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Effect of INM on Nutrient Concentration and their Uptake under Maize-Blackgram-Groundnut Cropping Sequence in Alfisols

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted at S.V. Agricultural College Farm, Tirupati during rabi (maize) summer (blackgram) and kharif (groundnut) seasons of 2019-20 with a view to study the direct and residual effects of integrated use of inorganic and organic sources of N and P on performance of maize - blackgram- groundnut cropping sequence in terms of yield. In this experiment, Ten treatments viz. control, fertilizers applied at 50, 75 and 100% of the recommended dose (N240P80K80), N240 only, P80 only, FYM (@ 5 t ha^{-1}) applied alone, and in combination with 100%,75% and 50% recommended NPK were applied to maize. These treatments were evaluated in comparison to no-fertilizer and manure controls. Blackgram was produced after maize without the use of fertilizer or manure. It was allowed to grow till maturity, and after two pickings, the stover

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was incorporated into the soil. During succeeding rabi season on the same field black gram was grown for which each main plot treatment of RBD was split into three sub plot treatments with three levels of recommended dose of fertilizers viz., S1 (control), S2 (75% RDF) and S3 (50% RDF) resulting in ninety treatment combinations replicated three times in split plot design. The results revealed that the total N and P uptake in maize varies from 56 - 142 kg/ha and 8.28 - 22.12 kg/ha, in blackgram it varies from 86 – 173 kg/ha and 11.1 – 22.7 kg/ha and in groundnut 75.8 – 126.9 and 9.5 -20.0 kg/ha respectively. The maximum nutrient concentration and uptakes in case of all treatments was found in INM treatments and lowest in T_1 (Control).

Keywords: INM; maize; blackgram; groundnut sequence; N and P uptake.

1. INTRODUCTION

"The excess use of high analysis fertilizers in an unbalanced manner has affected the soil health viz., acidity, alkalinity, the emergence of secondary and micro nutrient deficiencies and deterioration in soil physical environment" [1]. "This was more seen in recent years due to the advent of high yielding varieties (HYVs) which were responsive to chemical fertilizers and increased area under assured irrigation led to a major shift from organic based nutrient application to chemical fertilizers. The rapid spurt in the use of inorganic fertilizers is because of the quick yield responses of crops to their application. In this context, INM holds great promise not only for achieving optimum yields in a cropping system but also protecting soil health against degradation. Therefore, inorganic and organic sources of the nutrient were combined to study the possibility of substitution of N requirement of crops through organic sources and most effective combination of these materials the create impact on soil and plant systems" [1].

2. MATERIALS AND METHODS

Site Description: Field experiments were carried out during rabi, summer and kharif seasons of 2019-20 at S.V. Agricultural Farm, Tirupati, geographically situated at 13.5^o N latitude and 79.5^o E longitude at an altitude of 182.9 meters above mean sea level, categorised as the Southern Agroclimatic Zone of Andhra Pradesh. The soil of experimental site was sandy loam in texture with bulk density of 1.49 Mg m-3, neutral in reaction (pH 6.8), electrical conductivity 0.35 dSm^{-1}, low in organic carbon (0.30 per cent) and low in available nitrogen (95 kg ha^{-1}), medium in available phosphorus (21 kg ha^{-1}) and medium in potassium (162 kg ha^{-1}) [2].

Experimental Design and Treatments: The treatments consisted of integrated nutrient management viz., T_1- control, T_2- FYM @ 5 t ha^{-1}, T_3- 100 RDF, T_4- 75% RDF, T_5- 50% RDF, T_6 – 100% RDN, T_7 – 100% RDP, T_8 – 100% RDF+ FYM @ 5 t ha^{-1} , T_9- 75% RDF + FYM @ 5 t ha^{-1}, T_{10} – 50% RDF+ FYM @ 5 t ha^{-1} to maize

