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Effect of integrated nitrogen management and foliar spray of iron on groundnut yield, quality and economics in arid region

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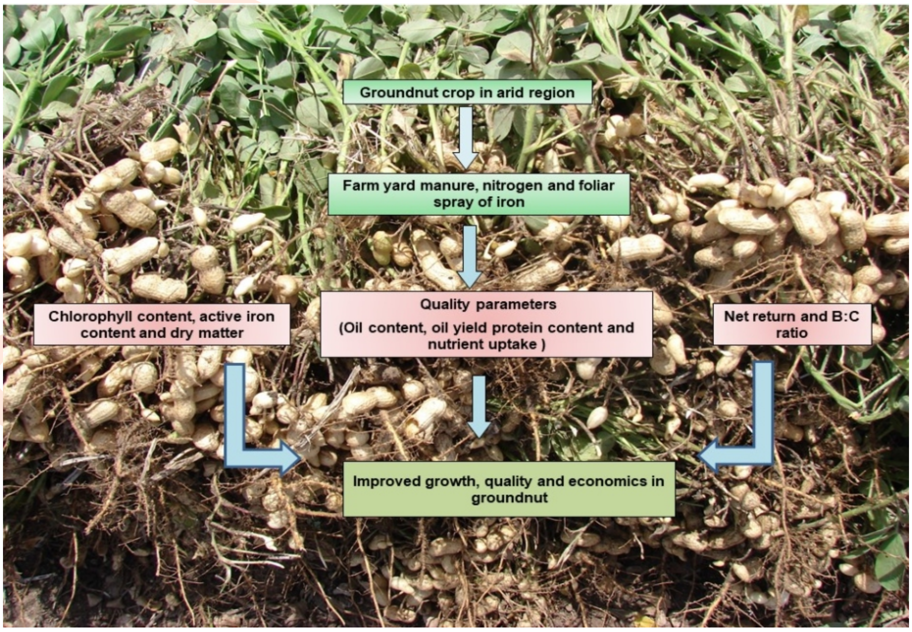
Abstract

Aim: This experiment was conducted to find out appropriate technical intervention for integrated management of nitrogen and iron chlorosis in irrigated groundnut in arid regions.

Methodology: Two levels of farmyard manure, five levels of nitrogen and three levels of iron spray were applied in irrigated groundnut. Chlorophyll content, active iron content, periodic dry matter accumulation, oil content and yield, protein content and nutrient uptake by groundnut were studied. Most effective level of farmyard manure, nitrogen application and iron spray were identified for optimum management of the resources.

Results: The results showed that application of farmyard manure @ 15 t ha^{-1}, nitrogen @ 60 kg ha^{-1} in two or three splits and foliar spray of $FeSO_4$ @ 1.0 % in combination with citric acid @ 0.1% was found supportive in correcting iron chlorosis by increasing chlorophyll and active iron content, improving oil content and yield, protein content and nutrient uptake and ultimately enhancing net return by groundnut under irrigated conditions.

Interpretation: Farmyard manure, higher dose of nitrogen in split application and foliar spray of iron is helpful in correcting iron chlorosis, improving growth, quality and nutrient uptake and increasing income of groundnut growers under irrigated condition in arid regions.



Key words: Arid region, Chlorophyll, Farm yard manure, Groundnut, Iron chlorosis

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Introduction

Indian agriculture is a gamble of monsoon and crop failure due to erratic rainfall is most common in arid regions. As these regions contributes nearly half of the national food grain production, where around 90% of sorghum and millets and about two third of oilseeds and three fourth of pulses are grown. This region is important for the economy of the country and likely to continue till turn of the century and even beyond (Rosegrant *et al*. 2002). Status of organic carbon and available nitrogen content in majority of the soils is very low. Improper nitrogen management and iron chlorosis, especially in calcareous soils of arid region of Rajasthan mainly affect the productivity of groundnut crop due to low nutrient uptake from hunger soils of this region. Therefore, integrated nutrient management along with soil test based fertilization will serve the purpose for practicing sustainable groundnut production in the region.

