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Energetics and economics of green gram [*Vigna radiata* (L.) Wilczek] as influenced by varying land configuration and nutrient management

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Abstract

Field experiments were carried out at the Agronomy Main Research Farm, O.U.A.T. Bhubaneswar, Odisha, India during 2019 and 2020 to find out energetics and economics of green gram as influenced by varying land configuration and nutrient management practices. Split-plot Design was adopted with three replications. Results of the experiment showed that raised bed method with PDM-139 cultivar in combination with F6 treatment gave the highest pooled yield (522.84 kg ha^{-1} and 455.29 kg ha^{-1}) respectively. Similar trend was observed in Energy productivity (0.358kg MJ/ha and 0.335 kg/MJ respectively) and efficiency (1.42 kg MJ ha^{-1} and 1.17 MJ ha^{-1}respectively). Economic analysis also revealed that flat bed with PDM-139 with F6 treatment combination gave the highest pooled B: C ratio (1.75) during the years of investigation.

Keywords

Economics, Energetics, Green gram, Land configuration, Nutrient management

Introduction

India holds the first place in producing as well as consuming pulses in the world and contributes 25.5% to the total global pulse production. The third most important pulse crop of India is green gram (*Vigna radiata* L.) and is grown in about 8 per cent of the total pulse area of the nation. Land configuration, by way of altering the soil physical environment can play a vital row towards increased population by unhindered and uniform germination (1). Odisha comes under the 'Eastern Plateau and Hill Region' agro-climatic zone of India. The predominant soil types are Alluvial and Lateritic and the climate is hot and humid.(Author can write some more details of study area about soil and nutrient management of study area, include climatic aspects also) The rising cost of fertilizers, and the sustainability issues due to overuse of chemical fertilizers in an indiscrete manner, has necessitated for balanced and appropriate use of nutrients. The concept of energy in agriculture is vital with respect to crop production and agro processing for value addition (2). Energy and agriculture have a close relationship. Agriculture is a major consumer of energy and a producer of bioenergy. Currently, energy usage determines the productivity and profitability of agriculture (3). Due to rising population levels, a decreasing amount of arable land, and a desire for higher living standards, energy use in agriculture has increased. These considerations have supported an increase in energy inputs across all societies in an effort to maximise yields, reduce labour-intensive behaviours, or both (4). Agriculture requires a significant amount of locally accessible commercial and non-commercial energy sources, including diesel, power, fertiliser, plant protection chemicals, irrigation water, machinery, and animate energy sources like seed, manure, and animals. Utilizing these resources effectively helps to boost production and productivity, as well as the economy, profitability, and competitiveness of agriculture, all of which are important for the sustainability of rural life (5). Keeping these things in view, the present experiment was conducted to study the energetics and economics of green gram production in relation to varying land configuration and nutrient management.

Materials and Methods

The experiment was conducted during summer season of 2016 and 2017 at the Agronomy Main Research Farm, O.U.A.T. Bhubaneswar, Odisha. Bhubaneswar is situated in the east and south eastern coastal plain Agro-Climatic Zone of Odisha. at 20015' N latitude and 850 52'E longitude with an altitude of 25.9 m above mean sea level. The soil of the experimental site was sandy loam (Bouyoucous Hydrometer method, Piper, 1950), having pH 5.5 (Glass electrode Beckman's pH meter, Jackson, 1973), organic carbon 0.75 % (Walkley and Black's Wet Digestion method), available nitrogen 225.5 kg ha^{-1} (Alkaline $KMnO_4$ method, Subbiah and Asija, 1956), available phosphorus 45.6 kg ha^{-1} (Bray's-1 'P' method, Jackson, 1973) and available potassium 129 kg ha^{-1} (Ammonium acetate Extraction by flame Photometer, Jackson,1973) (Author provide reference of experiment methods which followed for analysing the p^H, Organic Carbon, N, P, K). The experiment was laid out in Split-plot Design (20) (Author provide reference of design) with three replications and net plot size was 5 m x 4 m. There were four main plot treatments having a combination as of two land configuration (M1-flatbed method and M2- raised bed method) and two varieties (V1- Nayagarh local and V2- PDM-139). Sub-plots were allotted with six nutrient management practices like F1= Farmer's Practice (100 kg DAP ha^{-1} + need based plant protection), F2= F1+ seed inoculation with Rhizobium + PSB soil application, F3 = F2 + lime @ 5q ha-1, F4 = F2 + NPK as RDF i.e., 20-40-20 kg N-P_2O_5-K_2O ha^{-1} (no flat application of DAP), F5 = F2 + Soil test based NPK application, 25-40-25 kg N-P_2O_5 - K_2O ha^{-1}, F6= F2 + STCR based NPK application (Table 1). Under STCR ((F6) variety wise doses were arrived using following equations keeping a target yield of 6 and 8 q ha^{-1} for the variety Nayagarh local and PDM-139, respectively.