Table 1. Initial properties of the experimental soil

Particulars	Field Number
	50 B
Particle size distribution	
Sand (%)	82.24
Silt (%)	14.16
Clay (%)	3.60
Texture	Sandy loam
pH (1:2.5)	6.70
EC (dSm^{-1})	0.26
Organic C (%)	0.35
CEC [cmol (p+) kg^{-1} soil]	15
Available N (kg ha^{-1} soil)	98
Available P (kg ha^{-1} soil)	25
Available K (kg ha^{-1} soil)	166
Available Fe (ppm)	2.51
Available Mn (ppm)	3.35
Available Cu (ppm)	0.95
Available Zn (ppm)	0.72

in rabi season as main plot treatments replicated three times in randomized block design. Maize hybrid 'Pioneer 3396' was sown on 25th November, 2019 and harvested on march, 12 2020. Blackgram variety 'TBG-104' was grown as residual crop sown after harvest of maize on March 29, 2020 and was allowed to grow till maturity. After two pickings, the stover was incorporated into the soil on June 11, 2020. Groundnut variety 'Dharani' was sown on July 1, 2020 and harvested on October 23, 2020. FYM was incorporated before sowing of maize. The data recorded were statistically analyzed using OPSTAT Software. The purpose of analysis of variance was to determine the significant effect of treatments on maiz – blackgram - groundnut cropping sequence [2].

3. RESULTS AND DISCUSSION

Maize: Data related to N, P and K concentration in given in Table 2 showed that integration of FYM results higher N, P and K concentrations over remaining treatments. N concentration varied from 0.98% (control) to 1.63% in T_9 (100% RDF + FYM@ 5 t ha^{-1}). It was also observed that integration of FYM showed higher increase in N, P and K concentration over rest of the treatments.

Nitrogen: The treatments T_9 (1.75%), T_3 (1.75%), T_8 (1.73%), T_6 (1.70%), T_{10} (1.69%), T_4 (1.68%) and T_7 (1.66%) were found to be at par in terms of high nitrogen (N) content of maize grain. The lowest value was recorded under the treatment T_2 (1.63%), which was statistically similar to T_1 (1.56%) and T_5 (1.60%).The nitrogen content of maize stover lower than that in grain, indicating thereby translocation of nitrogen from the vegetative to the reproductive parts.

The maximum N uptake was observed by treatment T_3 (81 kg ha^{-1}), which was followed by treatments T_8 (79 kg ha^{-1}), T_9 (78 kg ha^{-1}), and treatment T_4 (74 kg ha^{-1}), all of which were on par. The treatments T_2 (33 kg ha^{-1}) and T_1 (32 kg ha^{-1}) were inferior to the treatments T_5 (61 kg ha^{-1}) T_7 (64 kg ha^{-1}) and T_{10} (69 kg ha^{-1}). In terms of nitrogen uptake by grain, smaller nitrogen applications or nitrogen applied only by FYM could not compete with other treatments because they could not provide enough nitrogen to the crop in a soil with low available N status.N intake by maize stover was increased under the T_9 (63 kg ha^{-1}), T_8 (60 kg ha^{-1}), and T_3 (58 kg ha^{-1}) which were not significantly different among themselves. Lowest value of 24 kg ha^{-1} recorded under control (T_1).

The results suggest that the treatment T_9, which involved applying 75% of the recommended dose of fertilizer (RDF) along with farmyard manure (FYM), resulted in the highest total nitrogen uptake by the maize crops (142 kg ha^{-1}). The second-highest nitrogen uptake was observed in treatment T_3 (139 kg ha^{-1}).The nitrogen uptake values were lower under treatments T_2 (65 kg ha^{-1}) and T_1 (56 kg ha^{-1}), and these values were statistically similar. The study indicates that applying nitrogen at the recommended rate led to higher nitrogen content and uptake by the maize crops. This outcome can be attributed to the ability of these treatments to provide a substantial amount of readily available nitrogen to fulfill the crop's demand for this essential nutrient. Additionally, the application of phosphorus alongside nitrogen appeared to enhance nitrogen uptake by the maize crops through a synergistic effect. This suggests that the combination of phosphorus and nitrogen contributed to better nutrient uptake by the plants. Interestingly, substituting 25% of the inorganic nitrogen with farmyard manure seemed to be as effective as using 100% NPK (nitrogen, phosphorus, and potassium) fertilizer. This could be attributed to the rapid mineralization of farmyard manure in an environment rich in readily available nutrients. The study suggests that the organic matter in the farmyard manure contributed to a continuous release of nutrients, supporting the growth and nutrient uptake of the maize crops [3].