The domestic demand for vegetable oils and fats has been rising rapidly, @ 6 per cent per annum, but our domestic output has been increasing at just about 2 per cent per annum. In India, the average yield of most oilseeds are extremely low as compared to other countries of the world. Among nine major oilseeds crops, groundnut (*Arachis hypogaea* L.) occupies a pre-eminent position in the national edible oil economy. India ranks first in acreage and second in production of groundnut in the world, after China (FAOSTAT, 2018). Groundnut is the 3rd most important oilseed crop of the world cultivated in 96 countries in tropical, sub-tropical, and warm temperate regions of the world (Rai *et al*., 2016). In India, there is great fluctuation in production from year to year, whereas area remaining almost constant under the crop. Groundnut ranks third position among oilseeds in India after soybean and rapeseed-mustard, occupying 4.91 M ha area producing 9.18 Mt with average productivity of 1868 kg ha^{-1} (Anonymous, 2018). Groundnut containing one and half times more protein requires more nitrogen than cereals for its growth. As a legume, it can fix atmospheric nitrogen and improve soil fertility by adding about 150 kg N ha^{-1} to soil through its root nodules (Seymour *et al*., 2015). The demand of nitrogen for groundnut is large in the synthesis of seeds with high protein concentration (Pradhan *et al.,* 2020). Though, it is called as a self-fertilizing crop, it is very exhaustive crop as compared to other legumes as very little portion of the plant is left in the soil after harvesting. It removes fairly large quantities of nutrients from the soil. Cultivation of groundnut, therefore, depletes the soil rapidly unless the crop is adequately manured, although it is capable of fixing atmospheric nitrogen. Widespread occurrence of yellowing due to iron deficiency is also being observed in several crops including groundnut mainly grown on high pH calcareous soils in arid regions and irrigated with high bicarbonate containing water and this is particularly true for the coarse textured soils. Probably, the crop may be suffering from hidden hunger for iron and, thus, are not able to express their potential productivity. Depending upon the management practices, the yield losses due to iron-chlorosis in groundnut, in India, was 20 to 41 %, which is a very high amount and has to be looked seriously (Singh *et al*. 2003).The problem gets enhanced in light textured calcareous soils with low organic matter content and alkaline reaction, which are common features in arid Rajasthan. Demand for edible oil is increasing day by day which can only be met out by increased oilseed production in the country. The present experiment was carried out to delineate the effect of integrated nitrogen management and foliar spray of iron on productivity, quality and economics of groundnut in arid regions.

Materials and Methods

A field experiment was conducted at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner. The region enjoys a typical arid climate characterized by extremes of temperature both in summer and winter with average annual rainfall of about 250 mm mostly received in rainy season from July to September. The soils of the experimental fields were sandy in texture, slightly alkaline (pH 8.4 and 8.3) in reaction, low in organic carbon (0.12 and 0.15), available nitrogen (79.7 and 83.2 kg ha^{-1}) and available phosphorus (14.8 and 15.9 kg ha^{-1}), medium in available potassium (186 and 202 kg ha^{-1}) and deficient in DTPA extractable iron (3.72 and 3.94 ppm).

The experiment was laid out in split plot design with three replications. The treatments consisted of 2 levels of farm yard manure (FYM) (M_0 = No FYM and M_1 = 15 t FYM ha^{-1}) and 5 levels of nitrogen viz.,N_0 = Control, N_1 = 20 kg N ha^{-1} whole as basal, N_2 = 40 kg N ha^{-1}(½ as basal and ½ top dressed at 30 days after sowing, (DAS), N_3 = 60 kg N ha^{-1}(½ as basal and ½ top dressed at 30 DAS) and N_4 = 60 kg N ha^{-1}, ($^1/_3$ as basal, $^1/_3$ top dressed at 30 DAS and $^1/_3$ top dressed at 60 DAS) were randomly allotted to main plots and 3 levels of foliar spray of iron (F_0 = Control, F_1 = two sprays of $FeSO_4$ @ 1.0 % at 30 and 40 DAS and F_2 = two sprays of $FeSO_4$ @ 1.0 % with citric acid @ 0.1 % at 30 and 40 DAS) to sub plots. FYM and nitrogen through urea were applied as per treatments at the time of sowing of groundnut in both seasons.

