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Energetics and economics of green gram [*Vigna radiata* (L.) Wilczek] as influenced by varying level of nitrogen

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ABSTRACT : A field experiment was carried out at Instructional farm of Uttar Banga Krishi Viswavidyalaya, West Bengal, India during 2016 and 2017 to find out energetics and economics of green gram as influenced by varying levels (9) of nitrogen fertilizer. Randomized Block Design was adopted with three replications. Results of the experiment showed that 25 kg nitrogen ha^{-1} in the form of urea, at constant level of phosphorus and potassium recorded highest growth attributes, which leads to more grain (914.54 and 926.83 kg ha^{-1} during 2016 and 2017, respectively) yield followed by 30 kg N ha^{-1} (T_7) and 35 kg N ha^{-1} (T_8). Treatment receiving no nitrogen recorded significantly lowest plant height, number of branches $plant^{-1}$ and grain yield of green gram. For every kg increase of nitrogen beyond 25 kg there was a yield reduction to the extent of 8 to 16 kg ha^{-1}. Energy productivity (0.14 kg MJ^{-1}) and efficiency (2.07 kg MJ^{-1}) was also found to be highest under T_6, whereas plot receiving no nitrogen recorded highest values of specific energy (12.23). Economic analysis also revealed that T_6 recorded highest B: C ratio (1.52 and 1.54) during both the year of investigation.

KEY WORDS : Economics, Energy productivity, Green gram, Specific energy

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India is the highest producer as well as consumer of pulses in the world and contributes 25.5% of total global pulse production. Green gram (*Vigna radiata* L.) is the third important pulse crop of India grown in nearly 8 per cent of the total pulse area of the country. Energy in agriculture is important in terms of crop production and agro processing for value adding (Karimi *et al.,* 2008). The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy. At present, productivity and profitability of agriculture depends on energy consumption (Alam *et al.,* 2005). Energy use in agriculture has developed in response to increasing populations, limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximise, yields, minimise labour-intensive practices, or both (Esengun *et al.,* 2007). Agriculture uses large quantities of locally available non-commercial energies, such as seed, manure and animate energy, and commercial energies directly and indirectly in the form of diesel, electricity, fertilizer, plant protection, chemicals, irrigation water, machinery, etc. Efficient use of these energies helps to achieve increased production and productivity and contribute to economy, profitability and competitiveness of agriculture sustainability to rural living

(Singh *et al.,* 2002). Keeping these things in view, the present experiment was conducted to study the energetics and economics of green gram production in relation to varying level of nitrogen.

Research Procedure

The experiment was conducted during pre-*Kharif* season of 2016 and 2017 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. Cooch Behar is situated in the terai agro climatic zone at $26^0 19'86''$ N latitude and $89^0 23'53''$ E longitude and at an elevation of 43 meters above mean sea level. The soil of the experimental site was sandy loam having pH 5.51, organic carbon 0.74 %, available nitrogen 158.19 kg ha^{-1}, available phosphorus 25.30 kg ha^{-1} and available potassium 112.20 kg ha^{-1}. The experiment was laid out in Randomized Complete Block Design with three replications and net plot size was 5 m x 4 m. The experiment comprised of the nine treatments T_1 = No nitrogen fertilizer (control); T_2 = Nitrogen@5 kg ha^{-1}; T_3 = Nitrogen@10 kg ha^{-1}; T_4 = Nitrogen@15 kg ha^{-1}; T_5 = Nitrogen@20 kg ha^{-1}; T_6= Nitrogen@25 kg ha^{-1}; T_7 = Nitrogen@30 kg ha^{-1}; T_8 = Nitrogen@35 kg ha^{-1} and T_9 = Nitrogen@40 kg ha^{-1}. Green gram variety Pusa Baishaki was sown with the help of tyne in the row at a row distance of 30 cm on April 13^{th} and March 14^{th} during 2016 and 2017, respectively. A plant spacing of 10 cm within the rows was maintained by thinning done about 15 days after sowing. All other agronomic practices such as weeding, hoeing, irrigation, plant protection measures etc. were kept normal and uniform for all the plots. Nitrogen was applied as per treatments in the form of urea (46% N), phosphorus @ 50 kg ha^{-1} in the form of single super phosphate (16% P_2O_5) and potassium @ 30 kg ha^{-1} in the form of muriate of potash (60% K_2O) were applied below the seeds at the time of sowing of the crop. The crop was harvested manually on 16^{th} June and 15^{th} July during 2016 and 2017, respectively. Energy input was calculated from sowing to harvest pertaining to each treatment. It was estimated in Mega Joule (MJ) ha^{-1} with reference to the standard values prescribed by Mittal *et al.* (1985). The standard energy coefficients for seed and straw were multiplied with their respective yields and summed upto obtain the energy output. Based on the energy equivalents of inputs and output, the energy indices such as energy ratio (energy output/energy input), energy productivity (grain yield/energy input) were calculated as per Rafiee *et al.* (2010) and specific energy (energy input/grain output) was calculated as per formulae as suggested by Singh *et al.* (1997).