Phosphorus: In terms of the high phosphorus (P) content of maize grain, the treatments T_3 (0.38%), T_8 (0.37%), and T_4 = T_9 (0.36%) were shown to be comparable. The treatment T_6 had the lowest value (0.31%), which was statistically comparable to T_7 (0.33%) and T_2 (0.32%).

Under T_3, T_9, and T_8, which were all equal, the P uptake by grain was maximum.Following these were statistically comparable treatments T_4, T_5, and T_7. T_2 recorded the lowest result of 6.8 kg ha^{-l}, which was followed by treatments T_1, T_6, and T_7 that had statistically equivalent effects.

Among all, significantly higher total P uptake by maize recorded by 100% RDF+FYM @ 5 t ha^{-1} (22.12 kg ha^{-l}) which was closely followed with 75% RDF+ FYM @ 5 t ha^{-1} (21.7 kg ha^{-l}) 100% RDF (20.99 kg ha^{-l}) and was found to be superior to T_7 (10.27 kg ha^{-l}). The lowest P uptake was recorded under T_2 (8.28 kg ha^{-l}). Compared to inorganic treatments, INM treatments recorded high total P uptake may be due to solubilization of fixed phosphorus by P-solubilizer due to secretion of organic acids. Similar findings corroborate with the studies of Venkata Lakshmi et al. [4].

Blackgram: None of the treatments given to maize were found to have a substantial impact on the amount of N and P in blackgram grain or its absorption. T_7 and all the other treatments were shown to produce statistically similar and superior N uptake by blackgram compared to the plots T_1 and when just phosphorus was treated to maize. T_9 recorded the highest N, P, and K intake of blackgram at the flowering stage (212, 71.3, and 214 kg ha^{-1}, respectively). The maximum P uptake was recorded with T_3, though. In terms of P uptake by blackgram haulms, the treatments T_8 and T_9 that combined FYM with fertilizer performed better than T_4. The treatments T_1, T_6, and FYM treatment T_2 that did not apply P to the maize showed decreased P absorption values. The remaining treatments, T_5 and T_{10}, statistically matched and outperformed T_7 considerably. Blackgram virtually followed the same path as haulms in terms of total P uptake. Similar to yield, significant N and P uptake in the case of blackgram was the outcome of INM treatment and 100% RDF application to maize.

Statistically similar treatments, namely T_2 (10.0 kg ha^{-1}) and T_1 (10.3 kg ha^{-1}), were found to be inferior to the rest of the treatments, all of which were found to be at par when the K uptake by blackgram grain was compared. The K content, uptake by blackgram haulms and total K uptake were found low under control (T_1).

The integrated application seems to result in higher nutrient uptake by plants due to the balanced and combined use of various nutrient sources. This leads to improved absorption, translocation, and assimilation of nutrients, ultimately resulting in increased dry matter accumulation and nutrient content in plants, particularly nitrogen (N), phosphorus (P), and potassium (K) nutrients.

Tyagi et al. [5] and Kalaiyarasi et al. (2019) likely support the idea that combining different nutrient sources leads to enhanced plant growth and nutrient uptake. This concept aligns with the principles of nutrient management and sustainable agriculture, where optimizing nutrient availability for plants is essential for higher yields and efficient resource utilization.

Higher N content was noticed under T_8 (3.14%), followed by T_9 (3.13%), T_{10} (3.11%), T_4 (3.01%), T_6 (2.95%) and T_3 (2.92%) lowest was under T_7 (2.40%) which received only 100% P. T_9 (212 kg ha^{-1}) recorded higher N content and low N uptake by T_1 (60 kg ha^{-1}).

Both P content (1.05%) and uptake (71.3 kg ha^{-1}) was higher under T_9, while T_1 recorded lower P content (0.85%) and uptake (19.8 kg ha^{-1}). Almost similar trend by K content and uptake, high values were observed by T_9 (3.17%) and (214 kg ha^{-1}).

