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Nutrient use efficiency of groundnut with organic manures

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Abstract

Field experiment was conducted on groundnut during *kharif*, 2014 at College of Agriculture, Rajendranagar, Hyderabad to study the effect of four organics (vermicompost with P enrichment using 3 % rock phosphate, vermicompost prepared with mushroom spent substrate, vermicompost and FYM) at two levels of nitrogen (100 % RDN i.e., 30 kg ha^{-1} and 75 % RDN i.e., 22.5 kg ha^{-1}) along with control (No NPK but gypsum @ 500 kg ha^{-1} at flower initiation) and absolute control (no NPK and gypsum) to find out the effect of different organic sources on nutrient use efficiencies viz., partial factor productivity, agronomic efficiency, partial nutrient balance, apparent recovery efficiency, internal utilisation efficiency and physiological efficiency. Significantly higher agronomic efficiency and partial productivity factor of 86.7 and 174.63 are obtained due to application of 75% RDN through of P (3%) enriched vermicompost; while apparent recovery efficiency of N was significantly higher (4.08 and 4.03 to absolute control and control with applied gypsum) when applied at 100% RDN level.

Keywords- Groundnut, organics and nutrient use efficiencies.

Introduction

Indiscriminate use of chemical fertilizers over years for crop production resulted in deterioration of soil quality and decline in crop yield. Use of only nitrogenous and phosphatic fertilizers, as practiced by farmers also creates nutrient imbalance in soil besides deficiency in micronutrients. Organic manures not only supply the plant nutrients but also improve soil health, the indirect effects being augmentation of beneficial microbial population and their activities in the soil for organic matter decomposition, biological nitrogen fixation and solubilisation of insoluble phosphates; while availability of plant nutrients, the direct effect, is through addition of nitrogen, phosphorus, potassium and small amounts of secondary and micronutrients such as calcium, sulphur manganese, sufficient to meet the requirement of crop zinc, copper and iron. Moreover, the amount of micronutrients present in organic manures may be production (Duhan and Mahendra, 2002). Use of organic manures in one form or the other has advantages like nutrient conservation, slow release, improvement of soil physical conditions and enhanced biological activities resulting in higher crop yields. Nutrient use efficiency can be expressed by several ways. Mosier *et al.*, (2004) described four agronomic indices commonly used to describe nutrient use efficiency: partial factor productivity (PFP, kg crop yield per kg nutrient applied); agronomic efficiency (AE, kg crop yield increase per kg nutrient applied); apparent recovery efficiency (RE, kg nutrient taken up per kg nutrient applied); and physiological efficiency (PE, kg yield increase per kg nutrient taken up). NUE is a critically important concept for evaluating crop production systems and can impacted by fertilizer management as well as soil- and plant-water relationships. Sustainable nutrient management must be both efficient and effective to deliver anticipated economic, social, and environmental benefits. As the cost of nutrients climb, profitable use puts increased emphasis on high efficiency, and the greater nutrient amounts that higher yielding crops remove means that more nutrient inputs will likely be needed and at risk of loss from the system.

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Providing society with a sufficient quantity and quality of food at an affordable price requires that costs of production remain relatively low while productivity increases to meet projected demand. Therefore, both productivity and NUE must increase. (Fixen, 2005). The objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field and supporting agricultural system sustainability through contributions to soil fertility or other soil quality components. Therefore, management practices that improve NUE without reducing productivity or the potential for future productivity increases are likely to be most valuable.Groundnut is an important oilseed crop in India with 5.86 M ha and 8.26 M tonnes production. Unified state of Andhra Pradesh ranked 2nd in area and production of groundnut next to Gujarat with the area, production and productivity of 1.03 M ha, 1.05 M tonnes and 1848 kg ha^{-1} respectively (Ministry of Agriculture, GOI, 2012). Though groundnut is primarily used as oilseed crop, some of the groundnut varieties are recommended as table purpose for direct consumption because of its high food value (Rajagopal *et al,* 2000) in terms of higher protein (22%),carbohydrates (10%), minerals (3%), niacin (17mg $100g^{-1}$) and vitamin B (1mg $100g^{-1}$). The area under organic farming in India increased from 42,000 ha during 2003-04 to 10.85 m ha^{-1} by 2012. Of which, oilseed crops occupy an area of 1.79 lakh ha with the production of 2.23 lakh tonnes (NCOF, 2012). The certified area under organic crops in unified Andhra Pradesh was 30,967 hectares. The availability of organic manures is decreasing due to reduction in cattle population and hence it is becoming difficult to meet the demand of organic manures to sustain the organic crop production. Hence there is need to identify alternate sources of nutrients and evaluate in organic farming system to sustain the productivity of crop as well as soil quality.

