Annals of Plant and Soil Research 17(3): 242-247 (2015)

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, QUALITY, NUTRIENTS UPTAKE AND ECONOMICS OF SUMMER GREEN GRAM

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Received: August, 2014; Revised accepted: April, 2015

ABSTRACT

A field experiment was carried out at Research Farm, College of Agriculture, Tikamgarh (Madhya Pradesh), during summer 2012 and 2013 to study the effect of integrated nutrient management on yield attributes, yield, nutrients uptake and economics of summer green gram. The experiment was laid out in randomized block design replicated thrice with ten nutrient management treatments. The results revealed that the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium recorded significantly higher pods plant^{-1} (13.5), seeds pod^{-1} (10.6), test weight (36.4g), seed yield (1.18 t ha^{-1}), stover yield (3.12 t ha^{-1}), biological yield (4.30 t ha^{-1}) and protein yield (262.1 kg ha^{-1}). The increase in seed yield due to the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium over control and RDF + Rhizobium were 57.3% and 10.2%, respectively. Similarly, N (40.3 and 32.6 kg ha^{-1}), P (4.1 and 4.3 kg ha^{-1}) and K (9.7 and 10.8 kg ha^{-1}) uptakes by seed and stover, respectively were also recorded with the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium . Gross return of ₹. 62125 ha^{-1} was the highest with the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium. Highest net return (₹. 39741 ha^{-1}) was recorded with 100% RDF + 2 t FYM ha^{-1} + Rhizobium, while the maximum B: C of 1.97 with the application of 100% RDF + Rhizobium.

Key words: Economics, nutrients uptake, quality, seed yield, summer green gram and yield

INTRODUCTION

Green gram (*Vigna radiata* (L.) is important short duration, drought tolerant pulse crop cultivated throughout India for its multipurpose uses as vegetable, pulse, fodder and green manure crop. Its seed contains 24.7% protein, 0.6% fat, 0.9% fiber and 3.7% ash (Potter and Hotchkiss, 1997) as well as sufficient quantity of calcium, phosphorus and important vitamins. In India, it occupies an area of about 3.54 million hectares with total annual seed production of 1.81 million tonnes giving an average grain yield of 512 kg ha^{-1} (Anonymous, 2012), which is low as compared to other agriculturally advanced countries of the world. In Madhya Pradesh, it is grown over an area of 80.6,000 hectares with total production of 19.7,000 tonnes and average productivity of 227 kg ha^{-1} during 2010-11. The area, production and productivity of green gram in Tikamgarh district of Madhya Pradesh is 5.2,000 hectares, 0.9,000 tonnes and 175, respectively during 2010-11. The productivity of this crop is very low because of its cultivation on marginal and sub marginal lands of low soil fertility where little attention is paying to adequate fertilization (Saravanan *et al.*, 2013). In summer green gram, a high reduction in yield has been reported to occur due to non-use of fertilizers (Singh and Sekhon. 2008). Although, chemical fertilizer are playing a crucial role to meet the nutrients need of the crop, the imbalance and continuous use of chemical fertilizers has adverse effect on soil physical, chemical and biological properties thus affecting the sustainability of crop production, besides causing environmental pollution. Besides, persistent nutrient depletion is posing a greater threat to the sustainable agriculture. Consumption of chemical fertilizers will also be quite a limiting factor of agricultural production in future. Because of escalating energy cost, chemical fertilizers are not available at affordable price to the farmers. Reliance on the increased use of chemical fertilizers and associated hazards put back attention on organic sources which are effective in promoting soil health and productivity of the crop with quality produce (Bairwa *et al.* 2009). On the other hand, use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient status. Therefore, integrated management of chemical fertilizers and organic may be an important strategy for sustainable production of crops. This may not only improve the efficiency of chemical fertilizers along with their minimal use in crop production besides providing stability in crop production with higher crop yield and improving available major and minor nutrients (Rautaray *et al.*, 2003). A field experiment therefore, was formulated to study the effect of integration of inorganic fertilizer, organic manure (FYM/vermicompost) and *Rhizobium* on yield, quality and nutrients uptake of summer green gram.