Differential treatment effects were delineated by recording chlorophyll content (Arnon, 1949) and active iron content (Katyal and Sharma, 1980) in fresh leaves at 30 and 50 DAS. Five plants were randomly uprooted from the sampling rows in each plot at 30, 60, 90 DAS and at harvesting stage. After removing the root portion and sun drying in paper bags for 2-3 days and finally in an electric oven at 70ºC for 24 hr till constant weight, the samples were weighed on an electronic balance. The mean weight per plant was worked out and recorded as dry matter (g) per plant. Oil content in the kernels from each treatment was determined with the help of Soxhlet apparatus using petroleum ether (60-80º C) as an extractant (AOAC, 1960). Oil yield was calculated by the following formula:

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%) x pod yield (kg ha}^{-1}\text{) x shelling\%}}{100 \times 100}$$

The per cent crude protein content in kernels was estimated by the following formula:

Crude protein percent = N content in kernels (%) x 5.46

Since globulins contain 18.3 % N, the conversion factor for protein content (of oilseeds and particularly groundnuts) was taken as 5.46 (Jones, 1931). The uptake of nitrogen, phosphorus, potassium and iron at harvest in kernel, haulm and shell were estimated by the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) in kernel/haulm/shell x kernel/haulm/shell yield (kg ha}^{-1}\text{)}}{100}$$

To find the most profitable treatment, cost economics of different treatments was worked out in terms of net return (Rs. ha^{-1}) on the basis of prevailing market rates. Treatment wise benefit: cost ratio (B : C ratio) was calculated to ascertain economic viability of each treatment by dividing gross return with the cost of cultivation. The results were analyzed statistically using split plot experimental design by Analysis of Variance (ANOVA) through MS Excel worksheet.

Results and Discussion

Data presented in Table 1 show that application of FYM @ 15 t ha^{-1} increased the chlorophyll and active iron content of groundnut leaves significantly at 30 and 50 DAS over control by 14.04 and 13.10 per cent and 22.23 and 33.83 per cent, respectively. Application of FYM @ 15 t ha^{-1} also increased periodic dry matter accumulation significantly by 3.53, 11.20, 12.35 and 13.11 per cent, respectively at 30, 60, 90 DAS and at harvest over control. In this study, FYM enhanced the supply of major and micro nutrients and energy in terms of carbon through optimum mineralization. Thus, such a favourable environment in the root zone coupled with higher chlorophyll content and nodule growth must have stimulated photosynthesis and growth of seedlings and resulted in significant improvement in these growth parameters. Similar results were also reported by Rahevar *et al.* (2015) and Ravichandra *et al*. (2015). The growth improvement could be attributed to continuous availability of nutrients, growth promoting effect of vermicompost, ultimately leading to enhanced photosynthetic activities, cell division and cell elongation, carbohydrate as well as metabolic process (Murugan *et al.*, 2020). Significant improvement in chlorophyll content of groundnut leaves and dry matter accumulation at the observation dates was recorded up to 60 kg N ha^{-1} applied in two or three splits. Application of 60 kg N ha^{-1} in two splits recorded the highest chlorophyll content, which was significantly higher over control by

Table 1 : Effect of integrated nitrogen management and foliar spray of iron on chlorophyll content (mg g^{-1}), active iron content of fresh leaves (mg kg^{-1}) and dry matter accumulation (g plant^{-1})