Table 2. Effect of fertilizer and manurial treatments on N, P and K content (%) and uptake (kg ha^{-1}) by maize at silking stage

Treatments	N		P		K	
	N content	N uptake	P content	P uptake	K content	K uptake
T_1	0.98^{f}	54.0^{d}	0.10^{b}	5.64^{c}	3.03^{a}	168^{d}
T_2	1.14^{ef}	68.6^{d}	0.10^{b}	6.01^{c}	3.01^{b}	180^{d}
T_3	1.58^{ab}	164.4^{a}	0.14^{ab}	14.01^{a}	3.17^{a}	328^{a}
T_4	1.50^{abc}	119.8^{b}	0.11^{b}	8.54^{c}	3.16^{a}	252^{b}
T_5	1.36^{cd}	102.3^{bc}	0.10^{b}	7.47^{c}	3.06^{a}	229^{c}
T_6	1.36^{cd}	110.4^{bc}	0.12^{b}	9.34^{bc}	3.17^{a}	258^{b}
T_7	1.20^{de}	91.2^{cb}	0.11^{b}	8.60^{c}	3.13^{a}	237^{b}
T_8	1.60^{ab}	170.7^{a}	0.16^{a}	16.93^{a}	3.17^{a}	337^{a}
T_9	1.63^{a}	185.1^{a}	0.15^{a}	17.02^{a}	3.16^{a}	359^{a}
T_{10}	1.44^{bc}	107.8^{bc}	0.13^{ab}	9.73^{b}	3.16^{a}	237^{b}
Mean	1.38	117.49	0.12	10.33	3.12	259
SEm ±	0.06	7.89	0.01	1.29	0.05	12.08
CD (P=0.05)	0.18	23.65	0.04	3.85	0.16	36.21

Table 3. Effect of fertilizer and manurial treatments on N and P content (%) and uptake (kg ha^{-1}) by maize at harvest

Treatments	Grain		Stover			Grain		Stover		
	N content	**N uptake**	**N content**	**N uptake**	**Total N Uptake**	**P content**	**P uptake**	**P content**	**P uptake**	**Total P Uptake**
T_1 : Control	1.56^{c}	32^{a}	0.37^{e}	24^{f}	56^{e}	0.34^{cde}	7.0de	0.02^{b}	1.36^{c}	8.33^{d}
T_2 : FYM @5 t ha^{-1}	1.55^{c}	33^{a}	0.36^{e}	32de	65^{e}	0.32^{ef}	6.8 ^{e}	0.02^{b}	1.46^{c}	8.28^{d}
T_3 : 100% RDF	1.75^{a}	81^{a}	0.53^{b}	58^{ab}	139^{b}	0.38^{a}	17.1^{a}	0.04^{b}	3.85^{b}	20.99^{a}
T_4 : 75% RDF	1.68^{ab}	74^{ab}	0.50^{bc}	54^{b}	128^{b}	0.36^{abc}	9.0^{c}	0.03^{b}	2.16^{c}	11.18^{c}
T_5 : 50% RDF	1.60^{bc}	61^{c}	0.40^{de}	38^{d}	99^{d}	0.35^{bcd}	8.1^{cd}	0.03^{b}	2.06^{c}	10.14^{c}
T_6 : 100% RDN	1.70^{ab}	73^{ab}	0.45^{cd}	38^{d}	111^{c}	0.31^{f}	7.3^{de}	0.03^{b}	2.48^{c}	9.79a^{cd}
T_7 : 100 % RDP	1.66^{abc}	64^{c}	0.40^{e}	30^{ef}	94^{d}	0.33^{def}	7.9^{cde}	0.03^{b}	2.40^{c}	10.27^{c}
T_8 : 100 % RDF + FYM @5 t ha^{-1}	1.73^{a}	79^{a}	0.52^{b}	60^{ab}	139^{b}	0.37^{ab}	16.7^{a}	0.05^{a}	5.44^{a}	22.12^{a}
T_9 : 75% RDF + FYM @5 t ha^{-1}	1.75^{a}	78^{a}	0.54^{a}	63^{a}	142^{a}	0.36^{abc}	16.9^{a}	0.04^{b}	4.77^{ab}	21.70^{a}
T_{10} : 50% RDF + FYM @5 t ha^{-1}	1.69^{ab}	69^{bc}	0.48^{bc}	46^{c}	115^{c}	0.34^{cde}	11.7^{b}	0.03^{b}	2.21^{c}	13.93^{b}
Mean	1.67	64	0.46	44	109	0.35	10.9	0.03	2.82	13.67
SEm$\pm$	0.04	2.76	0.02	2.11	3.79	0.01	0.37	0.01	0.45	0.52
CD (P=0.05)	0.12	8.26	0.06	6.31	11.36	0.03	1.11	0.03	1.36	1.57

In later stages i.e., at harvest stage, content and uptakes gradually decrease, which might be due to translocation of nutrients from vegetative part of crop plant to grain at the time of maturity. INM treatments showed more content and uptakes of N, P and K when compared to sole application of inorganics, due to favourable effect of incorporation of organic sources together with inorganic nutrients.

