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Effect of combined application of nitrogenous fertilizers and organic adjuvants on growth and yield of green gram (*Vigna radiata* L.)

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Abstract
A field experiment was conducted at Research farm of the Maharishi Markandeshwar (Deemed to be Unviversity), Mullana, Ambala during Summer season of 2023 to determine the "Effect of combined application of nitrogenous fertilizers and organic adjuvants on growth and yield of green gram (*Vigna radiata* L.)". The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications and five treatments (control, 100% RDF (20 Kg N, 40 kg P_2O_5, 20 Kg K_2O and 25 Kg $ZnSO_4$), 100% RDF + 25% higher Nitrogen, 100% RDF + 25% N through vermicompost, and 100% RDF + 25% N through vermicompost + *Rhizobium*) applied to two varieties PDM-139 and SML-668. Variety SML-668 accomplished highest number of all parameters like growth parameters, yield attributes and yield. The data was recorded on growth parameters, yield attributes and yield. The results revealed that the highest plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1} and dry weight (g plant^{-1}) was recorded with the application of 100% RDF + 25% N through vermicompost + *Rhizobium* and the lowest was recorded in control. Maximum grain yield, stover yield, biological yield and harvest Index was recorded with 100% RDF + 25% N through vermicompost + *Rhizobium* and minimum was recorded in control. Highest gross return, net return and B:C was recorded in 100% RDF + 25% N through vermicompost + *Rhizobium* and the lowest was recorded in control.

Keywords: Vermicompost, *Rhizobium*, green gram, SML-668, nitrogenous fertilizers

Introduction
Green gram (*Vigna radiata* L.) also known as mung bean or moong, is widely grown as a pulse crop in the country. Among pulses, green gram is the 3rd most essential cultivated crop in India. It provides a reliable source of protein, carbs, water, fat, and fiber. Besides other countries in Asia, green gram is also widely cultivated in India, Pakistan, Bangladesh, Sri Lanka, and Thailand. In India, around (33.45 lac ha) were planted with green gram during 2022-2023 growing season. In 2021-2022, it was (34.80 lac ha). Rajasthan (20.54 lac ha), Karnataka (4.14 lac ha), Maharashtra (2.78 lac ha), Odisha (2.03 lac ha), Madhya Pradesh (1.58 lac ha), and Telangana (0.27 lac ha) were the states that produced the most green gram in India (Green gram Outlook December, 2022, Agricultural Market Intelligence Centre, PJTSAU). Nitrogen is a main element for the growth and development of plants, as well as an essential element of chlorophyll. It is a significant part of amino acids and proteins. Impaired initial vitality due to a nitrogen deficit results in decreased crop production (Sohrabi, 1991) [8]. According to Mainual *et al*. (2014) [5], the Lack of nitrogen decreased the height of the plant, stem diameter, pod length, and the number of branches plant^{-1}. *Rhizobium* and other organic fertilizers are crucial to the growth and development of green gram. It associates symbiotically with the leguminous plants nodules of roots. *Rhizobium* is a key component of various biofertilizers that aid in nitrogen fixation. According to Bhatt *et al*. (2014), *Rhizobium* culture applied to various legumes is a typical agronomic method for improving pulse yield. Earthworms are used in vermicomposting to turn decaying matter into nutritious manure.

According to Eswaran and Mariselvi (2016) [2], the continuous use of synthetic fertilizers brings health and environmental risks, including nitrate leaching that contaminates surfaces and groundwater. According to Todawat *et al*. (2017) [10], the nutritional value of nitrogen (N), phosphorus (P), and potassium (K) in the grain and stover of green gram was considerably enhanced by the application of vermicompost at increasing rates.