Treatment	Chlorophyll content		Active iron content		Dry matter accumulation			
	30 DAS	50 DAS	30 DAS	50 DAS	30 DAS	60 DAS	90 DAS	Harvest
Farm yard manure								
M_0	5.34	5.80	38.47	54.65	1.730	17.15	33.13	46.13
M_1	6.09	6.56	47.02	73.14	1.791	19.07	37.22	52.18
S.Em.+	0.04	0.04	0.22	0.21	0.014	0.25	0.52	0.69
C.D. (p = 0.05)	0.12	0.12	0.64	0.61	0.040	0.71	1.48	1.99
Nitrogen								
N_0	5.14	5.39	42.24	63.40	1.631	12.74	24.89	34.96
N_1	5.73	5.97	42.52	63.67	1.737	16.44	32.26	45.29
N_2	5.78	6.39	42.79	63.96	1.760	19.28	37.83	51.90
N_3	6.13	6.74	42.99	64.12	1.890	21.70	40.94	56.49
N_4	5.80	6.42	43.17	64.32	1.785	19.88	39.95	57.15
S.Em.+	0.07	0.07	0.35	0.34	0.022	0.39	0.82	1.10
C.D. (p = 0.05)	0.19	0.19	NS	NS	0.064	1.12	2.34	3.15
Iron spray								
F_0	5.70	5.46	42.59	50.58	1.729	16.55	32.03	43.67
F_1	5.71	6.25	42.86	64.97	1.765	18.13	35.17	49.39
F_2	5.73	6.83	42.77	76.13	1.788	19.65	38.33	54.42
S.Em.+	0.04	0.04	0.20	0.20	0.022	0.29	0.65	1.04
C.D. (p = 0.05)	NS	0.13	NS	0.55	NS	0.82	1.82	2.92

M_0 = No FYM, M_1 = 15 t FYM ha^{-1} N_0 = Control, N_1 = 20 kg N ha^{-1} (whole as basal), N_2 = 40 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_3 = 60 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_4 = 60 kg N ha^{-1} ($^1/_3$ as basal, $^1/_3$ top dressed at 30 DAS and $^1/_3$ top dressed at 60 DAS) F_0 = Control, F_1 = two sprays of $FeSO_4$ @ 1.0 % at 30 and 40 DAS F_2 = two sprays of $FeSO_4$ @ 1.0 % with Citric Acid @ 0.1 % at 30 and 40 DAS

19.26 and 25.05 per cent, respectively (Purbajanti *et al*., 2018). Application of increasing levels of nitrogen progressively and significantly increased dry matter accumulation up to 60 kg N ha^{-1} applied in two splits at all stages, except at 30 DAS. When compared with the dry matter production of 34.96 g $plant^{-1}$ recorded under control at harvest, application of 60 kg N ha^{-1} in two splits increased it significantly by 61.58 per cent at this stage. The overall improvement in crop growth under the influence of nitrogen fertilization might be broadly attributed to the availability of better nutritional environment in the rhizosphere as well in the plant system. Increased supply of nitrogen increased the formation of chloroplasts, number of grana and quantasomes as it is the constituent of chlorophyll molecule. Therefore, application of higher rates of nitrogen @ 60 kg N ha^{-1} provided greater photosynthetic surface to intercept more radiant energy compared with control (Barik *et al*., 1994 and Kakati and Sarmah, 1995) and improved the capacity of plants to utilize available nutrients and net photosynthesis. Application of nitrogen did not improve the active iron content of groundnut significantly at both the stages. Chlorophyll and active iron content at 50 DAS and dry matter accumulation at 60, 90 DAS and at harvest significantly increased in response to foliar spray of $FeSO_4$ @ 1.0 % + citric acid @ 0.1 % by 25.09 and 50.51 per cent and 18.73, 19.67 and 24.62 per cent over control, respectively. The higher content of active iron in fresh leaves treated with $FeSO_4$ in integration with citric acid could be ascribed to the fact that it is absorbed and translocated more efficiently in its citrate form due to its improved solubility within the plants (Rogers and Shive, 1932) on one hand and, faster movement of negatively charged Fe citrate complex through xylem (Tiffin, 1967) on the other. Besides, anions of citric acid are known to induce photochemical reduction of Fe^{3+} (Abadia *et al.,* 1984), which is a prerequisite for Fe uptake by leaf disks. The concentration of chlorophyll in leaves is directly related to the level of iron supply to the plants. Kulkarni *et al.* (1994) also observed highly significant positive correlation between chlorophyll content and active iron content. It has been suggested that iron is not directly involved in the biosynthesis of chlorophyll but it is required indirectly as it controls the formation of its precursor d-amino livulenic acid (Marchner, 1986). Significant improvement in the chlorophyll content with foliar spray of iron was reported by Singh *et al.* (2001). Akhtar *et al.* (2019) also reported increased photosynthetic rate, transpiration rate, SPAD values and active Fe concentration in Fe deficiency groundnut cultivar with foliar application of iron through various sources.