Materials and Methods

Field experiment was conducted during *kharif,* 2014 at College of Agriculture, Rajendranagar, Hyderabad. During the crop growth period (12th July 2014 to 12th Nov 2014) weekly mean maximum and minimum temperature was 31.1 ^{o} and 21.6 ^{o} C. Weekly mean relative humidity (maximum and minimum) was 82.5 and 57.5 per cent; whereas weekly mean sunshine hours, evaporation and wind velocity was 5.2 hours, 3.7 mm day^{-1} and 6.1 km $hour^{-1}$ respectively, while, 379.9 mm rainfall was received during the crop growing season in 28 rainy days. Soil was sandy clay loam in texture with a pH of 7.9 (slightly alkaline), low in available nitrogen (225 kg ha^{-1}), high in available phosphorus (49 kg ha^{-1}) and potassium (448 kg ha^{-1}), medium in available sulphur (11.5 ppm) and low calcium (13.7 meq 100 g^{-1} soil) with a bulk density of 1.47 g cc^{-1}. Soil organic carbon was medium (0.75 %).

Local variety of sunhemp was broadcast in experimental site with seed rate of 40 kg ha^{-1} before sowing of main crop. Sunhemp was allowed to grow up to 45 DAS and incorporated into the soil. After field preparation, healthy and matured seed with germination > 96% of groundnut variety TG-47 (Bheema) with seed rate of 150 kg ha^{-1} was sown by dibbling on 12-07-2014 using one seed per hill with a spacing of 30 x 10 cm at a depth of 4 to 5 cm. The experiment was laid out in a randomized block design with three replications. Four organic manures *viz*., vermicompost, FYM, vermicompost prepared with mushroom spent substrate and vermicompost enriched with 3% rock phosphate were tested at two levels of nitrogen i.e. 100 % RDN (30 kg ha^{-1}) and 75 % RDN (22.5 kg ha^{-1}) along with two checks i.e. control (no NPK but gypsum application @ 500 kg ha^{-1} at flower initiation) and absolute control (no NPK and no gypsum. Vermicomposting was initiated during the month of April, 2014. For preparing phosphorus enriched vermicompost, rock phosphate @ 3 g kg^{-1} cow dung was added. Mushroom spent substrate was collected from Mushroom unit, Dept of plant pathology and was mixed with cow dung in 2:1 ratio and allowed for vermicomposting. Nutritional composition (N-P-K %) of tested organic manures was 1.13 - 0.67 - 1.21 per cent for vermicompost, 0.65 - 0.4 - 0.8 per cent for FYM, 1.93- 1.44-2.74 per cent for vermicompost prepared with mushroom spent substrate and 1.95- 2.15- 2.66 per cent for vermicompost enriched with rock phosphate @ 3 per cent. All the organic manures were prepared (except FYM) by the end of June, 2014. Well decomposed FYM was brought from

Dairy unit, live stock experimental station, Rajendranagar. Three fourth dose of recommended organic manures were applied basally and remaining 25 per cent at 30 DAS.
Data on growth and yield attributes from randomly selected five plants from each net plot was recorded and the mean value was worked out. The crop was harvested on November 12^{th}, 2014. The pods were hand stripped and sundried to reach constant weight and expressed as q ha^{-1}. After stripping the pods, the haulm yield was also recorded after sun drying and expressed in q ha^{-1}.The data was statistically analyzed by using WINDOSTAT Software Version-7. Significance of the treatments was determined on the basis of F test and critical difference was calculated at 5% level of probability.

Formulae for calculating

- Partial Factor Productivity
  (PFP) = Y/F
- Agronomic efficiency**
  $AE = (Y-Y_0)/F$
- Partial nutrient balance
  $PNB = U_H/F$
- Apparent recovery efficiency by difference**
  $RE = (U-U_0)/F$
- Internal utilization efficiency
  IE = Y/U
- Physiological efficiency**
  $PE = (Y-Y_0)/(U-U_0)$

- Y = Yield of harvested portion of crop with nutrient applied
- Y_0 = Yield with not nutrient applied
- F = Amount of nutrient applied
- U_H = Nutrient content of harvested portion of the crop
- U = Total nutrient uptake in aboveground crop biomass with nutrient applied
- U_0 = Nutrient uptake in aboveground crop biomass with no nutrient applied Units are not shown since the expressions are ratios on a mass basis and are therefore unit less in their standard form. P and K can either be expressed on an elemental basis (most common in scientific literature) or on an oxide basis as P_2O_5 or K_2O (most common within industry).