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MATERIALS AND METHODS

A field experiment was conducted at Research Farm, J.N.K.V.V., College of Agriculture, Tikamgarh (24° 43' N latitude, 78° 49' E longitude at an altitude of 358 m above mean sea level), Madhya Pradesh, India during summer seasons of 2012 and 2013. The experimental site is of sub-tropical climate characterized by hot dry summers and cool dry winter lies in the Bundelkhand Zone (Agro-climatic Zone-VIII). The average annual rainfall of this region is about 1000 mm, which is mostly received between June to September and a little rainfall (90 mm) is also obtained during October to May. The average temperature ranges between 4.5 °C to 45 °C. The soil of experimental plot was medium to deep black and clayey loam in texture having pH 7.0, EC 0.12 dS m^{-1}, organic carbon 5.0 g kg^{-1}, available N 266 kg ha^{-1}, available P 11 kg ha^{-1} and available K 255 kg ha^{-1}, respectively.The experiment was laid out in randomized block design having 3 replications with ten nutrient management treatments *viz*., T_1: control; T_2: 100% recommended dose of fertilizers (RDF) + *Rhizobium*; T_3: 4.0 t FYM ha^{-1} + *Rhizobium*; T_4: 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium*; T_5: 75% RDF + 2.0 t FYM ha^{-1}+ *Rhizobium*; T_6: 50% RDF + 2.0 t FYM ha^{-1}+ *Rhizobium*; T_7: 2.0 t Vermicompost ha^{-1}+ *Rhizobium*; T_8: 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium*; T_9: 75% RDF + 1.0 t Vermicompost ha^{-1}+ *Rhizobium* and T_{10}: 50% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium*. The green gram variety 'K 851' was sown at spacing 30 cm row to row and 10 cm plant to plant on 10 April, 2012 and 12 April, 2013. The RDF was 20 kg N, 60 kg P and 20 kg K ha^{-1}, applied as basal dose through di-ammonium phosphate and murate of potash (KCl) as per treatments. Biofertilizers were applied as seed treatment just before sowing. The FYM and Vermicompost were applied about 20 and 4 days before sowing of green gram, respectively. All other operations were performed as per recommendations of the crop. The data on various yield attributes, seed and stover yields were recorded after harvest the crop. Seed and stover samples were digested in H_2SO_4 for determination of nitrogen (AOAC, 1995) and in di-acid mixture (HNO_3: $HClO_4$, 9:4 v/v) for phosphorus and potassium estimation (Bhargava and Raghupathi, 1984). The nutrients uptake by seed and stover were calculated by multiplying nutrient content with seed and stover yield, respectively. The protein content was calculated by multiplying the nitrogen content by 6.25 and protein yield was computed by multiplying protein content with seed yield. Economic analysis was carried out on the basis of current price of inputs and out put. The results of both the years were more or less similar and hence data were pooled and analyzed statistically to draw suitable inference (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Yield attributes and yield

The data (Table 1) revealed that the integration of inorganic fertilizers, organic (FYM/Vermicompost) and *Rhizobium* as a source of nutrients significantly influenced the different yield attributes of summer green gram.

Table 1: Effect of integrated nutrient management on yield attributes, yield, quality and economics of summer green gram (pooled over two years)

Treatment	Pods (plant^{-1})	Seeds (pod^{-1})	Test weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Protein content (%)	Protein yield (kg ha^{-1})	Net return (₹. ha^{-1})	B:C
T_1	10.3	8.90	33.9	0.75	2.65	3.40	21.9	164.4	24915	1.63
T_2	12.5	10.1	36.0	1.07	2.99	4.07	22.0	235.7	37509	1.97
T_3	11.6	9.30	34.3	1.01	2.87	3.88	21.2	214.1	34145	1.77
T_4	13.1	10.4	36.3	1.14	3.03	4.17	21.8	249.7	39741	1.94
T_5	12.7	10.2	36.2	1.09	3.28	4.37	21.8	237.6	37680	1.88
T_6	12.2	9.80	35.6	1.05	2.94	3.98	21.6	225.3	36040	1.88
T_7	12.0	9.60	35.2	1.03	2.92	3.94	21.2	217.6	28962	1.14
T_8	13.5	10.6	36.4	1.18	3.12	4.30	22.2	262.1	38095	1.59
T_9	13.0	10.2	36.3	1.12	3.07	4.19	22.0	245.9	35959	1.56
T_{10}	12.5	9.90	36.0	1.05	2.95	4.01	21.8	229.5	33535	1.51
S.Em ±	0.31	0.35	0.49	0.033	0.094	0.093	0.45	1.01		
CD (0.05%)	0.90	1.36	1.45	0.101	0.280	0.278	NS	3.03		