The study (Table 2) revealed that application of farm yard manure increased the oil content, oil yield and protein content in groundnut significantly. The quantum of increase in these parameters under the influence of farm yard manure application was to the tune of 6.36, 15.02 and 6.49 per cent, respectively. Better CO_2 production and greater exchange of ions that enhanced the mobility of nutrients under this treatment led to favourable environment in the plant system, thereby increased oil content of groundnut. Similar findings was also reported by Ismail *et al.* (1998) and Rao and Shaktawat (2001). Since, crude protein content of seed is essentially a manifestation of N content, the

Table 2 : Effect of integrated nitrogen management and foliar spray of iron on quality parameters of groundnut

Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Protein content (%)
Farm Yard Manure			
M_0	47.77	1445	17.72
M_1	50.81	1662	18.87
S.Em.+	0.29	27	0.08
C.D. (p = 0.05)	0.84	79	0.22
Nitrogen			
N_0	48.59	1066	16.20
N_1	48.89	1385	17.65
N_2	49.42	1617	18.64
N_3	49.67	1821	19.35
N_4	49.90	1876	19.64
S.Em.+	0.46	43	0.12
C.D. (p = 0.05)	NS	125	0.34
Iron Spray			
F_0	47.68	1396	17.67
F_1	49.24	1551	18.31
F_2	50.96	1713	18.91
S.Em.+	0.30	26	0.09
C.D. (p = 0.05)	0.84	74	0.25

M_0 = No FYM, M_1 = 15 t FYM ha^{-1} N_0 = Control, N_1 = 20 kg N ha^{-1} (whole as basal), N_2 = 40 kg N ha^{-1} (½ as basal and ½ top dressed at 30 days after sowing, DAS), N_3 = 60 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_4 = 60 kg N ha^{-1} ($^1/_3$ as basal, $^1/_3$ top dressed at 30 DAS and $^1/_3$ top dressed at 60 DAS) F_0 = Control, F_1 = two sprays of $FeSO_4$ @ 1.0 % at 30 and 40 DAS and F_2 = two sprays of $FeSO_4$ @ 1.0 % with Citric Acid @ 0.1 % at 30 and 40 DAS increased kernel N content under the influence of farm yard manure led to higher crude protein content in kernel. Findings of this investigation are in close conformity with those of Lognathan *et al*. (1996). Application of nitrogen, by and large, had a slight tendency to improve the oil content in groundnut but the improvement was found to be statistically non-significant. Application of increasing levels of nitrogen increased the oil yield and protein content progressively and significantly up to the level of 60 kg ha^{-1} applied in two splits and the magnitude of increase was 755 kg ha^{-1} and 3.15 per cent, respectively, over control. The increase in oil yield as a result of increased kernel yield due to nitrogen application in groundnut has also been noted by Barik and Mukherjee (1997) and Gogoi *et al.* (2000). Increased nitrogen concentration in kernel has increased the synthesis of crude protein in groundnut kernel. This study corroborates the results of Siam *et al.* (2015). Data (Table 2) further indicated that foliar spray of $FeSO_4$ @ 1.0 % applied alone or in combination with citric acid @ 0.1 % improved the oil content, oil yield and protein content over control significantly by 3.27 and 6.88 per cent, 11.10 and 22.71 per cent and 3.62 and 7.02 per cent, respectively. It is evident that iron is important in redox system in the process of photosynthesis as a constituent of a number of enzymes in the development and function of chloroplast, protein synthesis which resulted in positive effect of iron spray on these parameters.

