30 and 45 DAS, soil application of $FeSO_4$ @ 25 kg ha^{-1}, foliar application of $FeSO_4$ @ 0.5% at 30 and 45 DAS, soil application of $FeSO_4$ @ 25 kg ha^{-1} + foliar application of $FeSO_4$ @ 0.5% at 30 and 45 DAS) in the sub-plots.

(I) TMV-2

TMV-2 is a Spanish bunch type with light green color foliage, small to medium size pod without beak. It is most suited for summer season and has a shelling turnover of 76% and oil content of 49.7%. The crop duration is about 100-105 days. This is the most popular and widely grown variety in Andhra Pradesh. But, it is highly susceptible to iron chlorosis. Its yield potential is 1600-2000 kg ha^{-1}. It is drought-tolerant variety.

(II) K-9

K-9 is also known as MK-374. This variety was released from ANGRAU, Kadiri in 2009. It matures in 115-125 days. Plant height is 18 – 23 cm. It has two seeded bold pods. Seeds are of medium size and of brownish rose colour. Its seeds contain 43.75% oil and shelling percentage is 76%. It has a yield potential of 2800 to 3500 kg ha^{-1}. It is tolerant to thrips, jassids, nematodes, late leaf spot, rust, dry root rot and collar rot.

(III) ICGV-00351

ICGV-00351 is a spanish bunch type of variety developed by ICRISAT, Patancheru, Telangana. It is also known as CO-2. It matures in 105 to 110 days. Its yield potential is 3800-4000 kg ha^{-1}.

The recommended dose of fertilizer nitrogen, phosphorus and potassium were applied at the rate of 25:75:25 kg N, P_2O_5 and K_2O ha^{-1} in the form of 12:36:12, a complex fertilizer. The entire quantity of fertilizer was applied at the time of sowing in the furrows opened with 5 cm spacing away from the seed line and later the furrows were covered with soil. Zinc as $ZnSO_4$ @ 25 kg ha^{-1} and iron as $FeSO_4$ @ 25 kg ha^{-1} were applied to the respective plots as per the treatments at the time of sowing. Foliar application of $ZnSO_4$ @ 0.5% and $FeSO_4$ @ 0.5% at 30 and 45 DAS were applied as per the treatments. Zinc and iron each @ 2.25 kg ha^{-1} were dissolved in 450 liters of water and sprayed using power sprayer. FYM was uniformly applied over all the treatments.

Groundnut seeds were treated with *Trichoderma,* Rhizobium and phosphate solubilizing bacteria @ 4 g, 2.5 kg and 2.5 kg ha^{-1}, respectively. Gypsum as a soil application was applied at the rate of 500 kg ha^{-1} at 35 DAS. The furrows were opened with the help of a wooden marker. The seeds were hand dibbled and covered by soil. The sowing operation was carried on 19th November, 2014 at a spacing of 30 × 10 cm. All the genotypes were harvested on 18th March 2015. Shelling was done manually. Bold and healthy seeds of groundnut (TMV-2, K-9 and ICGV-00351) were selected for sowing. Seeds were weighed separately for each plot at the rate of 125 kg ha^{-1} (TMV-2 and K-9) and 150 (ICGV-00351) kg ha^{-1}. The seeds were winnowed, cleaned and the seed weight per net plot was recorded on hectare basis and expressed in kg ha^{-1}.

Method of measuring Leaf area index (LAI)

Leaf area index (LAI) was worked out by dividing the leaf area per plant by land area occupied by the plant (Sestak *et al.* 1971).

$$LAI = \frac{A}{P}$$

Where,

A = Leaf area per plant (dm^2)

P = Land area occupied by the plant (dm^2)

Method of measuring Shelling percentage

From each net plot produce, 100 g of cleaned pods were weighed and the kernels obtained after shelling were also weighed. The shelling percentage was worked out by the following formula:

$$\text{Shelling percentage} = \frac{\text{Kernel weight}}{\text{Pod weight}} \times 100$$

Method of measuring Kernel yield (kg ha^{-1})

The kernel yield was worked out by the following formula:

Kernel yield (kg ha^{-1}) =

$$\frac{\text{Shelling percentage}}{100} \times \text{Pod yield (kg ha}^{-1}\text{)}$$

Method for analysis of iron uptake by plant

The zinc and iron concentration (ppm) in plant sample was determined by taking a known volume of the digested samples by adopting Atomic Absorption Spectrophotometer (AAS) method as described by Follett and Lindsay (1969).

RESULTS AND DISCUSSION

Performance of groundnut genotypes

Groundnut genotypes exhibited significant influence on leaf area index at harvest. Among the genotypes, ICGV-00351 recorded significantly higher leaf area index (1.79 at harvest) as compared to TMV-2 (1.46 at harvest) but on par with K-9 (1.71 at harvest).