Groundnut: Higher N uptake (Table 6) was noticed under T_8 (52.77%), followed by T_3 (52.09%) and T_9 (51.11%), lowest was under T_2 (42.28%). Both P content (0.38%) and uptake (8.26 kg ha^{-1}) was higher under T_7, while T_1 recorded lower P content and uptake. Data on potassium uptake also manifested the similar trend as was noticed with N and P uptake. Among the doses of phosphorus to *kharif* groundnut, 100% RDF + FYM recorded significantly higher potassium uptake (43.21 kg ha^{-1}) in haulm which was closely followed with 75% RDF + FYM (41.80 kg ha^{-1}), and lowest was under control (32.75 kg ha^{-1}).

Nitrogen: Consequent to the high yield, the nitrogen uptake by both pod and haulm was highest under the treatment T_8, the values were 83.8 and 43.1 kg ha^{-1} for pod and haulm, respectively (Table 7). T3 (81.8 kg ha^{-1}) followed T8 in the case of pod. With the exception of T_1 (54.4 kg ha^{-1}) and T_2, T_9, T_4, T_6, T_5, T_7, and T_{10}, all were at par. It was evident that none of the treatments given to maize significantly affected the haulm's N content. This suggests that the FYM had a lasting impact on the release of N to groundnut. Due to the increase in microbial population, adding blackgram before planting groundnuts may improve the N recovery from FYM applied to maize. In terms of total N uptake, the treatments applied to the maize were administered in the following order: T_8 (127 kg ha^{-1}) > T_3 (124 kg ha^{-1}) > T_9 (122 kg ha^{-1}) > T_4 (120 kg ha^{-1}) > T_6 (120 kg ha^{-1}) > T_5, T_7, T_{10} (117 kg ha^{-1}) > T_2 (90 kg ha^{-1}) > T_1 (75 kg ha^{-1}). Significantly higher N uptake of pod (79.66 kg ha^{-1}) and haulm (45.7 kg ha^{-1}) was observed under S_2 compared to the S_3 and S_1. The nutrient availability, slow nutrient release and reduction of nutrient fixation in soil enhances the nutrient uptake by groundnut. The total N uptake followed the order: S_2 (125.3 kg ha^{-1}) > S_3 (116.0 kg ha^{-1}) > S_1 (97.5 kg ha^{-1}).

Phosphorus: It was evident from the (Table 7), the phosphorus content and uptake of pod, haulm and total P uptake was maximal under treatment (T_7) supplied only with 100% P, followed by (T_8) in all cases. Total P uptake was found low under T_1 (9.5 kg ha^{-1}) which was found to be at par with T_2 (12.1 kg ha^{-1}).

As regards, subplot treatment, S_2 (75% RDF) was superior to S_3 and S_1 in case of P content and uptake of pod, haulm and total P uptake. Total P uptake is in the order: S_2 (19.42 kg ha^{-1}) > S_3 (17.63 kg ha^{-1}) > S_1 (13.81 kg ha^{-1}). Phosphorus recovery and uptake has been observed to improve either by the application of P to maize crop [6] or by application of FYM along with chemical fertilizers to the preceding wheat crop [7].