FN= 11.48 T – 0.51 SN

FP2O5 = 8.76 T – 0.76 SP2O5

FK2O = 12.21 T – O.51 SK2O

Where, T- target yield, SN- soil nitrogen value

Accordingly, the dose for the variety V1- Nayagarh local and V2 -PDM-139, the dose was worked as 5:22:7.5kg N-P2O5-K2O ha^{-1} and the seeds were treated with fungicide, carbendazim @ 1.5g kg-1 of seed at 7 days before sowing followed by treatment wise inoculation with Rhizobium and PSB @ 20 g kg^{-1} of seeds. To reduce the crop weed competition and to provide better crop growth one hand weeding was done at 21 DAS in all the treatments. The crop was sown on 19th February, 2019 and 22nd February, 2020 with the help of tyne and was harvested manually on 10th April, 2019 and 13th April, 2020 respectively. For each treatment, the energy input from seeding to harvest was calculated. With accordance to the standards set forth by Mittal et al. (6), it was calculated in Mega Joule (MJ) ha^{-1} (Table 2). To calculate the energy output, the conventional energy coefficients for seed and straw were multiplied by the corresponding yields. Based on the energy equivalents of inputs and outputs, Rafiee et al. (7) derived energy indices such as energy ratio (energy output/energy input), energy productivity (grain yield/energy input), and specific energy (energy input/grain output) using formulas recommended by Singh et al. 1997 (8). The cost of the inputs and the income from the output were taken into consideration while calculating the economics of various treatments (grain and stover yield). For each therapy, the gross and net returns as well as a benefit: cost ratio were calculated as follows.

Table 1: Seed yield, haulm yield and Harvest Index as influenced by varying land configuration and nutrient management (Pooled data of two years)

Treatments	Seed yield (kg ha^{-1})	Haulm Yield (kg ha^{-1})	Harvest Index
Land configuration and variety			
Flat bed with Nayagarh Local	378.65	988.21	27
Flat bed with PDM 139	423.75	1316.14	24
Raised Bed with Nayagarh Local	339.62	1213.27	21
Raised bed with PDM 139	522.84	1418.09	26
LSD (0.05)	26.64	25.60	
Nutrient management			
1. Farmer's Practice(100 kg DAP ha^{-1}+ need based plant protection)	341.90	988.47	26
F2. F1+ seed inoculation with Rhizobium + PSB soil application	410.64	1083.33	27
F3. F2 + lime @ 5q ha^{-1}	433.65	1181.34	27
F4. F2 + NPK as RDF i.e. 20-40-20 kg N-P2O5-K2O ha^{-1} (no flat application of DAP)	452.27	1299.81	26
F5. F2 + soil test based NPK application i.e. 25-40-25 kg N-P2O5-K2O ha^{-1}	402.82	1398.26	22
F6. F2 + STCR based NPK application	455.29	1461.34	24
LSD (0.05)	76.13	22.19	