Materials and Methods

A field experiment was conducted at Maharishi Markandeshwar Research Farm (Deemed to be University), Mullana, Ambala is located at 30°17'0" N latitude, 77°3'0" E longitude, and at an altitude of 264 meters over the average above, during summer season 2023. Mullana is classified as subtropical region. Mullana experiences extremely chilly winters and warm, dry summers. In the winter, the temperature can drop as low as-1°C, and in the summer, it can get as high as 48 °C. The south-west monsoon, which lasts from July-September, accounts for 70-80% of the region's rainfall, with the remaining 20-30% falling between December and February. This region is classified as one of Haryana's high rainfall zones with an average yearly rainfall of 650-750 mm. There are significant fluctuations in the region's rainfall totals and distribution. From July to March, the average morning relative humidity is 80-90%; however, from April to June, it drops to 40-50%. The texture of the research plot was sandy loam. The experiment was laid out in FRBD (Factorial randomized block design) having three replication two varieties *viz*., PDM-139, SML-668 and five treatments *viz*., T_1: Control, T_2: 100% RDF T_3: 100% RDF + 25% higher Nitrogen, T_4: 100% RDF + 25% Nitrogen through Vermicompost, T_5: 100% RDF + 25% Nitrogen through Vermicompost + *Rhizobium*. PDM-139 and SML-668 green gram cultivars were sown in lines using seed rate as 20 kg ha^{-1}, with 30 x 10 cm spacing All the organic fertilizer and inorganic fertilizer were applied at the time of sowing as basal in the field. Chemical Fertilizers (20 kg N, 40 kg P_2O_5, 20 kg K_2O and 25 zinc kg ha^{-1}) were supply through urea, SSP, MOP and zinc from $ZnSO_4$. Similarly, vermicompost and *Rhizobium* were added as per treatment requirement and incorporated in the plot.

Results and Discussion

Growth Parameters

The recorded data in Table 1 revealed that the maximum plant height (cm) was recorded by SML-668 at 45 DAS and at harvest (39.03 and 48.16 cm) as compared to PDM-139. Among the various levels of fertilizer, Treatment T_5 (100% RDF + 25% N through vermicompost + *Rhizobium*) showed the maximum plant height at 45 DAS (42.58 cm) and at harvest (50.71cm), and the minimum plant height was recorded in T_1 (Control) at 45 DAS (31.66 cm) and at harvest (40.83 cm). The variety SML-668 obtained maximum number of leaves $plant^{-1}$ at 45 DAS (18.35) and at harvest (23.68) as compared to PDM-139 (17.36 and 21.55). Treatment T_5 (100% RDF + 25% N through vermicompost + *Rhizobium*) observed a higher number of leaves $plant^{-1}$ at 45 DAS (19.85) and at harvest (25.66). The lowest number of leaves $plant^{-1}$ was observed in T_1 (control) at 45 DAS (15.05) and at harvest (18.48). The growth parameters were greatly enhanced by the inoculation of seeds with *Rhizobium* (Singh and Singh, 2021). SML-668 recorded a higher number of branches $plant^{-1}$ at 45 DAS (6.08) and at harvest (7.81). Treatment T_5 (100% RDF + 25% N through vermicompost + *Rhizobium*) obtained the maximum number of branches $plant^{-1}$ at 45 DAS (6.70) and at harvest (9.20). Treatment T_1 (Control) obtained the minimum number of branches $plant^{-1}$ at 45 DAS (4.80) and at harvest (5.75). SML-668 recorded a higher dry weight at 45 DAS (9.31 g $plant^{-1}$) and at harvest (17.97 g $plant^{-1}$) as compared to PDM-139 (8.17 and 16.94 g $plant^{-1}$). Among the various treatments, T_5 (100% RDF + 25% N through vermicompost + *Rhizobium*) recorded maximum dry weight at 45 DAS (10.98 g $plant^{-1}$) and at harvest (20.77 g $plant^{-1}$). The minimum dry weight was found in Treatment T_1 (control) at 45 DAS (6.97 g $plant^{-1}$) and harvest (13.33 g $plant^{-1}$). Similar results were also found by Tyagi and Upadhyay (2015) [11]. Thus, combined management of both chemical and organic fertilizers could be a vital strategy for crop production.

Yield Attributes and Yield

The data in Table 2 revealed that the variety SML-668 recorded significantly higher number of pods $plant^{-1}$, seeds pod^{-1}, and 100-seed weight (19.25, 9.18, and 4.77 g) and the lowest was recorded in PDM-139 (18.44, 8.88, and 4.60 g). The pods $plant^{-1}$, seeds pod^{-1}, and test weight, were greatly enhanced by the inoculation of seeds with *Rhizobium* (Singh and Singh, 2021). Among the various treatments, Treatment T_5 (100% RDF + 25% N through vermicompost + *Rhizobium*) recorded significantly higher number of pods $plant^{-1}$ (20.84), number of seeds pod^{-1} (10.14), and 100-seed weight (4.82 g) and the lowest was recorded in T_1 control (15.93, 7.04, and 4.55 g). SML-668 recorded the maximum grain yield, Stover yield, biological yield, and harvest index (8.93 q ha^{-1}, 23.55 q ha^{-1}, 32.48 q ha^{-1}, and 27.36%) and minimum was recorded in PDM-139 (7.93 q ha^{-1}, 22.24 q ha^{-1}, 30.18 q ha^{-1} and 25.97%). Similar results were also found by Tyagi and Upadhyay (2015) [11]. Among the various treatments, Treatment T_5 (100% RDF + 25% N through vermicompost + *Rhizobium*) recorded significantly higher grain yield, Stover yield, biological yield and harvest index (10.43 q ha^{-1}, 27.06 q ha^{-1}, 37.49 q ha^{-1} and 27.85%) and the lowest was recorded in treatment T_1 (Control) (5.10 q ha^{-1}, 15.42 q ha^{-1}, 20.52 q ha^{-1}, and 24.91%). *Rhizobium* inoculation helps fix atmospheric nitrogen in plants and increase N content in seeds. The outcomes were similar to the findings of Jamwal *et al.* (1989) [4].

