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Influence of integrated nutrient management on yield under maize-blackgram-groundnut cropping sequence in red loamy soils

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Abstract
A field experiment was carried out 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. Ten treatments *viz.* control, fertilizers applied at 50, 75 and 100% of the recommended dose ($N_{240}P_{80}K_{80}$), N_{240} only, P_{80} only, FYM (@ 5 t ha^{-1}) applied alone, and in combination with100%,75% and 50% recommended NPK were applied to maize. These treatments were compared with no-fertilizer and manure control. Blackgram was grown following maize without any fertilizer or manure application. It was allowed to grow till maturity, and after two pickings, the stover 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.*, S_1 (control), S_2 (75% RDF) and S_3 (50% RDF) resulting in ninety treatment combinations replicated three times in split plot design. The treatments where higher amounts of fertilizer and INM i.e., 100% RDF and 75% RDF + FYM 5 t ha^{-1} registered higher grain and stover yield in maize. It was observed that none of the treatments applied to maize had any significant effect on the grain and root biomass yield of blackgram, while the stover and total biomass yield was significantly affected. The residual effects on groundnut with respect to pod and haulm yield at harvest were highest with the application of 100% RDF + FYM @ 5 t ha^{-1}.

Keywords: INM, maize, blackgram, groundnut sequence, grain/pod yield

Introduction
Fertilizers have played and are continuing to play an important role in the productivity of both irrigated and rainfed crops. But the use of chemical fertilizers alone is not sufficient to sustain the productivity due to imbalance of certain elements, resulting in impairing the productivity with time. Further, in recent years, long-term sustainability of agricultural productivity and environmental safety are being questioned due to the facts such as yield stagnation, deterioration of soil organic matter, low FUE and widening of NPK ratio (Chesti *et al.*, 2015) [1]. It is widely recognized that neither organic manures alone nor mineral N, P and K fertilizers can achieve the yield sustainability at a higher order under the modern intensive farming in which the nutrient turnover in the soil-plant system has to be quite high. So far, research had been focusing attention on individual crops disregarding the fact that each crop was only a component of a cropping sequence. Hence, the nutrient management practices for the individual crops were based on the responses of individual crops to the major nutrients without considering the residual effects and the cropping sequence as a whole. Under these circumstances, there is an urgent need for developing nutrient management practices for the cropping sequence as a whole rather than for individual crops. The practice of cultivating cereal based rotation continuously might have an adverse effect on physico-chemical properties and fertility status of soil. Inclusion of legumes in the sequence improves significantly the soil fertility. Hence, there is a need for the development of nutrient management strategies that are technically sound, economically attractive, practically feasible and environmentally safe. It has, therefore, been considered worth while to carry out an experiment, which deals with the integration of inorganic and organic sources of the nutrients with an objective to study the possibility of substitution of N and P requirement of corps through organic sources and to find out the most effective combinations of these materials which create impact on soil and plant systems grown in the sequence.

Material 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° N latitude and 79.5° E longitude at an altitude of 182.9 meters above mean sea level, categorised as the Southern Agro-climatic 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 (21kg ha^{-1}) and medium in potassium (162kg ha^{-1}).

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 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. Standard package of practices were followed for all the three crops. Phosphorus and potassium were applied as basal whereas nitrogen was applied in three splits, *viz*., before sowing, at knee high stage and before silking satges. 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 maize- blackgram-groundnut cropping sequence.

Results and Discussion

The highest grain yield was recorded under the treatment T_3, which is 100% of the recommended dose of fertilizer. It was statistically at par with the treatment T_8 (100% RDF + FYM), T_9 **(**75% RDF + FYM), T_4 (75% RDF) and T_6 (100% RDN), which registered grain yields 4555,4490,4404 and 4295 kg ha^{-1}, respectively. The lowest yield 2046 kg ha^{-1} was obtained under control (T_1), but it was on par with T_2 (FYM @5 t ha^{-1}) recorded grain yield of 2130 kg ha^{-1}. Treatments T_5 (50% RDF) T_7 (100% RDP) and T_{10} (50% RDF+ FYM @ 5 t ha^{-1}) were found at par with each other. Application of FYM alone did not bring about significant improvement in the maize yield as compared to control, which could be attributed to the slow rate of nutrient supply that failed to meet the immediate demands of the crop. Also addition of FYM @ 5 t ha^{-1}, which supplied about 25 kg N ha^{-1}, was not suffcient to bring about substantial increase in yield. The highest stover yield was recorded under treatment T9 (75% RDF + FYM @ 5 t ha^{-1}) and lowest was under control (T1). Similar yield of wheat straw was found under treatments receiving more than 50% of the recommended dose of N, *viz*, T_3 (100 RDF),T_4 (75% RDF) and T_8 (100% RDF + FYM) with the values of 11018, 10740 and 11481 kg ha^{-1}, respectively. Increase in straw yield with the application status. The highest dry matter yield was registered under the treatment T_7 (16157 kg ha^{-1}) followed by T_8 (16037 kg ha^{-1}), T_3 (15620 kg ha^{-1}) and T_4 (15145 kg ha^{-1}).It is visualized from the data, study on judicious integrated nutrient management strategy revealed that application of recommended dose of inorganic fertilizer and INM practices to maize not only enhanced productivity of maize over the control and recommended N, P and K respectively, but also improved soil fertility in terms of higher available N, P, K and organic carbon. These results are in line with the findings of Sarwar *et al*., (2012) [8]. Rama Lakshmi (2015)) [7], Gundlur *et al*., (2015)) [3] and Thavaprakash and Velayudham, (2007) [10].