The data given in Table 3 showed that application of FYM increased the uptake of nitrogen, phosphorus, potassium and iron by groundnut significantly and the extent of increase was 16.68, 13.07, 14.62 and 17.36 per cent, respectively when compared with un-manured plots. Increased availability of nutrients in the root zone coupled with increased metabolic activity at cellular level probably might have increased the uptake and accumulation of these nutrients in the various plant parts. Integrated management of nitrogen plays effective role, in general, on plant vigor contribution, particularly which are related to root development, water and nutrient uptake (Selim, 2020). It appears that organic acids produced from farm yard manure as a source of organic substances may be partly responsible for quick release of nutrients, which resulted into more uptake of nutrients (Mehta *et al*., 1996). Data (Table 3) indicated that increasing levels of nitrogen brought about progressive and significant improvement in nitrogen, phosphorus, potassium and iron uptake. Application of nitrogen @ 60 kg ha^{-1} in two splits recorded uptake of nitrogen, phosphorus, potassium and iron to the levels of 188.9 kg ha^{-1}, 34.31 kg ha^{-1},141.5 kg ha^{-1} and 3989 ppm ha^{-1}, respectively, which were significantly higher over control by 90.62, 81.25, 78.66 and 90.32 per cent, respectively. Overall improvement in the availability of nitrogen due to its application, increased nodulation which interacted favourably with general supply of phosphorus created a better nutritional environment in the crop root zone. Since nutrient uptake is a function of nutrient content of plant parts and total dry mass of the crop in terms of pod and haulm yields, split application of nitrogen up to 60 kg ha^{-1} increased the uptake of nitrogen, phosphorus, potassium and iron at harvest significantly. Singh *et al.* (2013) reported that application of organics and inorganics resulted in better soil pH,

Table 3 : Effect of integrated nitrogen management and foliar spray of iron on total uptake of nutrients by groundnut

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Iron (ppm)
Farm yard manure				
M_0	145.1	27.16	111.5	3053
M_1	169.3	30.71	127.8	3583
S.Em.+	1.75	0.30	1.14	38
C.D. (p = 0.05)	5.02	0.86	3.26	109
Nitrogen				
N_0	99.1	18.93	79.2	2096
N_1	135.4	25.31	105.7	2838
N_2	164.0	30.18	125.2	3443
N_3	188.9	34.31	141.5	3989
N_4	198.6	35.94	146.7	4223
S.Em.+	2.77	0.47	1.80	60
C.D. (p = 0.05)	7.93	1.36	5.16	172
Iron spray				
F_0	143.2	27.11	112.1	2918
F_1	157.3	28.98	120.1	3325
F_2	171.1	30.72	126.8	3710
S.Em.+	2.06	0.35	1.36	44
C.D. (p = 0.05)	5.78	1.00	3.81	122

M_0 = No FYM, M_1 = 15 t FYM ha^{-1} N_0 = Control, N_1 = 20 kg N ha^{-1} (whole as basal), N_2 = 40 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_3 = 60 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_4 = 60 kg N ha^{-1} ($^1/_3$ as basal, $^1/_3$ top dressed at 30 DAS and $^1/_3$ top dressed at 60 DAS) F_0 = Control, F_1 = two sprays of $FeSO_4$ @ 1.0 % at 30 and 40 DAS F_2 = two sprays of $FeSO_4$ @ 1.0 % with Citric Acid @ 0.1 % at 30 and 40 DAS