** Short-term omission plots often lead to an underestimation of the long-term AE, RE, or PE due to residual effects of nutrient application.

Results and Discussion

Agronomic efficiency

This is a short term indicator that indicates how much productivity improvement was gained by use of the nutrient input. It more closely reflects the direct production impact of an applied fertilizer and relates directly to economic return. Agronomic efficiency was significantly higher i.e. 86.7 with 75% RDN through phosphorus enriched vermicompost using rock phosphate 3%. This could be due to the supply of phosphorus for nodule formation when P enriched vermicompost was applied thus enhancing N fixation and yields. While, the agronomic efficiency derived with the applications of 100% RDN through phosphorus enriched vermicompost using rock phosphate 3% and 100% RDN through vermicompost prepared from mushroom spent substrate, 75% RDN through vermicompost prepared from mushroom spent substrate and vermicompost were at a par. Lowest Agronomic efficiency was 35.1 resulted due to the application of gypsum alone.

Partial factor productivity

This indicates how crop was productive in comparison to its nutrient input. Partial factor productivity was higher with 75% RDN through phosphorus enriched vermicompost using rock phosphate 3% (174.3) but which was at par with 75% RDN through vermicompost prepared from mushroom spent substrate and vermicompost. Next to this 100% RDN through phosphorus enriched vermicompost using rock phosphate 3% but at par with 100% RDN through vermicompost prepared from mushroom spent substrate, vermicompost, farmyard manure and 75% RDN through farmyard manure. A very high IE suggests deficiency of that nutrient. Low IE suggests poor internal nutrient conversion due to other stresses (deficiencies of other nutrients, drought stress, heat stress, mineral toxicities, pests, etc.).

Table 1. Agronomic efficiency and Partial Factor Productivity as influenced by organic nutrient management

Treatments		Agronomic efficiency kg kg^{-1}	Partial factor productivity
T_1	100% RDN through vermicompost	69.20	134.80
T_2	100% RDN through farm yard manure	55.23	120.80
T_3	100% RDN through vermicompost prepared from mushroom spent substrate	74.80	140.30
T_4	100% RDN through phosphorus enriched vermicompost using rock phosphate (3%)	79.77	146.60
T_5	75% RDN through vermicompost	75.80	163.20
T_6	75% RDN through farm yard manure	48.23	135.20
T_7	75% RDN through vermicompost prepared from mushroom spent substrate	78.80	166.20
T_8	75% RDN through phosphorus enriched vermicompost using rock phosphate (3%)	86.70	174.63
T_9	Absolute control (no NPK and gypsum)	0.00	0.00
T_{10}	Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation)	35.10	0.00
	SEm ±	1.69	7.79
	CD (P=0.05)	5.02	23.15
	CV (%)	4.85	11.42

Table 2. Internal utilization efficiency as influenced by different organic nutrient management

Treatments		Internal utilization efficiency				
		N	P	K	Ca	S
T_1	100% RDN through vermicompost.	23.64	107.81	54.10	51.70	75.85
T_2	100% RDN through farm yard manure	26.84	128.51	57.60	68.45	77.44
T_3	100% RDN through vermicompost prepared from mushroom spent substrate.	23.74	91.70	49.80	45.95	71.70
T_4	100% RDN through phosphorus enriched vermicompost using rock phosphate 3%.	22.27	78.40	47.13	46.39	69.92
T_5	75% RDN through vermicompost.	29.09	135.96	54.60	58.27	76.95
T_6	75% RDN through farm yard manure.	29.36	153.64	57.40	53.00	82.12
T_7	75% RDN through vermicompost prepared from mushroom spent substrate.	25.59	112.96	52.00	45.99	77.25
T_8	75% RDN through phosphorus enriched vermicompost using rock phosphate 3%.	26.78	107.61	50.50	45.16	71.78
T_9	Absolute control (no NPK and gypsum)	31.09	0.00	0.00	0.00	0.00
T_{10}	Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation)	36.10	160.12	59.00	74.23	97.66
	SEm ±	1.64	5.79	2.74	2.66	4.05
	CD (P=0.05)	4.88	17.21	8.14	7.90	12.03
	CV (%)	10.36	9.32	9.84	9.42	10.00

FOR: N

When the crop was supplemented with gypsum alone @ 500 kg ha^{-1} at flower initiation, the Internal Utilisation Efficiency of nutrients was significantly higher showed significantly higher IUE. Significantly lower IE of nitrogen i.e., 22.27 was realised with 100% RDN through P enriched vermicompost that could be due to the excess application of P through high doses of vermicompost to supplement 100% RDN might have resulted in the poor utilisation or deficiencies of other nutrients.