Table 4. Effect of fertilizer and manurial treatments on N, P and K content (%) and uptake (kg ha^{-1}) by blackgram at flowering stage

Treatments	N		P		K	
	N content	N uptake	P content	P uptake	K content	K uptake
T_1	2.60^{bc}	60^{f}	0.85^{e}	19.8^{e}	2.71^{e}	62^{e}
T_2	2.56^{c}	108^{e}	0.85^{e}	35.7^{d}	2.97^{b}	125^{d}
T_3	2.92^{a}	149^{cd}	1.04^{ab}	52.7^{c}	3.17^{a}	161^{c}
T_4	3.01^{a}	190^{ab}	0.97^{abc}	60.9^{bc}	3.01^{b}	190^{ab}
T_5	2.87^{ab}	206^{a}	0.89^{cde}	63.5^{ab}	2.95^{bc}	211^{a}
T_6	2.95^{a}	122de	0.70^{f}	29.2^{d}	2.80^{de}	116^{d}
T_7	2.40^{c}	174^{bc}	0.87^{de}	62.9^{ab}	2.82^{cde}	204^{a}
T_8	3.14^{a}	186^{ab}	1.00^{ab}	59.0^{bc}	2.96^{b}	175^{bc}
T_9	3.13^{a}	212^{a}	1.05^{a}	71.3^{a}	3.17^{a}	214^{a}
T_{10}	3.11^{a}	199^{ab}	0.94^{bcd}	59.8^{bc}	2.92^{bcd}	187^{abc}
Mean	2.87	160	0.91	51.5	2.95	165
SEm ±	0.10	10.03	0.03	3.12	0.04	9.12
CD (P=0.05)	0.29	30.06	0.08	9.35	0.13	27.36

Table 5. Effect of fertilizer and manurial treatments on N and P uptake (kg ha^{-1}) by blackgram at harvest

Treatments	Grain		Haulm		Root		Total N uptake	Grain		Haulm		Root		Total P uptake
	N content	N uptake	N content	N uptake	N content	N uptake		P content	P uptake	P content	P uptake	P content	P uptake	
T_1	3.62	27.0	1.7^{c}	56^{d}	0.77^{c}	3.74	86^{c}	0.45	3.32	0.22^{a}	7.14^{f}	0.15	0.731	11.1^{f}
T_2	3.66	27.4	1.7^{c}	84^{c}	0.82^{bc}	5.51	117^{b}	0.45	3.40	0.23^{c}	11.24^{e}	0.12	0.828	15.4^{e}
T_3	3.56	30.8	2.0^{ab}	126^{ab}	1.07^{a}	6.56	164^{a}	0.45	3.93	0.28^{a}	17.90^{a}	0.15	0.902	22.7^{a}
T_4	3.66	31.4	2.0^{ab}	127^{ab}	0.88^{abc}	5.41	164^{a}	0.46	3.97	0.26^{ab}	16.23^{b}	0.13	0.817	21.0^{b}
T_5	3.59	30.8	1.9^{b}	119^{b}	0.79^{c}	4.90	155^{a}	0.44	3.81	0.24^{bc}	14.74^{bc}	0.12	0.752	19.3^{c}
T_6	3.69	30.6	2.0^{ab}	123^{ab}	0.84^{bc}	5.23	159^{a}	0.44	3.69	0.19^{d}	11.77^{de}	0.13	0.791	16.2^{de}
T_7	3.59	29.0	1.5^{d}	82^{c}	0.89^{abc}	5.72	116^{b}	0.45	3.66	0.23^{c}	12.65^{d}	0.12	0.786	17.0^{d}
T_8	3.70	32.3	2.1^{a}	132^{ab}	1.03^{ab}	6.61	171^{a}	0.47	4.13	0.26^{ab}	16.6^{ab}	0.15	0.926	21.6^{ab}
T_9	3.63	31.4	2.0^{ab}	126^{ab}	0.89^{abc}	5.82	163^{a}	0.48	4.14	0.27^{a}	16.55^{ab}	0.14	0.895	21.5^{ab}
T_{10}	3.67	31.3	2.1^{a}	136^{a}	0.87^{abc}	5.94	173^{a}	0.46	3.92	0.24^{bc}	15.63^{bc}	0.13	0.933	20.4^{bc}
Mean	3.64	30.2	1.90	111	0.83	5.54	147	0.46	3.80	0.24	14.04	0.13	0.836	18.674
SEm ±	0.05	1.93	0.06	5.63	0.07	1.04	6.44	0.01	0.21	0.01	0.46	0.01	0.09	0.52
CD (P=0.05)	NS	NS	0.19	16.88	0.21	NS	19.31	NS	NS	0.02	1.39	NS	NS	1.55