Table 1: Effect of integrated nutrient management on yield (kg ha^{-1}) of *rabi* maize

Treatments	Grain yield	Stover yield	Total yield (G+S)
T_1: Control	2046^{d}	6503^{g}	8549^{f}
T_2: FYM @5 t ha^{-1}	2130^{d}	8712^{de}	10842^{e}
T_3: 100% RDF	4602^{a}	1101^{gb}	15620^{b}
T_4: 75% RDF	4404^{ab}	10740^{b}	15145^{b}
T_5: 50% RDF	3812^{c}	9344^{cd}	13156^{cd}
T_6: 100% RDN	4295^{ab}	8426^{e}	12721^{d}
T_7: 100% RDP	3851^{c}	7500^{f}	11351^{e}
T_8: 100% RDF + FYM @5 t ha^{-1}	4555^{a}	11481^{b}	16037^{b}
T_9: 75% RDF + FYM @5 t ha^{-1}	4490^{a}	11666^{a}	16157^{a}
T_{10}: 50% RDF + FYM @5 t ha^{-1}	4069^{bc}	9629^{c}	13699^{c}
Mean	3825	9502	13327
S.Em ±	116.40	284.79	318.97
CD (P=0.05)	348.99	853.85	956.32

Table 2: Residual effect of integrated nutrient management on yield (kg ha^{-1}) of summer black gram

Treatments	Grain yield	Stover yield	Root yield	Total biomass yield
T_1: Control	741	3213^{d}	486	4440^{d}
T_2 FYM @5 t ha^{-1}	750	4907^{c}	671	6329^{c}
T_3: 100% RDF	867	6472^{a}	615	7953^{a}
T_4: 75% RDF	864	6342^{a}	611	7817^{a}
T_5: 50% RDF	859	6231^{a}	611	7702^{ab}
T_6: 100% RDN	831	6305^{a}	620	7757^{a}
T_7: 100% RDP	806	5592^{b}	639	7038^{b}
T_8: 100% RDF + FYM @5 t ha^{-1}	872	6370^{a}	630	7872^{a}
T_9: 75% RDF + FYM @5 t ha^{-1}	863	6204^{a}	644	7710^{ab}
T_{10}: 50% RDF + FYM @5 t ha^{-1}	852	6426^{a}	694	7972^{a}

Mean	831	5806	622	7259
S.Em ±	49.83	200.73	61.28	231.24
CD (P=0.05)	NS	601.80	NS	693.28

Blackgram variety TBG-104 was grown after harvest of maize without any fertilizer or manurial treatment. It was observed that none of the treatments applied to maize had any significant effect on the grain and root biomass yield of blackgram, while the stover and total biomass yield was significantly affected (Table.2) The differences in the grain yield were not evident as a result of incomplete picking of blackgram pods. The highest stover yield was obtained in the treatment T_3 (6472 kg ha^{-1}), where 100% RDF was added to maize. However, it was found to be at par with T_{10} (6426 kg ha^{-1}), T_8 (6370 kg ha^{-1}), T_4 (6342 kg ha^{-1}), T_6 (6305 kg ha^{-1}), T_5 (6231 kg ha^{-1}) and T_9 (6204 kg ha^{-1}). The lowest stover yield of 3213 kg ha^{-1} was recorded under control (T_I). The total biomass yield of was lowest under TI (4440 kg ha^{-1}), followed by T2 (6329 kg ha^{-1}). Both of them were significant and inferior to rest of the treatments applied to maize. Application of FYM along with inorganics during maize was found to have a residual effect on blackgram grown in succession. These results are in conformity with Kodeeswarn (2015)) [5] and Chaudary *et al*., (2016)) [2].

