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Review/Overview

Integrated nutrient management in groundnut (*Arachis hypogaea*) in sub-tropical humid climate of North-East India

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ABSTRACT

An experiment was carried out at the ICAR Research Complex for NEH Region, Lembucherra, Tripura during 3 consecutive *kharif* seasons 2008–2010 to study the effect of integrated nutrient management on groundnut (*Arachis hypogaea* L.). The experiment was laid out in randomized block design with 3 replications and 10 treatments, viz. T_0, control, T_1, 10 t FYM/ha; T_2, 50 kg P_2O_5/ha; T_3, 50 kg P_2O_5 + 10 t FYM/ha; T_4, 50 kg P_2O_5 + 50 kg K_2O/ha; T_5, *Rhizobium*; T_6, 10 t FYM/ha + *Rhizobium*; T_7, 50 kg P_2O_5/ha + *Rhizobium*; T_8, 50 kg K_2O + 10 t FYM/ha and T_9, 50 kg P_2O_5 + 50 kg K_2O/ha + *Rhizobium*. Application of *Rhizobium* culture in combination with 50 kg P_2O_5 + 50 kg K_2O/ha resulted in the highest pod and seed weight/plant. The inoculation of *Rhizobium* culture along with 50 kg P_2O_5 + 50 kg K_2O/ha showed 45% increment in pod yield (from 1.37 to 1.95 t/ha) over the control. The highest haulm yield (3.57 t/ha) was obtained with FYM 10 t/ha, The lowest cost of cultivation and energy input were recorded with the control. However, significantly higher total returns (₹84,020/ha), net returns (₹58,447/ha), energy output (49.8 × 10^3 MJ/ha) and net energy (43.2 × 10^3 MJ/ha) were recorded with inoculation of groundnut seed with rhizobium culture along with soil application of 50 kg P_2O_5 + 50 kg K_2O/ha. The highest benefit: cost ratio (3.52) was recorded in plot, which was inoculated with rhizobium culture. Highest energy-use efficiency (7.50), energy productivity (0.30 kg pod yield/MJ) and lowest specific energy (337.6 MJ/kg pod yield) were recorded in plot inoculated with rhizobium culture

Key words : Crop management, Economics, Energy requirement, Groundnut, Integrated nutrient management, Productivity

Groundnut is an important annual legume in the world, mainly grown for oilseed, food and animal feed (Pande *et al.*, 2003). It is a safe, cheap and renewable N source for crops, which are capable of fixing N_2 and therefore profitable for agriculture and eco-friendly for environment (Vance, 2001). The crop also has potential to increase soil fertility, check soil erosion along with meeting the requirement of vegetable oil and protein. Now groundnut has emerged a potential crop for *jhum* and upland areas in North-East hilly region of India. But its productivity is low primarily due to its cultivation in acidic soils with low nutrient and organic matter content. Groundnut is an exhaustive crop and removes large amount of macro- and micro-nutrients from soil. None of the sources of nutrients alone can meet the total plant nutrient need of crop adequately. Hence integrated use of nutrients from chemical, organic and biofertilizers is the most efficient way to supply plant nutrients for sustained crop productivity and improved soil fertility (Singh *et al.*, 2002). Therefore, present investigation was conducted to study the effect of integrated nutrient management on productivity, economics and energetics of groundnut.

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MATERIALS AND METHODS

The experiment was carried out during 2008–10 at the experimental farm of ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra (24°32'N, 92°20' E; 215 m elevation), located in North-East Hilly Agro-Ecological region of India. The soil of experimental plots was a sandy loam with pH 5.2 (acidic), having 0.56% organic carbon, 320 kg/ha available nitrogen, 18 kg/ha available P and 270 Kg/ha available K. The average annual rainfall of the region is 2,200 mm. The experiment consisted of 10 treatments, viz. T_0, control; T_1, 10 t FYM/ha; T_2, 50 kg P_2O_5/ha; T_3, 50 kg P_2O_5 + 10 t FYM/ha; T_4, 50 kg P_2O_5 + 50 kg K_2O/ha; T_5, *Rhizobium*; T_6, 10 t FYM/ha + *Rhizobium*; T_7, 50 kg P_2O_5/ha + *Rhizobium*; T_8, 50 kg K_2O + 10 t FYM/ha and T_9, 50 kg P_2O_5 + 50 kg K_2O/ha + *Rhizo-*

bium. Treatments were laid out in randomized block design with 3 replications.