Table 6. Effect of fertilizer and manurial treatments on N,P and K content(%) and uptake (kg ha^{-1}) by groundnut at flowering stage

Treatments	N		P		K	
	Content	**Uptake**	**Content**	**Uptake**	**Content**	**Uptake**
Main plots						
$\mathbf{T_1}$: Control	2.19	42.28^{c}	0.27^{c}	5.32^{b}	1.64^{b}	32.75^{j}
$\mathbf{T_2}$: FYM @5 t ha^{-1}	2.21	43.62^{bc}	0.29^{bc}	5.59^{b}	1.77^{ab}	33.89^{i}
$\mathbf{T_3}$: 100% RDF	2.36	52.09^{a}	0.33^{abc}	7.41^{a}	1.80^{ab}	39.87^{e}
$\mathbf{T_4}$: 75% RDF	2.31	49.51^{ab}	0.34^{ab}	7.41^{a}	1.79^{ab}	38.60^{f}
$\mathbf{T_5}$: 50% RDF	2.25	47.79^{abc}	0.33^{abc}	7.10^{a}	1.79^{ab}	38.25^{h}
$\mathbf{T_6}$: 100% RDN	2.34	49.98^{ab}	0.33^{abc}	7.08^{a}	1.80^{ab}	38.52^{g}
$\mathbf{T_7}$: 100 % RDP	2.30	48.95^{abc}	0.38^{a}	8.26^{a}	1.91^{a}	41.09^{c}
$\mathbf{T_8}$: 100 % RDF + FYM @5 t ha^{-1}	2.36	52.77^{a}	0.36^{a}	8.04^{a}	1.93^{a}	43.21^{a}
$\mathbf{T_9}$: 75% RDF + FYM @5 t ha^{-1}	2.36	51.11^{a}	0.36^{a}	7.81^{a}	1.93^{a}	41.80^{b}
$\mathbf{T_{10}}$: 50% RDF + FYM @5 t ha^{-1}	2.34	49.47^{ab}	0.34^{ab}	7.24	1.88^{ab}	40.00^{d}
SEm$\pm$	0.066	2.301	0.020	0.481	0.082	0.023
CD (P=0.05)	NS	6.84	0.06	1.43	0.24	0.07
Sub plots						
$\mathbf{S_1}$: Control	2.16^{c}	39.55^{c}	0.30^{c}	5.41^{c}	1.62	29.72^{c}
$\mathbf{S_2}$: 75% RDF	2.44^{a}	56.34^{a}	0.37^{a}	8.49^{a}	1.97	45.59^{a}
$\mathbf{S_3}$: 50% RDF	2.31^{b}	50.37^{b}	0.34^{b}	7.46^{b}	1.88	41.08^{b}
SEm$\pm$	0.014	0.693	0.004	0.130	2.408	0.725
CD (P=0.05)	0.04	1.98	0.01	0.37	NS	2.07
Interaction						
S at T						
SEm$\pm$	0.004	2.192	0.014	0.412	0.074	2.292
CD (P=0.05)	NS	NS	NS	NS	NS	NS
T at S						
SEm$\pm$	0.097	3.491	0.030	0.720	0.123	3.732
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 7. Effect of fertilizer and manurial treatments on N and P content (%) and uptake (kg P ha^{-1}) by groundnut at harvest