T_1: control; T_2: 100% recommended dose of fertilizers (RDF) + Rhizobium; T_3: 4.0 t FYM ha^{-1} + Rhizobium; T_4: 100% RDF + 2.0 t FYM ha^{-1} + Rhizobium; T_5: 75% RDF + 2.0 t FYM ha^{-1}+ Rhizobium; T_6: 50% RDF + 2.0 t FYM ha^{-1}+ Rhizobium; T_7: 2.0 t Vermicompost ha^{-1}+ Rhizobium; T_8: 100% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium; T_9: 75% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium and T_{10}: 50% RDF + 1.0 t Vermicompost ha^{-1} + Rhizobium.

The results clearly indicate that application of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8), being statistically at par with 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_4) recorded significantly higher pods $plant^{-1}$ (13.5), seeds pod^{-1} (10.6) and test weight (36.4 g) as compared to rest of the treatments. The lowest pods $plant^{-1}$ (10.3), seeds pod^{-1} (8.9) and test weight (33.9 g) were registered in control. Integrated use of organic, inorganic and biofertilizer resulted in better growth of plants associated with increased availability of nutrients might have resulted in better development of yield attributes under these treatments. The favourable effects of integration of organic, inorganic fertilizers and biofertilizer on yield attributes of green gram were also reported by Kumpawat (2010). The results (Table 1) also reveal that nutritional management practices had a significant effect on seed yield of summer green gram. The maximum seed yield (1.18 t ha^{-1}) was observed in the treatment consisting of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8), which was at par with 100% RDF + 2 t FYM ha^{-1} + *Rhizobium* (T_4), 75% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_9) and 75% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_5). On the contrary, application of nutrients either through inorganic sources (T_2: RDF + *Rhizobium*), or sole Vermicompost (T_7: 2.0 t Vermicompost ha^{-1} + *Rhizobium*) and sole FYM (T_3: 4.0 t FYM ha^{-1} + *Rhizobium*) showed poor performance with respect to seed yield. The extent of increase in seed yield of summer green gram due to application of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8), 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_4), 75% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_9) and 75% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_5) were 57.3%, 52.4%, 49.2% and 45.2%, respectively over control and 10.2%, 6.79%, 4.57% and 1.78%, respectively over application of RDF + *Rhizobium* (T_2). The better expression of yield attributes might have led to increase in the seed yield under these treatments. Regression analysis depicted in Fig. 1 and 2 also proved that seed yield (t ha^{-1}) was highly associated with yield attributes *viz*., pods $plant^{-1}$ (R^2=0.95**), seeds pod^{-1} (R^2=0.85**) and test weight (R^2=0.77**) and growth parameters *viz*., plant height (R^2=0.76**), leaf area index (R^2=0.91**) and total dry matter production (R^2=0.90**).

The minimum seed yield (0.75 t ha^{-1}) was noticed when the crop was not given any nutrition (control). The reduction in the seed yield in control plots could be attributed to poor yield attributes *viz*., pods $plant^{-1}$, seeds pod^{-1} and test weight on account of decreased growth in term of biomass accumulation during vegetative phases leading to decreased bearing capacity (pods $plant^{-1}$, seeds pod^{-1} and test weight), which ultimately decreased the seed yield. The results are in the line with the findings of Singh *et al.* (2015).

The higher stover and biological yields were obtained with 75% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_5), which was remained at par with treatments consisting of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8), 75% RDF + Vermicompost @ 1.0 t ha^{-1} + *Rhizobium* (T_9) and 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_4). Benefits accruing from the integrated use of organic with inorganic fertilizers might be attributed to better supply of nutrients along with conducive physical environment leading to better root activity and higher nutrient absorption, which resulted into better plant growth and superior yield attributes responsible for higher yield (Thakur *et al.,* 2011). Regression analysis between seed yield (t ha^{-1}) and nutrients uptake (kg ha^{-1}) had also exhibited that increased nutrients uptake reflected into higher seed yield (Fig. 3). The favourable effects of integration of organic, inorganic fertilizers and *Rhizobium* on yield attributes and yield were also reported by Rajkhowa *et al.* (2003), Khanda *et al.* (2005), Afzal and Bano (2008) and Kumpawat (2010).