During all the years, groundnut was grown under rainfed conditions with improved agronomic practices. Groundnut 'ICGS 76' was sown @ 120 kg/ha in the second fortnight of June every year, at 30 cm × 12 cm spacing. The NPK were applied in the form of urea, single superphosphate and muriate of potash respectively, at the time of sowing as per treatment. Under the *Rhizobium*–inoculated treatment, groundnut seed was treated with IGR-6 *Rhizobium* culture. Farmyard manure (FYM) was applied 15 days before sowing in respective treatments. The pre-emergence herbicide, pendimethalin was applied @ 1.0 kg a.i/ha, and the plots were maintained weed free by hand-weeding during growing period. No additional irrigation was applied during the growing period. Chloropyriphos was sprayed 2 ml/litre to control the insects, 2 times in each year. The crop was harvested in the second fortnight of October every year.

Five randomly selected plants from each plot were harvested and separated into pods and haulms, and pod weight (g/plant) and seed weight (g/plant) were determined at maturity. Then, 3 central rows in each plot were hand harvested to determine yield. Pods were air dried to reach 12% moisture content and pod yield/ha was calculated. Haulm yield was determined by subtracting pod yield from total biomass yield. The economics of different treatment of groundnut was calculated by taking into account the various inputs required and outputs realized as per the present cost of inputs and outputs; the formulae used for economic analysis are presented in Table 2.

Energy analysis was taken into account for all the forms of energy input into the production system and energy output from the system and establishes energy relationship for understanding the energy conversion process (Table 1). The data were converted into suitable energy units and expressed in MJ/ha. The input output energy ratio was determined by calculating energy equivalent yields harvested and energy consumed in production. The formulae were used in the experiment to calculate energy analysis as explained in Table 2. All the data were statistically analysed according to the standard method (Panse and Sukhatme, 1978). Means were separated using Fisher's protected least significance difference (LSD) test at 95% level of probability.

RESULTS AND DISCUSSION

Yield attributes and yield

Groundnut yield components were significantly influenced by different nutrient management (Table 3). Significantly highest pod weight/plant and kernel weight/plant were recorded under treatment, where seeds were inoculated with *Rhizobium* culture and crop received 50 kg P_2O_5 and 50 kg K_2O/ha. The results confirm the findings of Zalate *et al*. (2009). The lowest pod and seed weight/plant were observed under the control plot.

Table 1. Energy coefficients

SNo.	Particular	Units	Equivalent energy (MJ)	Reference
Input				
1.	*Human labour*			
		Adult men	Man hour	1.96 Singh *et al*. (2002)
		Women	Woman hour	1.57 Singh *et al*. (2002)
2.	Diesel	Litre	56.31	Pahlavan *et al*. (2012)
3.	Electricity	KWH	11.93	Pahlavan *et al*. (2012)
4.	Chemical fertilizer			
	(a) Nitrogen	kg	60.6	Singh *et al*. (2002)
	(b) P_2O_5	kg	11.1	Singh *et al*. (2002)
	(c) K_2O	kg	6.7	Singh *et al*. (2002)
5.	Organic manure			
	FYM	kg	0.3	Pahlavan *et al*. (2012)
6.	Biofertilizers			
	Rhizobium	kg	120	Ozkan *et al*. (2004)
7.	Plant protection (Superior)			
	Granulated chemical	kg	120	Pahlavan *et al*. (2012)
	Liquid chemical	Litre	120	Pahlavan *et al*. (2012)
8.	Seeds			
		Groundnut	kg	25.0 Mittal *et al*. (1985)
Output				
1.	Groundnut pod	kg (dry mass)	25.0	Mittal *et al*. (1985)
2.	Groundnut Stover	kg (dry mass)	0.24	Singh *et al*. (2002)

Pod and haulm yields were significantly influenced by different nutrient management (Table 3). *Rhizobium* inoculation of groundnut seed along with soil application of 50 kg P_2O_5/ha and 50 kg K_2O/ha recorded significantly maximum pod yield (1.96 t/ha). This may be owing to the fact that seed inoculation with biofertilizer and soil phosphorus and potassium significantly increased the yield components and yield of groundnut. Zalate *et al*. (2009), also reported similar result. Minimum pod yield was recorded in the control plot. Highest stover yield was obtained with application of 10 t FYM/ha. The FYM not only supplied macro and micro nutrients, viz. N, P, K, and S but also improved soil physical condition and availability of nutrients thereby increased growth and stover yield of crops. Similar result was reported by Mohapatra *et al*. (2010). Lowest haulm yield was found in the control plot.