Table 3: Effect of integrated nutrient management on yield (kg ha^{-1}) of kharif groundnut

Treatments	Pod	Haulm	Total drymatter
Main plots			
T_1: Control	1231^c	2085^b	3316^b
T_2: FYM @5 t ha^{-1}	1648^b	2120^{ab}	3768^c
T_3: 100% RDF	2407^a	2331^{ab}	4739^a
T_4: 75% RDF	2333^a	2261^{ab}	4594^a
T_5: 50% RDF	2306^a	2239^{ab}	4544^a
T_6: 100% RDN	2324^a	2246^{ab}	4570^a
T_7: 100% RDP	2258^a	2231^{ab}	4490^a
T_8: 100% RDF + FYM @5 t ha^{-1}	2426^a	2363^a	4789^a
T_9: 75% RDF + FYM @5 t ha^{-1}	2324^a	2269^{ab}	4593^a
T_{10}: 50% RDF + FYM @5 t ha^{-1}	2259^a	2222^{ab}	4481^a
S.Em+	69.4	85.5	109.5
CD (P=0.05)	206	254	325
Sub plots			
S_1: Control	1983^b	1966^c	3929^c
S_2: 75% RDF	2256^a	2443^a	4699^a
S_3: 50% RDF	2216^a	2301^b	4518^b
S.Em+	19.3	26.7	35.1
CD (P=0.05)	55	76	100
Interaction			
S at T			
S.Em+	60.9	84.5	110.1
CD (P=0.05)	NS	NS	NS
T at S			
S.Em+	104.3	130.4	107.7
CD (P=0.05)	NS	NS	NS

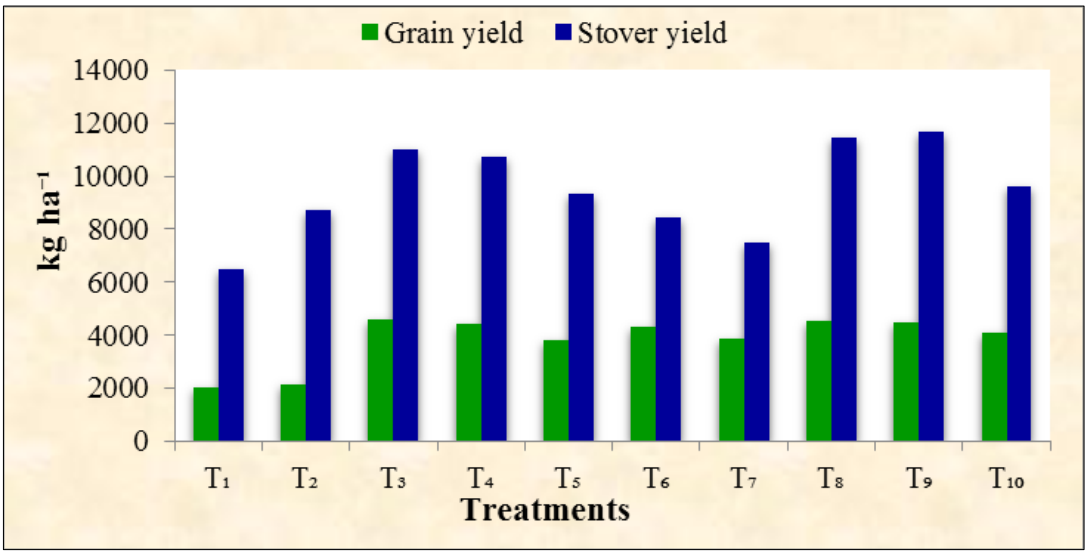

Fig 1: Effect of integrated nutrient management on yield (kg ha^{-1}) of *rabi* maize