Research Analysis and Reasoning

The findings of the present study as well as relevant discussion have been presented under following heads :

Plant height, number of branches plant^{-1} and seed yield:

The data pertaining to plant height at maturity as influenced by the nitrogen levels at constant level of phosphorus and potassium are presented in Table 1. Maximum plant height of 51 and 57.04 cm during 2016 and 2017, respectively, which was closely followed by T_7 (nitrogen @ 30 kg ha^{-1}) and T_8 (nitrogen @ 30 kg ha^{-1}) though all the treatments were statistically at par. This might be due to favorable function of nitrogen being a major structural constituent of cell helps in stimulating the cell division and cell enlargement, which increased plant height. These results are in conformity with the findings of Singh *et al.* (2011); Azadi *et al.* (2013) and Achakzai *et al.* (2012). Shorter plant height at control plot (T_1) might be due to inhibition of cell division or cell enlargement. Maximum number of branches plant^{-1} (2.89 and 3.11 during 2016 and 2017, respectively) was recorded under T_6 (25 kg N ha^{-1}) which was followed by T_7, T_8, T_9 and T_5, though all were statistically at par. In general number of branches plant^{-1} was found to be higher in second year. Similar findings were also scrutinized by Achakzai *et al.* (2012); Sultana *et al.* (2009) and Patel (2012).

Seed yield is the result of cumulative effects of varietals potential and integrated management of different agronomic practices. Seed yield ranged from 404.53 to 914.54 kg ha^{-1} during 2016, 415.03 to 926.83 kg ha^{-1} during 2017. Highest seed yield (914.54 and 926.83 kg ha^{-1}) was noted with T_6 *i.e.* nitrogen @ 25 kg ha^{-1}, which was closely followed by T_7 *i.e.* nitrogen @ 30 kg ha^{-1}, T_8 (nitrogen @ 35 kg ha^{-1}) and T_5 (nitrogen @ 20 kg ha^{-1}) during both the years of experimentation. The positive response to application of 25 kg nitrogen ha^{-1} may be attributed to the better nutrient availability and its favourable effect on soil physical and biological properties resulting in increased growth and yield attributes and finally higher yields. The results are in close agreement with the observation of Sharma *et al.* (2003); Mozumdar *et al.* (2003); Malik *et al.* (2003); Yakadri *et al.* (2004); Singh *et al.* (2011); Rajkhowa *et al.* (2002) and Srinivas and Mohammad (2002). It was also noticed from that seed yield was found to be higher in the second year of investigation irrespective of treatments. It is clear that seed of green gram decreased with the increased application of nitrogen beyond 25 kg ha^{-1}. Lower pod yield might be due to comparatively lower crop growth rate at vital stages of growth.

Energetics of green gram:

Data presented in the Table 3 revealed that energetics of green gram crop varied due to different levels of nitrogen fertilizer influence. Application of 40 kg nitrogen ha^{-1} to green gram used the maximum energy (7436.80 MJ ha^{-1}) followed by 35 kg nitrogen ha^{-1} (7133.80 MJ ha^{-1}) and the least energy were used by treatment with no nitrogen fertilizer (5009.80 MJ ha^{-1}) for production of green gram. The application of 25 kg nitrogen ha^{-1} (T_6) recorded highest energy output of green gram (13534 MJ ha^{-1}) and the lowest energy output (6023.77 MJ ha^{-1}) was registered under T_1 (No nitrogen fertilizer).