Protein content and yield

The results (Table 1) reveal that protein content did not differ significantly due to different nutrient management treatments. However, protein yield varied significantly with the different nutrition management treatments. The maximum protein yield (262.1 kg ha^{-1}) was recorded with 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* followed by 100% RDF + 2 t FYM ha^{-1} + *Rhizobium*, 75% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* and 75% RDF + 2.0 t FYM ha^{-1} + *Rhizobium*. The higher protein yield in these treatments might be due to the fact that better availability of all the nutrients to the green gram plants through both organic and inorganic sources resulting into higher seed yield, which reflected into maximum protein yield. On the contrary, lowest protein yield of 164.4 kg ha^{-1} was noticed in control which might be due to lower seed yield on account of reduced growth and development due to poor nutrition of the crop (Malik *et al.* 2003).

Nutrients uptake

The results (Table 2) reveal that the highest N uptake by seed (40.3 kg ha^{-1}), stover (32.6 kg ha^{-1}) and total N uptake (72.9 kg ha^{-1}) was recorded with the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8) followed by 100 % RDF + 2.0 t FYM ha^{-1} + *Rhizobium*, 75% RDF + 1.0 t

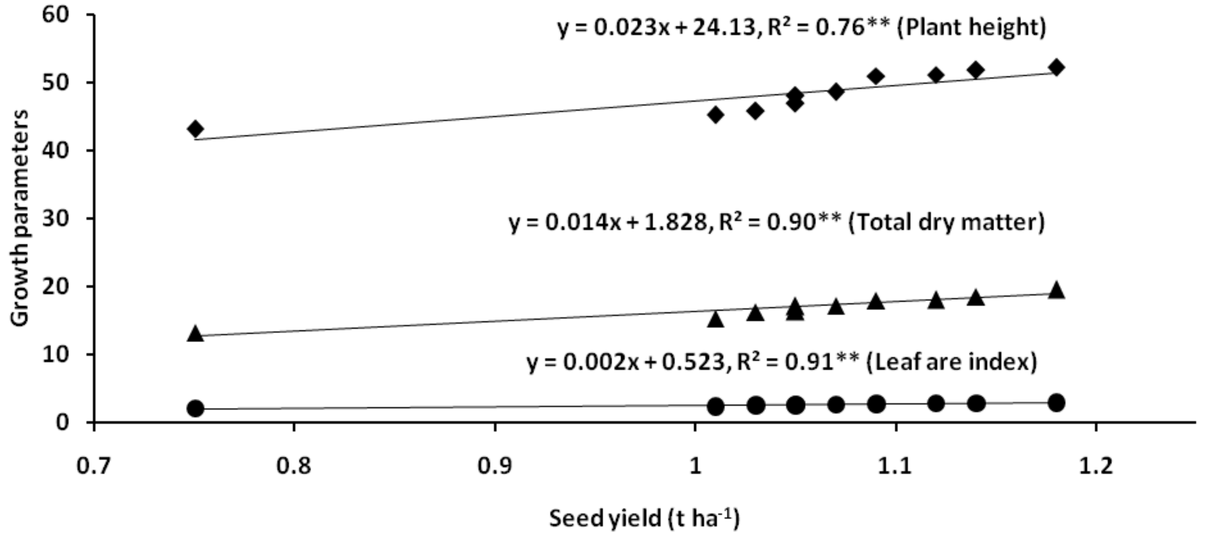

Fig. 1: Association of seed yield with plant height (cm) at harvest, leaf area index at 45 DAS and total dry matter production (g plant^{-1}) at harvest