FOR: P

Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation) showed highest IUE. However, it was on par with 75% RDN through farm yard manure, 75% RDN through vermicompost and 100% RDN through farm yard manure and 75 % RDN through phosphorus enriched vermicompost, vermicompost prepared from mushroom spent substrate, phosphorus enriched vermicompost prepared from 100 and 75 % RDN. Lowest IUE was seen in 100% RDN through phosphorus enriched vermicompost. This could be due to the reason that the excess P absorbed by the crop has not been turned into the yield.

FOR: K

Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation) showed highest IUE but at par with 100% RDN through farm yard manure, vermicompost, 75% RDN through farm yard manure, vermicompost, vermicompost prepared from mushroom spent substrate. Lowest IUE was seen in through phosphorus enriched vermicompost in both100 & 75 % RDN and absolute control.

FOR: Ca

Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation) showed highest IUE but at par with 100% RDN through farm yard manure. Fallowed by 75% RDN through vermicompost this is also at par with 100% RDN through farm yard manure and 75 % RDN through vermicompost, vermicompost farm yard manure. Lowest IUE was seen in through phosphorus enriched vermicompost in both100 & 75 % RDN and absolute control.

FOR: S

Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation) showed highest IUE next to this 75% RDN through farm yard manure. This is also at par with 100% RDN through farm yard manure, vermicompost, vermicompost prepared from mushroom spent substrate, 75 % RDN through vermicompost, vermicompost prepared from mushroom spent substrate and phosphorus enriched vermicompost. Lowest IUE was seen in through phosphorus enriched vermicompost100 % RDN and absolute control.

Table3. Physiological efficiency as influenced by different organic nutrient management

Treatments	Physiological efficiency				
	N	P	K	Ca	S
T_1- 100% RDN through vermicompost.	19.68	73.69	51.18	35.22	56.62
T_2- 100% RDN through farm yard manure	23.80	87.78	57.60	48.79	54.93
T_3- 100% RDN through vermicompost prepared from mushroom spent substrate.	20.00	61.31	44.44	30.99	53.30
T_4- 100% RDN through phosphorus enriched vermicompost using rock phosphate 3%.	18.40	51.99	40.89	31.85	52.55
T_5- 75% RDN through vermicompost.	28.01	95.71	51.54	38.95	62.49
T_6- 75% RDN through farm yard manure.	28.12	98.24	56.98	28.19	56.35
T_7- 75% RDN through vermicompost prepared from mushroom spent substrate.	21.96	74.54	46.93	28.57	55.79
T_8- 75% RDN through phosphorus enriched vermicompost using rock phosphate 3%.	24.12	61.13	44.97	29.19	54.94
T_9- Absolute control (no NPK and gypsum)	--	--	--	--	--
T_{10}- Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation)	--	--	--	--	--
SEm ±	1.50	3.56	2.77	1.83	2.97
CD (P=0.05)	4.46	10.57	8.22	5.43	8.83
CV (%)	10.22	8.75	10.48	10.03	9.99

FOR: N

Among the organic treatments, supplementing the 75% RDN through farm yard manure or vermicompost or P enriched vermicompost through 3% rock phosphate or supplementing 100% RDN through vermicompost were on par showing physiological efficiency of 28.12, 28.01, 24.12 and 23.8 respectively. Lowest physiological efficiency of 18.4 was obtained with 100% RDN through P enriched vermicompost through 3% rock phosphate.

FOR: P

Highest PE with regard to P was exhibited by 75% RDN through farm yard manure which was on par with 75 % RDN through vermicompost and 100 % RDN through farm yard manure. Significantly lower PE obtained when the crop was supplemented with 100 & 75 % RDN through phosphorus enriched vermicompost.

FOR: K

Significantly lower physiological efficiency was seen when nitrogen either 100 or 75% RDN was applied through vermicompost prepared from mushroom spent substrate or P enrichment through 3% rock phosphate.

FOR: Ca

100 % RDN through farm yard manure was showed highest PE this is also at par with Control (no NPK and gypsum @ 500 kg ha-1 at flower initiation). Next to this 75% RDN through vermicompost but at par with 100 % RDN through vermicompost. Fallowed to this 100 & 75 % RDN through phosphorus enriched vermicompost. Lowest PE was seen in 100 & 75 % RDN through vermicompost prepared from mushroom spent substrate and absolute control.