The data on energy productivity showed that application of 25 kg nitrogen ha^{-1} recorded significantly the highest value of energy productivity (0.14 kg MJ^{-1}), which was higher by 24.11 and 41.84 % than those recorded from T_9 (Nitrogen@ 40 kg ha^{-1}) and T_1 (No nitrogen fertilizer), respectively.

Similar to the trend in energy output and energy productivity, the energy ratio was the highest (2.07) under T_6 (Nitrogen @ 25 kg ha^{-1}) followed by T_3 (2.04), T_4 (1.97) and T_2 (1.86) and the least from no nitrogen fertilizer (1.20). The higher values of energy parameters exhibited by different levels of nitrogen to green gram were on

Table 1 : Plant height, branching and seed yield of green gram as influenced by varying level of nitrogen

Treatments	Plant height (cm) at harvest		No. of branches plant^{-1} at harvest		Seed yield (kg ha^{-1})	
	2016	2017	2016	2017	2016	2017
T_1= No nitrogen fertilizer	40.89	42.40	2.00	2.22	404.53	415.03
T_2= Nitrogen@5 kg ha^{-1}	44.33	46.52	2.22	2.33	664.32	683.74
T_3= Nitrogen@10 kg ha^{-1}	45.00	47.17	2.33	2.44	773.07	783.27
T_4= Nitrogen@15 kg ha^{-1}	45.67	47.20	2.44	2.56	793.84	793.01
T_5= Nitrogen@20 kg ha^{-1}	45.67	48.54	2.56	2.61	810.94	811.84
T_6= Nitrogen@25 kg ha^{-1}	51.00	57.04	2.89	3.11	914.54	926.83
T_7= Nitrogen@30 kg ha^{-1}	50.67	54.38	2.78	2.89	841.55	837.11
T_8= Nitrogen @ 35kg ha^{-1}	50.22	50.74	2.67	2.67	829.85	811.01
T_9= Nitrogen@40 kg ha^{-1}	46.33	48.54	2.44	2.56	800.04	798.50
S.E. ±	2.80	2.60	0.27	0.22	0.72	2.72
C.D. (P=0.05)	NS	7.87	NS	NS	2.18	NS

NS=Non-significant

Table 2 : Input and output energy of green gram cultivation

Sr. No.	Input and output	Units	Equivalent energy (MJ)	Total energy (MJ)	References
Input					
1.	Human labor	Man hour	1.96	1238.72 (79 Man days)	Mittal *et al.* (1985)
2.	Diesel	Litre	56.31	1661.14 (29.5 L)	Mittal *et al.* (1985)
3.	Farm Machinery	Hour	62.70	940.50 (15 hr)	Mittal *et al.* (1985)
4.	Bullock	Pair hour	10.10	161.60	Devasenapathy *et al.* (2008)
5.	Fertilizer				
	Nitrogen	kg	60.6	As per treatment	Mittal *et al.* (1985)
	Phosphorus	kg	11.10	555 (50 kg)	Mittal *et al.* (1985)
	Potassium	kg	6.7	201 (30 kg)	Mittal *et al.* (1985)
6.	Fungicide	kg	196.00	7.84 (40 g Bavistin)	Khosruzzaman *et al.* (2010)
7.	Seed	kg	14.70	294 (20 kg)	Mandal *et al.* (2002)
Output					
Seed yield		kg	14.70	As per treatment	Mandal *et al.* (2002)

Table 3: Energy productivity of green gram cultivation as influenced by varying level of nitrogen

Treatments	Input energy equivalents (MJ ha^{-1})	Input energy equivalents (MJ ha^{-1}) for treatments	Total energy equivalent (MJ ha^{-1})	Energy output (MJ ha^{-1})	Energy productivity (kg MJ^{-1})	Specific energy	Energy efficiency (kg MJ^{-1})
T_1= No nitrogen fertilizer	5009.80	-	5009.80	6023.77	0.082	12.23	1.20
T_2= Nitrogen@5 kg ha^{-1}	5009.80	303.00	5312.80	9908.24	0.127	7.88	1.86
T_3= Nitrogen@10 kg ha^{-1}	5009.80	606.00	5615.80	11439.10	0.139	7.22	2.04
T_4= Nitrogen@15 kg ha^{-1}	5009.80	909.00	5918.80	11663.42	0.134	7.46	1.97
T_5= Nitrogen@20 kg ha^{-1}	5009.80	1212.00	6221.80	11927.43	0.130	7.67	1.92
T_6= Nitrogen@25 kg ha^{-1}	5009.80	1515.00	6524.80	13534.00	0.141	7.09	2.07
T_7= Nitrogen@30 kg ha^{-1}	5009.80	1821.00	6830.80	12338.15	0.123	8.14	1.81
T_8= Nitrogen @ 35kg ha^{-1}	5009.80	2124.00	7133.80	12060.32	0.115	8.70	1.69
T_9= Nitrogen@40 kg ha^{-1}	5009.80	2427.00	7436.80	11749.27	0.107	9.30	1.58