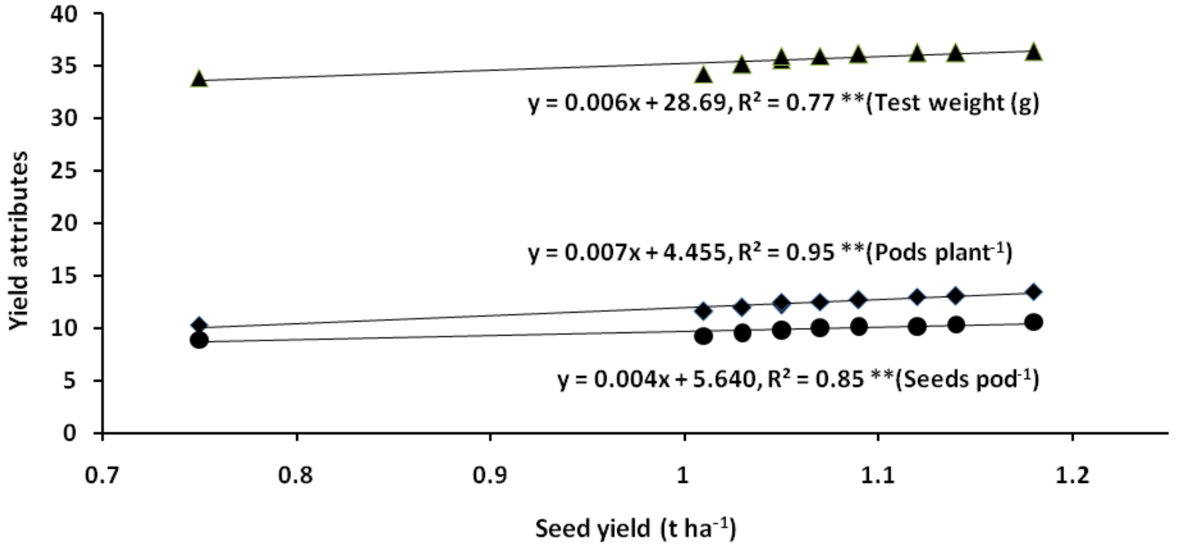

Fig. 2: Association of seed yield and different yield attributes

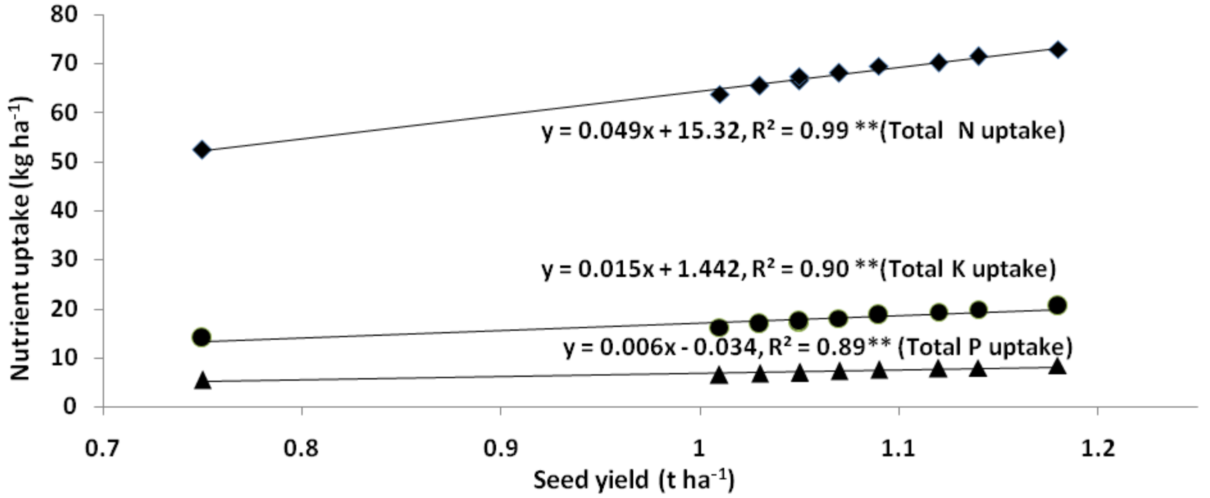

Fig. 3: Association of seed yield with total uptake

vermicompost ha^{-1} + *Rhizobium* and 75% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_5). These treatments increased the total N uptake by 39.4, 36.7, 34.2 and 32.9%, respectively over control and 7.21, 5.15, 3.2 and 2.2%, respectively over 100% RDF + *Rhizobium* (T_2). Similarly, the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8) recorded the highest P and K uptake by seed (4.1 and 9.7 kg ha^{-1}, respectively), stover (4.3 and 10.8 kg ha^{-1}, respectively) and total P (8.4 kg ha^{-1}) and K (20.5 kg ha^{-1}) over rest of the treatments but was at par with 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_4), 75% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_9) and 75% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_5). The significantly lowest N, P and K uptakes by seed (25.7, 2.5 and 6.0 kg ha^{-1}, respectively), stover (26.6, 3.0 and 7.9 kg ha^{-1}, respectively) and total uptake (52.3, 5.5 and 13.9 kg ha^{-1}, respectively) was registered under control plots.