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ ha}-1)}{\text{Energy input (MJ ha}-1)} \quad \text{..........(22)}$$

$$\text{Energy productivity} = \frac{\text{crops output (Kg ha}-1)}{\text{Energy input (MJ ha}-1)} \quad \text{............(22)}$$

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}-1)}{\text{crops output (Kg ha}-1)} \quad \text{..................(22)}$$

Table 2: Input and output energy of green gram cultivation (Pooled data of two years)

Sl.No.	Input and Output	Units	Equivalent energy (MJ)	Total energy (MJ)	References
INPUT					
1.	Human Labour	Man hour	1.96(67 man days)	1050.56	(6)
2.	Diesel	Litre	56.31(31.1 L)	1751.24	(6)
3.	Farm Machinery	Hour	62.70 (16 hr)	1003.2	6)
4.	Bullock	Pair hour	10.10	161.60	(15)
5.	Fertilizer				
5.a.	Nitrogen	Kilogram	60.6	As per treatment	6)
5.b.	Phosphorous	Kilogram	11.10	As per treatment	(6)
5.c.	Potassium	Kilogram	6.7	As per treatment	(6)
6.	Fungicide	Kilogram	196.00	7.84 (40 g Bavistin)	(16)
7.	Biofertilizers	Kilogram	10	8 (20g Rhizobium+20g PSB)	(17,18)
	Lime	Kilogram	0.6	300 (5 q ha^{-1})	
8.	Seed	Kilogram	14.70	294 (20 kg)	(19)
OUTPUT					
	Seed Yield	Kilogram	14.70	As per treatment	(19)

Results and discussion

Seed yield, Haulm Yield and Harvest Index

The data pertaining to seed yield, haulm yield and Harvest Index are presented in Table 1. The nutrient management had a substantial impact on the seed and haulm yield of green gram. The treatment F6 produced significantly higher seed (455.69 kg ha^{-1}) and haulm yield (1461.3 kg ha^{-1}) over the other treatments (Table 1). Higher growth and yield attributing features were correlated with an increase in it. Additionally, the STCR -based nutrient management helped to increase yield by translocating more photosynthetic products to seeds. More than 80% of the trials carried out by various STCR centres revealed favourable outcomes for the STCR strategy (9).

Energetics

Data presented in the Table 3 revealed that energetics of green gram crop varied due to different land configuration and varying nutrient management practices. In the main plot treatments, the highest energy was used with the PDM-139 varieties (5420.89 MJ ha^{-1}). This is due to the fact that, as per STCR equations, the fertilizer rates for that cultivar was higher than Nayagarh Local cultivar. In the sub-plots, the maximum energy was used in F5 treatment (6404 MJ ha^{-1}) followed by F3 (6188.84 MJ ha^{-1}). The least energy was used by Nayagarh local in the main plots (5173.89 MJ ha^{-1}) and F6 in the sub-plots (5720.34 MJ ha^{-1}).

The maximum energy output was recorded in raised bed method with PDM-139 cultivar (7685.75 MJ ha^{-1}) and in the sub-plots from F6 treatment (6692.76 MJ ha^{-1}).

Table 3: Energy productivity of green gram cultivation as influenced by varying land configuration and nutrient management (Pooled data of two years)