Table 1: Leaf area index, Kernel yield and Shelling percentage of groundnut genotypes at harvest as influenced by ferti-fortification

Micronutrient application	Leaf Area Index				Kernel yield (kg ha^{-1})				Shelling (%)			
	Genotypes											
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1: Control (RDF+ FYM)	0.93	1.03	1.22	1.06	937	1529	1676	1381	64.47	69.96	67.73	67.39
S_2: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	1.48	1.93	2.37	1.93	1514	1763	2170	1816	68.87	72.16	75.21	72.08
S_3: Foliar application of $ZnSO_4$ @ 0.5%	1.20	1.87	1.93	1.67	1262	1668	1888	1606	70.77	64.95	73.81	69.84
S_4: Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar application of $ZnSO_4$ @ 0.5%	2.09	2.21	2.00	2.10	1743	2312	2099	2051	67.80	78.07	73.77	73.21
S_5: Soil application of $FeSO_4$ @ 25 kg ha^{-1}	2.36	1.18	1.02	1.52	1571	1696	1883	1717	68.47	69.50	74.64	70.87
S_6: Foliar application of $FeSO_4$ @ 0.5%	0.80	1.68	1.66	1.38	1374	1675	1604	1551	67.47	70.80	70.30	69.52
S_7: Soil application of $FeSO_4$ @ 25 kg ha^{-1} + foliar application of $FeSO_4$ @ 0.5%	1.34	2.09	2.38	1.94	1527	2039	2220	1929	69.60	73.41	73.94	72.32
Mean	**1.46**	**1.71**	**1.79**	—	**1418**	**1812**	**1934**	—	**68.21**	**71.26**	**72.77**	—

	S.Em±	C. D. at 5%	S.Em±	C. D. at 5%	S.Em±	C. D. at 5%
Genotypes (M)	0.07	0.17	50	196	0.82	3.21
Micronutrients application (S)	0.19	0.27	72	208	1.27	3.66
S×M	0.30	NS	125	NS	2.21	NS
M×S	0.31	NS	126	NS	2.20	NS

M_1- TMV-2, M_2 - K-9, M_3 - ICGV-00351, NS - Non significant, foliar application at 30 and 45 DAS.

Significantly higher kernel yield and shelling percentage (1934 kg ha^{-1} and 72.77%) was recorded in genotype ICGV-00351 as compared to TMV-2 (1418 kg ha^{-1} and 68.21%) and it was on par with K-9 (1812 kg ha^{-1} and 71.26%). The increase in number of pods, pod weight, 100 kernel weight, shelling percentage and kernel yield with the genotypes, ICGV-00351 and K-9 may be attributed to the increased growth and more branching as a consequence of more surface area available for vegetative and reproductive sites as compared to TMV-2 which led to increased assimilation and accumulation of photosynthates for the formation of yield attributes. The genotype TMV-2 was found to be poor yielder because of its poor growth and canopy make-up. The yield is final expression of growth plant during course of its development. The poor growth, development and lower yield attributes recoded in TMV-2 genotype contributed for lower yields. Results obtained by Thorat *et al.* (1989), Adhikari *et al.* (2003) and Samui *et al.* (2004) also corroborate the findings of present investigation who reported higher kernel and pod yield of groundnut genotypes.

Significant difference in Fe uptake by kernels, haulm and their total uptake was observed among the groundnut genotypes. ICGV-00351 recorded significantly higher uptake of Fe in kernels and haulm (357.12, 517.71 and 874.83 g ha^{-1}, respectively) compared to TMV-2 (257.69, 439.13 and 696.82 g ha^{-1}, respectively). However, it was found on par with K-9 with respect to Fe uptake in kernels (331.48 g ha^{-1}). This might be due to positive responsive of genotype ICGV-00351 to Fe application. The increased Fe nutrition seemed to improve the metabolic activities of plant resulting in a significant increase in the Fe uptake.

Effect of micronutrients application

Different micronutrients application caused significant differences in the leaf area index at harvest. Significantly higher leaf area index (2.10