Treatments	N				Total N uptake	P				Total P uptake
	Pod		Haulm			Pod		Haulm		
	content	uptake	content	uptake		content	uptake	content	uptake	
Main plots										
T_1	3.29^{b}	40.6^{c}	1.68	35.2^{b}	75.8^{c}	0.51^{d}	6.2^{b}	0.16^{c}	3.31^{c}	9.5^{b}
T_2	3.37^{ab}	55.5^{b}	1.69	34.8^{b}	90.3^{d}	0.52^{cd}	8.6^{b}	0.17^{c}	3.54^{bc}	12.1^{b}
T_3	3.40^{a}	81.8^{a}	1.79	42.0^{a}	123.9^{ab}	0.56^{bcd}	13.6^{a}	0.20^{b}	4.62^{a}	18.2^{a}
T_4	3.42^{a}	80.0^{a}	1.77	40.2^{ab}	120.2^{ab}	0.57^{bcd}	13.5^{a}	0.20^{b}	4.64^{a}	18.1^{a}
T_5	3.41^{a}	78.8^{a}	1.71	38.4^{ab}	117.2^{b}	0.56^{bcd}	13.0^{a}	0.20^{b}	4.52^{a}	17.5^{a}
T_6	3.42^{a}	79.4^{a}	1.79	40.4^{ab}	119.8^{ab}	0.56^{bcd}	13.1^{a}	0.20^{b}	4.46^{ab}	17.5^{a}
T_7	3.41^{a}	77.1^{a}	1.77	39.6^{ab}	116.8^{b}	0.65^{a}	14.8^{a}	0.23^{a}	5.18^{a}	20.0^{a}
T_8	3.45^{a}	83.8^{a}	1.81	43.1^{a}	126.9^{a}	0.61^{ab}	14.7^{a}	0.21^{ab}	5.06^{a}	19.8^{a}
T_9	3.44^{a}	80.0^{a}	1.82	41.6^{a}	121.6^{ab}	0.60^{ab}	14.0^{a}	0.21^{ab}	4.88^{a}	18.9^{a}
T_{10}	3.39^{a}	76.8^{a}	1.79	39.9^{ab}	116.7^{b}	0.58^{bc}	13.2^{a}	0.20^{b}	4.56^{a}	17.8^{a}
SEm$\pm$	0.034	2.638	0.052	1.939	2.847	0.025	0.780	0.012	0.320	0.922
CD (P=0.05)	0.10	7.84	NS	5.76	8.46	0.07	2.32	0.03	0.95	2.74
Sub plots										
S_1 : Control	3.29^{c}	65.44^{c}	1.65^{c}	32.08^{c}	97.52^{c}	0.52^{c}	10.40^{c}	0.17^{c}	3.41^{c}	13.81^{c}
S_2 : 75% RDF	3.52^{a}	79.66^{a}	1.87^{a}	45.70^{a}	125.36^{a}	0.62^{a}	14.06^{a}	0.22^{a}	5.36^{a}	19.42^{a}
S_3 : 50% RDF	3.39^{b}	75.21^{b}	1.77^{b}	40.85^{b}	116.06^{b}	0.58^{b}	12.97^{b}	0.20^{b}	4.66^{b}	17.63^{b}
SEm$\pm$	0.011	0.747	0.011	0.580	1.076	0.006	0.201	0.003	0.089	0.248
CD (P=0.05)	0.03	2.14	0.03	1.66	3.08	0.02	0.58	0.01	0.25	0.71
Interaction										
S at T										
SEm$\pm$	0.034	2.364	0.034	1.833	3.403	0.020	0.637	0.009	0.281	0.785
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T at S										
SEm$\pm$	0.052	3.972	0.076	2.939	4.481	0.037	1.163	0.017	0.481	1.380
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

4. CONCLUSION

The application of integrated nutrient management (INM) substantially increased the content of nitrogen (N), phosphorus (P), and potassium (K) in both grain and stover compared to the control. This indicates that the utilization of INM practices positively influenced nutrient uptake by the crops. The incorporation of Farm Yard Manure (FYM) in combination with recommended fertilizer doses (100% RDF and 75% RDF) notably affected nutrient content in grain and stover. This underscores the contribution of organic matter (FYM) along with conventional fertilizers to elevated nutrient concentrations. Furthermore, integrating FYM led to a more pronounced increase in nutrient concentration, not only for nitrogen, phosphorus, and potassium, but also for other essential nutrients. This suggests that the integration of organic matter positively impacted overall nutrient availability and uptake. The observed heightened concentrations of N, P, and K were attributed to their synergistic effects during various crop growth stages. This highlights the interplay between these nutrients, enhancing their uptake and utilization by the plants. The discrepancy in potassium (K) concentration between grain and stover was attributed to nutrient translocation, with nitrogen and phosphorus moving from vegetative parts to grain during maturity. Conversely, the higher K concentration in stover was attributed to the response of fibrous cells, particularly sclerenchyma cells, to potassium supply, leading to increased turgidity, cellulose, and hemicellulose content. Similar results are also reported by other workers Karki et al. [8], Shashidhar et al. [9], Mann et al. [10], Mahala et al. [11] and Vikas et al. [12].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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