FOR: S

Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation) showed highest PE this is also at par with 75% RDN through vermicompost. Fallowed to this 100 % RDN through vermicompost but at par with farm yard manure, vermicompost prepared from mushroom spent substrate, 100 & 75 % RDN through vermicompost enriched with rock phosphate. Lowest PE was seen in absolute control.

Table 4. Apparent recovery efficiency as influenced by different organic nutrient management

Treatments	Apparent recovery efficiency of N by difference		Partial nutrient balance of N
	RE1	RE2	
T_1- 100% RDN through vermicompost.	3.52	3.15	5.70
T_2- 100% RDN through farm yard manure	2.32	1.95	4.50
T_3- 100% RDN through vermicompost prepared from mushroom spent substrate	3.74	3.37	5.92
T_4- 100% RDN through phosphorus enriched vermicompost using rock phosphate 3%.	4.08	4.03	6.58
T_5- 75% RDN through vermicompost.	2.71	1.66	5.61
T_6- 75% RDN through farm yard manure.	1.70	1.23	4.60
T_7- 75% RDN through vermicompost prepared from mushroom spent substrate.	3.59	2.32	6.49
T_8-75% RDN through phosphorus enriched vermicompost using rock phosphate 3%.	3.60	2.33	6.51
T_9- Absolute control (no NPK and gypsum)	--	--	0.00
T_{10}- Control (no NPK and gypsum @ 500 kg ha^{-1} at flower initiation)	--	--	0.97
SEm ±	0.26	0.16	0.19
CD (P=0.05)	0.78	0.47	0.57
CV (%)	12.54	13.67	7.14

*ARE with respect to absolute control *ARE with respect to control

Apparent recovery efficiency of nitrogen by difference

Apparent recovery efficiency (RE) is one of the more complex forms of NUE expressions and is most commonly defined as the difference in nutrient uptake in above-ground parts of the plant between the fertilized and unfertilized crop relative to the quantity of nutrient applied. It is often the preferred NUE expression by scientists studying the nutrient response of the crop.Apparent recovery with reference to absolute control is higher than the treatment that received gypsum. Among all the organics, supplementing 100%RDN trough P enriched vermicompost showed significantly higher apparent recovery the corresponding values being 4.08 and 4.03 absolute control or control with applied gypsum. Significantly lower apparent recovery of 1.70 and 1.23 respectively was obtained due to the application of 75% RDN through vermicompost.

Partial nutrient balance

Partial nutrient balance (PNB) is the simplest form of nutrient recovery efficiency, usually expressed as nutrient output per unit of nutrient input (a ratio of "removal to use"). Less frequently it is reported as "output minus input." Often the assumption is made that a PNB close to 1 suggests that soil fertility will be sustained at a steady state. A PNB greater than 1 means more nutrients are removed with the harvested crop than applied by fertilizer and/or manure, a situation equivalent to "soil mining" of nutrients. This situation may be desired if available nutrient contents in the soil are known to be higher than recommended. However, in cases where soil nutrient concentration is at or below recommended levels, a PNB >1 must be regarded as unsustainable (Brentrup and Palliere, 2010).Partial factor productivity indicates how much nutrient is being taken out of the system in relation to how much is applied. Among the organic nutrient management treatments Partial nutrient balance of N was higher with application of 100 per cent RDN through phosphorus enriched vermicompost respectively over all other treatments but was also on par with the Application of 75 per cent RDN through phosphorus enriched vermicompost and vermicompost prepared from mushroom spent substrate with corresponding PNBs of 6.58 and 6.5. The above treatment maintained higher level of nutrients throughout the crop growth period which was also supported by Elayaraja and Singaravel, (2011), Sailaja Kumari and Usha Kumari, (2002). Followed to this, vermicompost prepared from mushroom spent substrate equivalent to 100 per cent RDN showed higher partial nutrient balance of N but was on par with 100 per cent RDN through vermicompost and 75 per cent RDN through phosphorus enriched vermicompost. More nutrient balance was due to balanced release and reduction in loss of nitrogen by leaching might be responsible for this (Elayaraja and Singaravel, 2011) 100 per cent RDN through FYM showed lower Partial nutrient balance of N, P and K. Absolute control and control was showed very less amounts of nutrient balance this might be due to non availability or less availability of nutrients.

Conclusion

Low-input and organic agricultural systems present unique environmental conditions and objectives not present in the conventional agriculture. Organic source of N supplement the nutrients slowly over a long period matching the crop needs. This may reduce the leaching losses of nitrogen in nitrate form thus protect water bodies from being polluted. Above this, P enrichment of vermicompost supplies P also for enhanced nodule formation and N fixation. This has resulted in achieving higher use efficiency with organic sources even at 75% of recommended N level.

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