Table 4 : Economics of green gram as influenced by varying level of nitrogen

Treatments	Cost of cultivation (Rs. ha^{-1})		Gross return (Rs. ha^{-1})		Net return (Rs. ha^{-1})		B:C ratio (Rs. ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1= No nitrogen fertilizer	24449.80	24824.38	28541.51	29302.18	4091.70	4477.80	0.17	0.18
T_2= Nitrogen@5 kg ha^{-1}	24512.5	24890.38	45829.12	47067.13	21316.62	22176.75	0.87	0.89
T_3= Nitrogen@10 kg ha^{-1}	24575.2	24956.38	53660.52	53796.06	29085.32	28839.68	1.18	1.16
T_4= Nitrogen@15 kg ha^{-1}	24637.9	25022.38	55143.47	54494.83	30505.57	29472.45	1.24	1.18
T_5= Nitrogen@20 kg ha^{-1}	24700.6	25088.38	55731.98	55944.05	31031.38	30855.67	1.26	1.23
T_6= Nitrogen@25 kg ha^{-1}	24763.3	25154.38	62842.11	63447.61	38078.81	38293.23	1.54	1.52
T_7= Nitrogen@30 kg ha^{-1}	24826	25220.38	57747.67	57772.98	32921.67	32552.60	1.33	1.29
T_8= Nitrogen @ 35kg ha^{-1}	24888.7	25286.38	56690.04	55916.70	31801.34	30630.32	1.28	1.21
T_9= Nitrogen@40 kg ha^{-1}	24951.4	25352.38	55241.19	54870.38	30289.79	29518.00	1.21	1.16

account of higher seed and haulm yields and lower energy inputs under these treatments. Similar findings have also been reported by Roy *et al.* (2015); Chauhan *et al.* (2017); Salami and Ahmadi (2010) and Mohanty *et al.* (2014).

Economics:

Economic analysis revealed that maximum gross return of Rs. 62842.11 ha^{-1} and Rs. 63447.61 ha^{-1} were obtained with application of 25 kg nitrogen ha^{-1} *i.e.* T_6, which was closely followed by Rs. 57747.67 ha^{-1} and Rs. 57772.98 ha^{-1} with 30 kg nitrogen ha^{-1}*i.e.* $T_{7,}$ Rs. 56690.04 ha^{-1} and Rs. 55916.70 ha^{-1} with 35 kg nitrogen ha^{-1}*i.e.* T_8 and Rs. 55731.98 ha^{-1} and Rs. 55944.05 ha^{-1} with 20 kg nitrogen ha^{-1}*i.e.* T_5 during 2016 and 2017, respectively. Higher gross return was simply due to higher yield during both the years of experimentation (Table 4).

Perusal of data revealed that the highest net realization (Rs. 38078.81 and 38293.23 ha^{-1}) was obtained under the treatment T_6 (Nitrogen @ 25 kg ha^{-1}) with the BCR value of 1.54 and 1.52, followed by the treatment T_6 (Nitrogen @ 30 kg ha^{-1}) which recorded the net realization of Rs. 32291.67 and 32552.60 ha^{-1} with the BCR value of 1.33 and 1.29.

The net returns were less in first year of experiment as compared to the second year in almost all the treatments simply due to lesser yield green gram in the first year. Treatments receiving no nitrogen fertilizer (T_1) recorded lowest gross return (Rs. 28541.51 and Rs. 29302.18 ha^{-1}), net return (Rs. 4091.70 and 4470.80 ha^{-1}) and B: C (0.17 and 0.18) during both the years of experimentation. The results corroborate with the earlier findings of Ambhore (2004) and Patel (2012).

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