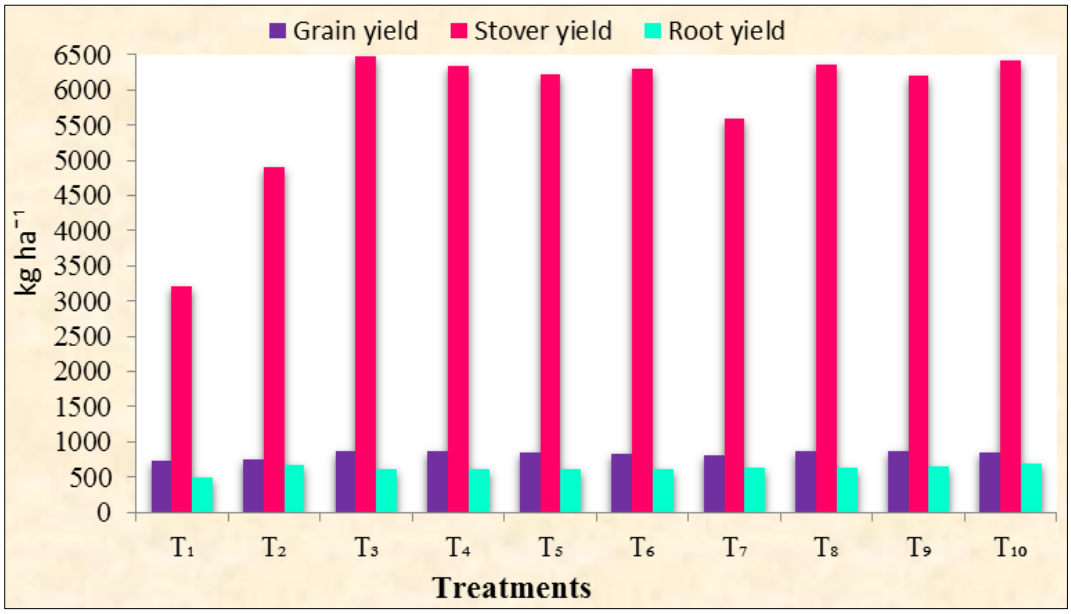

Fig 2: Residual effect of integrated nutrient management on yield (kg ha^{-1}) of summer black gram

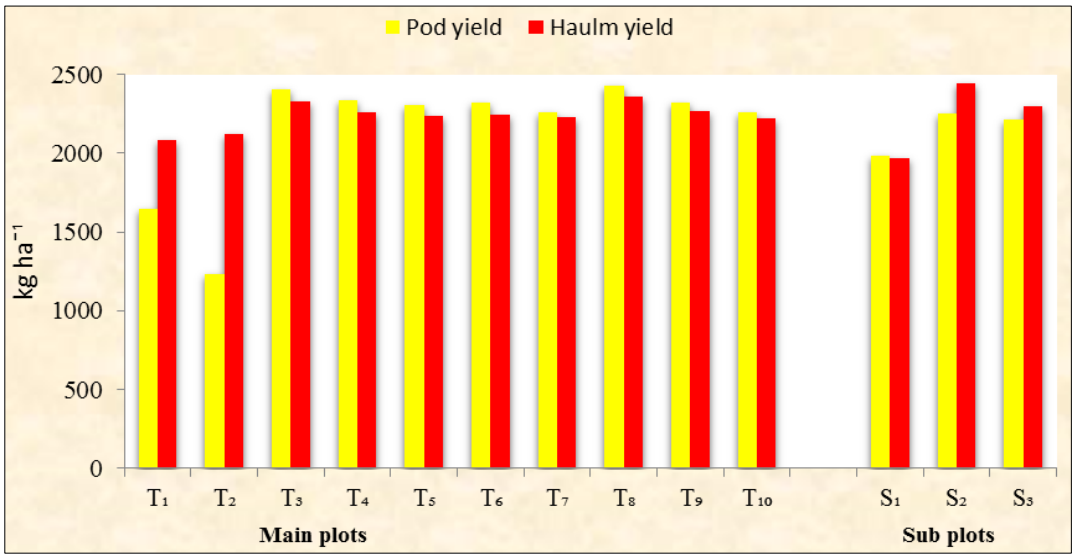

Fig 3: Effect of integrated nutrient management on yield (kg ha^{-1}) of *kharif* groundnut

The pod and haulm yields of groundnut were enhanced with increased level of application of fertilizer (Table 3). Among the treatments applied to maize, the treatment T_8 where FYM was supplemented along with inorganic fertilizer, resulted in higher pod, haulm yield and total dry matter of 2426 kg ha^{-1}, 2363 kg ha^{-1} and 4789 kg ha^{-1} respectively. The lowest pod yield of 1231 kg ha^{-1} was noticed under T_1 (control) followed by T2 (1648 kg ha^{-1}), application of FYM alone did not produce results as good as the treatments receiving integrated nutrient management. The higher yield observed with the application of FYM may be explained on the basis of faster decomposition and released nutrients in FYM and recycling of preceding crop residues besides enhancing the microbial population and higher root biomass.

While S_2 (75% of recommended dose for groundnut) recorded the highest pod, haulm yield of 2256 and 2443 kg ha^{-1} and total dry matter of 4699 kg ha^{-1}. This was superior to the yields of 2216, 2301 kg ha^{-1} and 4518 kg ha^{-1} of pod, haulm and total dry matter produced under S_3. The lowest yields were recorded under S_1 (control). (Kannan *et al.*, 2005) [4], Roul and Sarawgi (2005) [6] and Sharma *et al.* (2011) [9] reported similar findings.

Conclusion

This investigation supports the results of several earlier workers as regards to obtaining comparable, if not higher yields of crops by substituting a part of inorganic fertilizers with FYM and integration of different sources of nutrients either from chemical, organic or biofertilizers sources have been proven to be recorded success in different part of the world than sole use of either chemical fertilizers or organic manures and this system is not only improving the total crop productivity but it also maintain and sustains soil health for future generation as well as improving the economic stability of the farmers.

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