Table 2: Effect of integrated nutrient management on nutrients uptake (kg ha^{-1}) of summer moong (pooled over two years)

Treatment	Nitrogen			Phosphorous			Potassium		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1	25.7	26.6	52.3	2.5	3.0	5.4	6.0	7.9	13.9
T_2	36.9	31.1	68.0	3.5	3.7	7.2	8.5	9.5	18.0
T_3	33.8	30.0	63.8	3.3	3.2	6.5	7.8	8.4	16.2
T_4	39.7	31.8	71.5	3.8	4.1	7.9	9.3	10.5	19.8
T_5	37.8	31.7	69.5	3.6	3.9	7.6	8.6	10.1	18.7
T_6	35.5	31.0	66.5	3.4	3.5	6.9	8.2	9.0	17.2
T_7	34.6	30.9	65.5	3.3	3.4	6.7	8.0	8.8	16.8
T_8	40.3	32.6	72.9	4.1	4.3	8.4	9.7	10.8	20.5
T_9	38.6	31.6	70.2	3.7	4.0	7.8	9.1	10.2	19.3
T_{10}	36.0	31.4	67.4	3.4	3.6	7.0	8.3	9.1	17.4
S.Em ±	0.67	0.54	1.20	0.12	0.12	0.20	0.16	0.13	0.30
CD (0.05%)	1.98	1.58	3.59	0.36	0.35	0.57	0.46	0.39	0.86

Integration of organic and inorganic fertilizers resulted in more uptake of nutrients as compared to sole use of organic or inorganic ones and control. This may be due to the fact that the balanced and combined use of various plant nutrients sources results in proper absorption, translocation and assimilation of these nutrients, ultimately increasing the dry-matter accumulation and nutrient contents of green gram and thus showing more uptake of elemental nutrients. It is also a fact that improvement of physiological efficiencies of different macro and trace elements resulted from the combined application of organic and inorganic sources of nutrients produces crop with superior quality under investigation. Similar findings were reported by Kumpawat (2010) and Anandan and Natarajan (2012).

Economics

The data (Table 1) indicate that the maximum gross return (₹. 62125 ha^{-1}) was realized with integrated use of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8). The application of 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (T_4) proved as second best fetching the gross return of ₹. 60201 ha^{-1}. The higher seed and stover yields with these treatments may be the reason for the resultant gross profit. The minimum gross return (₹. 40165 ha^{-1}) was recorded in control plots on account of lower seed and stover yields. The net return was maximum (₹. 39741 ha^{-1}) with 100% RDF + 2 t FYM ha^{-1} + *Rhizobium* (T_4) followed by 100% RDF + @ 1.0 t Vermicompost ha^{-1} + *Rhizobium* (T_8) and the minimum net return (₹. 24915 ha^{-1}) under control. The results are in agreement with the findings of Kumpawat and Kumpawat (2009) and Kumpawat (2010). The income per rupee spent (B:C) was highest (1.97) with the application of 100% RDF + *Rhizobium* (T_2) closely followed by 100% RDF + 2.0 t FYM ha^{-1} + *Rhizobium* (1.94). This was due to more net profit than cost of cultivation involved with these treatments. The minimum value of B:C (1.14) was realized with application of 2.0 t Vermicompost ha^{-1} +*Rhizobium* (T_7) on account of high cost of Vermicompost. The results lead to a conclusion that the application of 100% RDF + 1.0 t Vermicompost ha^{-1} + *Rhizobium* registered higher seed yield, better quality of produce and higher NPK uptake by crop and would be useful to enhance the productivity of summer green gram. Thus, integrated use of organic, inorganic and biological sources of nutrients may be suggested for higher economic returns along with overall betterment of summer green gram crop.

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