Table 2: Iron uptake by groundnut genotypes as influenced by ferti-fortification

Micronutrient application	Iron uptake (g ha^{-1})											
	Kernel				Haulm				Total (kernel+haulm) uptake			
	Genotypes											
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1: Control (RDF+ FYM)	180.75	300.71	325.93	269.13	377.98	441.80	495.17	438.32	558.73	742.51	821.11	707.45
S_2: Soil application of $ZnSO_4$@ 25 kg ha^{-1}	237.09	263.22	340.04	280.12	393.76	451.30	379.32	408.13	630.85	714.52	719.36	688.24
S_3: Foliar application of $ZnSO_4$ @ 0.5%	179.08	247.75	295.85	240.89	328.88	364.99	396.48	363.45	507.96	612.74	692.33	604.34
S_4: Soil application of $ZnSO_4$@ 25 kg ha^{-1} + foliar application of $ZnSO_4$@ 0.5%	253.78	340.72	290.14	294.88	387.97	387.89	457.26	411.04	641.75	728.61	747.40	705.92
S_5: Soil application of $FeSO_4$@ 25 kg ha^{-1}	331.80	364.25	415.39	370.48	298.29	418.57	493.46	403.44	630.09	782.82	908.85	773.92
S_6: Foliar application of $FeSO_4$ @ 0.5%	285.83	350.53	338.56	324.97	439.08	495.47	740.46	558.34	724.92	845.99	1079.02	883.31
S_7: Soil application of $FeSO_4$@ 25 kg ha^{-1} + foliar application of $FeSO_4$@ 0.5%	335.53	453.21	493.95	427.56	847.92	595.12	661.82	701.62	1183.45	1048.32	1155.77	1129.18
Mean	**257.69**	**331.48**	**357.12**	**—**	**439.13**	**450.73**	**517.71**	**—**	**696.82**	**782.22**	**874.83**	**—**

	Kernel S.Em±	Kernel C. D. at 5%	Haulm S.Em±	Haulm C. D. at 5%	Total S.Em±	Total C. D. at 5%
Genotypes (M)	9.75	38.29	10.18	39.96	18.45	55.67
Micronutrients application (S)	15.35	44.01	28.88	82.82	30.28	91.23
S × M	26.58	NS	50.02	NS	53.45	NS
M × S	26.47	NS	47.41	NS	53.89	NS

M_1- TMV-2, M_2 - K-9, M_3 - ICGV-00351, NS - Non significant, foliar application at 30 and 45 DAS

at harvest) was recorded with soil (25 kg ha^{-1}) and foliar (0.5 %) application of $ZnSO_4$ (S_4) as compared to the other treatments. However, it was found on par with soil (25 kg ha^{-1}) and foliar (0.5%) application of $FeSO_4$ (1.94 at harvest) (S_7) and soil application of $ZnSO_4$ @ 25 kg ha^{-1} (1.93) at harvest. Leaf area index which depends on the leaf area per plant can be widely changed by manipulating cultural practices.

The kernel yield differed significantly due to micronutrients application. Significantly higher kernel yield was recorded with soil (25 kg ha^{-1}) and foliar (0.5 %) application of $ZnSO_4$ (S_4) (2051 kg ha^{-1}) over other treatments *viz.*, control (1381 kg ha^{-1}), soil application of $ZnSO_4$ (1816 kg ha^{-1}), foliar application of $ZnSO_4$ (1606 kg ha^{-1}), soil application of $FeSO_4$ (1717 kg ha^{-1}) and foliar application of $FeSO_4$ (1551 kg ha^{-1}). However, it was on par with soil (25 kg ha^{-1}) and foliar (0.5%) application of $FeSO_4$ (1929 kg ha^{-1}) (S_7). The difference in performance in yield attributes due to treatments could be due to variations in translocation of photosynthates from vegetative to reproductive parts. Improvement in soil fertility and productivity due to application of organic manures and micronutrients might have supported more number of pods and increased the number of pods and pod weight. These results are in conformity with the findings of Singh (2007) and Marious *et al.* (2011) who observed higher yield and yield parameters due to soil and foliar application of micronutrients in groundnut.

Among micronutrients application, soil (25 kg ha^{-1}) and foliar (0.5%) application of $ZnSO_4$ (S_4) recorded significantly higher shelling percentage (73.21%) as compared to control (67.39%) and foliar application of $FeSO_4$ (69.52%). However, it was found on par with other treatments.

Different micronutrient applications significantly influenced the uptake of Fe in kernels, haulm and their total uptake. Significantly higher uptake of Fe in kernels, haulm and total uptake of Fe in groundnut was recorded with soil (25 kg ha^{-1}) and foliar (0.5 %) application of $FeSO_4$ (427.56, 701.62 and 1129.18 g ha^{-1}, respectively) over other treatments. This might be due to synergistic effect between Fe and Zn. Higher Fe uptake under Zn application was due to their increased concentration in kernels and haulm coupled with more kernel and haulm yields.

CONCLUSION

Among the genotypes, ICGV-00351 gave best response to zinc and iron application through soil (25 kg ha^{-1}) and foliar (0.5%) application of $ZnSO_4$ at 30 and 45 DAS as compared to TMV-2 and it was comparable with K-9. Soil (25 kg ha^{-1}) and foliar (0.5 %) application of $ZnSO_4$ at 30 and 45 DAS was found to be more effective in increasing LAI, kernel yield, shelling percentage, net returns and BC ratio. Whereas, uptake of Fe in kernels, haulm and their total uptake. Significantly higher uptake of Fe in kernels, haulm and total uptake of Fe in groundnut was recorded with soil (25 kg ha^{-1}) and foliar (0.5%) application of $FeSO_4$ (427.56, 701.62 and 1129.18 g ha^{-1}, respectively) over other treatments.

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