Table 4 : Effect of integrated nitrogen management and foliar spray of iron on economics of groundnut (combined effect) Mean over two years of study

Treatments		Net return			B: C ratio		
		F_0	F_1	F_2	F_0	F_1	F_2
M_0	N_0	16093	19957	24206	1.692	1.840	2.001
	N_1	27729	34215	39602	2.181	2.428	2.622
	N_2	39170	44223	48226	2.643	2.817	2.946
	N_3	49206	51400	54172	3.045	3.094	3.167
	N_4	52704	53531	55783	3.178	3.167	3.219
M_1	N_0	19767	25619	30322	1.766	1.975	2.134
	N_1	33763	37915	41020	2.298	2.430	2.522
	N_2	42223	45822	48689	2.601	2.705	2.782
	N_3	49305	53057	57566	2.854	2.958	3.090
	N_4	49509	54847	60159	2.851	3.013	3.173

M_0 = No FYM, M_1 = 15 t FYM ha^{-1} N_0 = Control, N_1 = 20 kg N ha^{-1} (whole as basal), N_2 = 40 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_3 = 60 kg N ha^{-1} (½ as basal and ½ top dressed at 30 DAS), N_4 = 60 kg N ha^{-1} ($^1/_3$ as basal, $^1/_3$ top dressed at 30 DAS and $^1/_3$ top dressed at 60 DAS) F_0 = Control, F_1 = two sprays of $FeSO_4$ @ 1.0 % at 30 and 40 DAS F_2 = two sprays of $FeSO_4$ @ 1.0 % with Citric Acid @ 0.1 % at 30 and 40 DAS

physico-chemical properties of soil and instant availability of nutrients which improved photosynthesis and translocation of nutrients towards sink leading to higher contents and uptakes of nutrients. Table 3 further revealed that foliar spray of $FeSO_4$ @ 1.0 % applied in integration with citric acid @ 0.1 % recorded significantly higher nitrogen, phosphorus potassium and iron uptake by 9.85, 13.32, 13.11 and 27.14 per cent, respectively, as compared with control. It might be due to increased availability of physiologically active iron into the plant system that in turn affected various physiological functions of the plant favourably. The increased rate of these physiological functions favoured greater absorption of these nutrients from the soil and translocation of the same to the reproductive structures viz., pods, kernels and other plant parts (Arunachalam *et al.*, 2013).

Combining application of farm yard manure @ 15 t ha^{-1}, nitrogen @ 60 kg ha^{-1} in three splits and foliar spray of $FeSO_4$ @ 1.0 % + citric acid @ 0.1 % recorded the highest net return of Rs. 60159 ha^{-1} which was considerably higher by 274 per cent compared with absolute control and 4.5 per cent in comparison to the same quantity of nitrogen applied in two splits (Table 4). Contrary to this, combining nitrogen and foliar spray of iron at the same rates recorded the highest B:C ratio under plots not manured with farm yard manure. Combining farm yard manure with the above factors of production had reduced the B: C ratio slightly which suggested that it is a costlier input than nitrogen and iron sulphate with respect to monetary output per rupee investment under these inputs. The highest gross, net returns and B: C ratio were obtained by Joshi *et al.* (2019) an application of higher rates of nutrients, *i.e.*, with 125% RDF. Sui *et al.* (2019) also reported significant economic benefits with manure in wheat.

The findings of the present study indicate that application of farm yard manure @15 t ha^{-1}, nitrogen @ 60 kg ha^{-1} in two or three splits and foliar spray of $FeSO_4$ @ 1.0 % + citric acid @ 0.1 % may reduce the chances of iron deficiency and improve the quality of groundnut with greater returns in arid regions.

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