Economics

Data showed that cost of cultivation, gross returns, net returns and benefit: cost ratio were significantly influenced by integrated nutrient management. The lowest cost of cultivation was recorded with the control, while the highest with 50 kg P_2O_5 + 10 t FYM/ha, followed by 50 kg K_2O + 10 t FYM/ha. However, significantly higher gross returns and net returns were recorded with inoculation of groundnut seed with rhizobium culture along with soil application of 50 kg P_2O_5 + 50 kg K_2O/ha compared to all other treatments. Subrahmaniyan *et al*. (1998) also reported similar results. Benefit: cost ratio showed different trends compared to gross returns and net returns, Highest benefit: cost ratio was recorded in plot inoculated with *rhizobium* culture and *rhizobium* culture + 50 kg P_2O_5 + 50 kg K_2O/ha (3.29) compared to all other treatments. This is close conformity with the results reported by Subrahmaniyan *et al.* (2000) and Mohapatra *et al*. (2010).

Energetics

Energy input, output, energy ratio (energy-use efficiency), energy productivity, specific energy as well as net energy were significantly influenced by integrated nutrient management (Table 5). In general, the lowest energy (592 MJ/ha) was required for groundnut production under the

Table 2. Energetic and economic analysis

SNo.	Particular	Formulae	Where
Energetic			
1.	Machine	$ME = \sum_{i=1}^{n} (Tm \times Cvm)$	ME, energy output of machine (MJ); Tm, total machine operation (h); Cvm, caloric value of machine (h)
2.	Fuel	$FE = \sum_{i=1}^{n} (TF \times Cvf)$	FE, energy required for fuel (MJ); TF, Total fuel consumed in operation (L); Cvf, caloric value of the fuel (MJ)
3.	Total energy (MJ/ha)	$TE = \sum_{i=1}^{n} (C_1+C_2+......C_1)$	TE, total energy (MJ/ha); $C_1+C_2+ \ldots C_i$, energy of each component (MJ/ha)
4.	Energy use efficiency	$EUE = \sum_{i=1}^{n} (EU+El)$	EUE, energy use efficiency; EU, energy output (MJ/ha); EI, energy input (MJ/ha)
5.	Specific energy (MJ/kg)	$SE = \sum_{i=1}^{n} (EI+CY)$	SE, specific energy (MJ/kg); CY, crop yield (kg/ha); EI, energy input (MJ/ha)
6.	Energy productivity (kg/MJ)	$PE = \sum_{i=1}^{n} (CY+EI)$	PE, energy productivity (kg/MJ) EI, energy input (MJ/ha); CY, crop yield (kg/ha)
7.	Net energy (MJ/ha)	$NE = \sum_{i=1}^{n} (CY+EI)$	NE, net energy (MJ/ha); EU, energy output (MJ/ha); EI, energy input (MJ/ha)
Economics			
1.	Total cost of production (₹)	$TC = f(H \times M \times F X Ma \times S \times Fe \times P)$	TC, total cost of production; H, human power; M, machine; F, fuel; Ma, manure; S, seed; Fe, fertilizer; P, pesticide (insecticide and fungicide)
2.	Gross returns (₹)	$GR = \sum_{i=1}^{n} (RY - RBP)$	GR, gross return; RY, return from pod yield; RBP, return from stover
3.	Net returns (₹)	$NR = \sum_{i=1}^{n} (GR - TC)$	NR, net return; TC, total cost of production; GR, gross return
4.	Benefit: cost Ratio	$BC = \sum_{i=1}^{n} (GR+TC)$	BC, Benefit: cost ratio); TC, total cost of production; GR, gross return

Table 3. Effect of integrated nutrient management on yield components and yields of groundnut (pooled data of 3 year)

Treatment	Pod weight (g/plant)	Kernel weight (g/plant)	Pod yield (t/ha)	Haulm yield (t/ha)
T_0, Control	8.5	5.4	0.89	2.38
T_1, 10 t FYM/ha	12.0	8.9	1.49	357
T_2, 50 kg P_2O_5/ha	9.0	7.0	1.01	2.97
T_3, 50 kg P_2O_5 + 10 t FYM/ha	9.7	7.5	1.49	2.38
T_4, 50 kg P_2O_5 + 50 kg K_2O/ha	10.1	8.1	1.37	2.23
T_5, *Rhizobium*	10.5	11.5	1.67	2.52
T_6, 10 t FYM/ha + *Rhizobium*	13.9	12.6	1.67	2.63
T_7, 50 kg P_2O_5/ha + *Rhizobium*	12.3	9.0	14.88	2.43
T_8, 50 kg K_2O + 10 t FYM/ha	11.5	9.5	1.55	2.62
T_9, 50 kg P_2O_5 + 50 kg K_2O/ha + *Rhizobium*	15.8	14.1	1.96	2.73
SEm±	0.04	0.34	0.08	0.13
CD (P=0.05)	1.2	1.02	0.25	0.39