Treatments	Input Energy Equivalents (MJ ha^{-1})	Input Energy Equivalents for treatments (MJ ha^{-1})	Total energy Equivalent (MJ ha^{-1})	Energy Output (MJ/ha)	Energy Productivity (kg/MJ)	Specific Energy	Energy Efficiency (kg/MJ)
Land configuration and variety							
Flat bed with Nayagarh Local	4576.44	597.45	5173.89	5566.15	0.264	13.66	1.08
Flat bed with PDM 139	4576.44	844.45	5420.89	6229.13	0.321	12.79	1.15
Raised Bed with Nayagarh Local	4576.44	597.45	5173.89	4992.41	0.300	15.23	0.96
Raised bed with PDM 139	4576.44	844.45	5420.89	7685.75	0.358	10.37	1.42
1. Farmer’s Practice(100 kg DAP ha^{-1} + need based plant protection)	4268.44	1601.40	5869.84	5025.93	0.227	17.17	0.86
F2. F1+ seed inoculation with Rhizobium + PSB soil application	4278.44	1609.8	5887.84	6036.41	0.254	14.34	1.03
F3. F2 + lime @ 5q ha^{-1}	4279.04	1909.8	6188.84	6374.66	0.261	14.27	1.03
F4. F2 + NPK as RDF i.e. 20-40-20 kg N-P2O5-K2O ha^{-1} (no flat application of DAP)	4278.44	1790.0	6068.44	6648.37	0.289	13.42	1.10
F5. F2 + soil test based NPK application i.e. 25-40-25 kg N-P2O5-K2O ha^{-1}	4278.44	2126.50	6404.94	5921.45	0.281	15.90	0.92
F6. F2 + STCR based NPK application	4278.44	1441.90	5720.34	6692.76	0.335	12.56	1.17

The minimum energy output was observed from Raised bed method with Nayagarh Local (4992.41 MJ ha^{-1}) and F1 treatment (5025.93 MJ ha^{-1}).

The data on energy productivity showed that Raised bed method with PDM-139 (0.358 kg/MJ) and F6 (0.335 kg/MJ) recorded the highest value of energy productivity in main plots and sub-plots respectively. Similar to the trend in energy output and energy productivity, the energy ratio was the highest (1.42) under Raised bed method with PDM-139 and F6 (1.17) respectively. The higher values of energy parameters exhibited by different treatments were on account of higher seed and haulm yields and lower energy inputs under these treatments. Similar findings have also been reported by many literatures (10-14).

Economics

From Table 4, economic analysis revealed that maximum gross return of Rs. 35978 ha^{-1} was obtained with flatbed method of land configuration with PADM-139 cultivar and F6 treatment combination. Higher gross return was simply due to higher yield during both the years of experimentation (Table 1). Perusal of data revealed that the highest net realization (Rs. 15411) was obtained under the same treatment combination with the BCR value of 1.75.

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Authors contributions

SR was responsible for carrying out the work, manuscript preparation and communication of the manuscript, GM has reviewed the manuscript, JMLG and AKM has provided guidance and helped throughout the whole process.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

Table 4: Cost of cultivation, net profit and benefit: cost ratio under different treatments as influenced by varying land configuration and nutrient management (Pooled data of two years)

Treatment	Cost of cultivation, Rs ha^{-1}	Gross return, Rs ha^{-1}	Net return, Rs ha^{-1}	B-C ratio
M1F1	14100	23402	9302	1.66
M1F2	17132	26490	9358	1.55
M1F3	19632	29045	9413	1.50
M1F4	20043	29725	9682	1.48
M1F5	20935	23719	2785	1.13
M1F6V1	18561	23951	5390	1.29
M1F6V2	20567	35978	15411	1.75
M2F1	13750	17623	3783	1.28
M2F2	15682	22787	7105	1.45
M2F3	18482	22974	4492	1.24
M2F4	18893	24591	5698	1.30
M2F5	19784	24627	4843	1.25
M2F6V1	17411	22285	4874	1.28
M2F6V2	17517	27356	9839	1.56
M1F1	14100	23402	9302	1.66

Conclusion

Thus, from this study it is concluded that raised bed method with PDM-139 in combination with F6 treatment is more productive and energy efficient in East and South-eastern coastal plain of Odisha. Thus the modified raised bed method assures better growth of the green gram crop and the local variety can be replaced with the improved variety PDM 139. Moreover, the STCR strategy proves to be an efficient option for the nutrient management over the other treatments.

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