Table 4. Effect of integrated nutrient management on cost of cultivation, gross returns, net returns and benefit: cost ratio of groundnut (pooled data of 3 year)

Treatment	Cost of cultivation (× 10^3₹/ha)	Gross returns (× 10^3₹/ha)	Net returns (× 10^3₹/ha)	Benefit: cost ratio
T_0, Control	20.0	40.1	20.4	2.02
T_1, 10 t FYM/ha	30.6	66.7	36.1	2.18
T_2, 50 kg P_2O_5/ha	23.8	46.4	22.6	1.95
T_3, 50 kg P_2O_5 + 10 t FYM/ha	34.2	64.3	30.1	1.88
T_4, 50 kg P_2O_5 + 50 kg K_2O/ha	25.4	59.2	33.8	2.33
T_5, *Rhizobium*	20.4	71.7	51.3	3.52
T_6, 10 t FYM/ha + *Rhizobium*	30.9	71.9	41.0	2.33
T_7, 50 kg P_2O_5/ha + *Rhizobium*	24.2	64.4	40.2	2.67
T_8, 50 kg K_2O + 10 t FYM/ha	32.2	67.2	35.0	2.09
T_9, 50 kg P_2O_5 + 50 kg K_2O/ha + *Rhizobium*	25.6	84.0	58.4	3.29
SEm±		3.6	3.6	0.13
CD (P=0.05)		10.8	10.8	0.40

Table 5. Effect of integrated nutrient management on energy use efficiency of groundnut production (pooled data of 3 year)

Treatment	Energy input (× 10^3 MJ/ha)	Energy output (× 10^3 MJ/ha)	Net energy (× 10^3 MJ/ha)	Energy-use efficiency	Energy productivity (kg/MJ)	Specific energy (MJ/kg)
T_0, Control	5.6	22.9	17.4	4.17	0.16	6.14
T_1, 10 t FYM/ha	8.5	38.1	29.6	4.48	0.18	5.71
T_2, 50 kg P_2O_5/ha	6.1	26.0	19.9	4.30	0.17	5.98
T_3, 50 kg P_2O_5 + 10 t FYM/ha	9.1	37.8	28.7	4.17	0.16	6.08
T_4, 50 kg P_2O_5 + 50 kg K_2O/ha	6.4	34.8	28.4	5.44	0.21	4.67
T_5, *Rhizobium*	5.7	42.3	36.6	7.37	0.29	3.44
T_6, 10 t FYM/ha + *Rhizobium*	8.7	42.3	33.5	4.84	0.19	5.24
T_7, 50 kg P_2O_5/ha + *Rhizobium*	6.3	37.8	31.5	6.00	0.24	4.23
T_8, 50 kg K_2O + 10 t FYM/ha	8.8	39.3	30.5	4.45	0.18	5.70
T_9, 50 kg P_2O_5 + 50 kg K_2O/ha + *Rhizobium*	6.6	49.8	43.2	7.50	0.30	3.37
SEm±		2.1	2.1	1.03	0.14	
CD (P=0.05)		6.3	6.3	3.10	0.41	

control, while highest energy required for 50 kg P_2O_5 + 10 t FYM/ha and followed by 50 kg K_2O + 10 t FYM/ha plots. However, significant higher energy output and net energy recorded with inoculation of groundnut seed with rhizobium culture along with soil application of 50 kg P_2O_5 + 50 kg K_2O/ha than all the other treatments. The higher energy output and net energy under this treatment was mainly owing to higher pod yield and lower energy requirement. This was due to maximum energy produced with lowest energy expenditure (Shahan *et al*., 2008). Although energy-use efficiency, energy productivity and specific energy showed different trends compared to energy output and net energy, Highest energy-use efficiency, energy productivity and lowest specific energy were recorded with rhizobium + 50 kg P_2O_5 + 50 kg K_2O/ha compared to all other treatments.

It was concluded that to get maximum productivity, profitability and energy-use efficiency from groundnut in acidic soils of Tripura, the crop should be managed with *Rhizobium* inoculation along with application 50 kg P_2O_5 + 50 kg K_2O/ha.

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