Economics

The information regarding economics is presented in Table 3. Among the varieties, the cost of cultivation was same for both varieties, *i.e.*, PDM-139 (₹31135 ha^{-1}) and SML-668 (₹31135 ha^{-1}). The highest gross return, net return and B:C was recorded in variety SML-668 (₹71607 ha^{-1}, ₹40472 ha^{-1}, and 2.30) and the lowest was recorded in PDM-139 (₹63721ha^{-1}, ₹32586 ha^{-1}, and 2.05).Among the treatments, Treatment T_5 (100% RDF + 25% N through vermicompost + *Rhizobium)* recorded maximum cost of cultivation, gross return, net return, and B:C (₹36631 ha^{-1}, ₹83591 ha^{-1}, ₹46960 ha^{-1}, and 2.28) and lowest was recorded in (T_1) Control (₹31135 ha^{-1}, ₹41093 ha^{-1}, ₹9958 ha^{-1}, and 1.32) as displayed in Table 3. Similar results were also found by Tyagi and Upadhyay (2015) [11].

Interaction Effect

Interaction effects among the varieties and fertilizer were observed to be non-significant for all the characters. Similar results were also reported by Patel *et al.* (2020) [6].

Table 1: Effect of combined application of nitrogenous fertilizers and organic adjuvants on growth of green gram (*Vigna radiata* L.)

Treatments	Plant height (cm)			Number of leaves plant^{-1}			Number of branches plant^{-1}			Dry weight (g plant^{-1})		
	30	45	Harvest	30	45	Harvest	30	45	Harvest	30	45	Harvest
Varieties												
PDM-139	19.22	37.96	45.44	13.06	17.36	21.55	4.22	5.75	7.08	3.95	8.17	16.94
SML-668	19.32	39.03	48.16	13.22	18.35	23.68	4.23	6.08	7.81	4.14	9.31	17.97
S.EM±	0.12	0.31	0.36	0.06	0.11	0.15	0.06	0.09	0.11	0.07	0.23	0.29
C.D. at 5%	NS	0.94	1.10	NS	0.34	0.46	NS	0.29	0.34	NS	0.70	0.87
Fertilizer Levels												
T_1	19.03	31.66	40.83	12.91	15.05	18.48	4.01	4.80	5.75	3.76	6.97	13.33
T_2	19.08	37.83	45.81	13.13	16.96	21.40	4.20	5.71	6.76	4.06	7.50	16.58
T_3	19.23	39.83	47.96	13.16	18.56	23.42	4.26	6.17	7.60	4.11	8.64	17.97
T_4	19.50	40.58	48.68	13.20	18.86	24.12	4.30	6.21	7.92	4.11	9.61	18.63
T_5	19.51	42.58	50.71	13.30	19.85	25.66	4.36	6.70	9.20	4.16	10.98	20.77
S.EM±	0.19	0.50	0.58	0.10	0.18	0.24	0.10	0.15	0.18	0.11	0.37	0.46
C.D. at 5%	NS	1.49	1.74	NS	0.55	0.73	NS	0.45	0.54	NS	1.11	1.38
V×F Interaction												
S.EM±	0.27	0.70	0.82	0.14	0.26	0.34	0.14	0.21	0.25	0.16	0.52	0.65
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note:
T_1: Control
T_2: 100% RDF (N-20 Kg through urea, P_2O_5-40 Kg through SSP, K_2O-20 Kg through MOP, 25 Kg Zn through $ZnSo_4$)
T_3: 100% RDF + 25% Higher Nitrogen
T_4: 100% RDF + 25% Nitrogen through Vermicompost
T_5: 100% RDF + 25% Nitrogen through Vermicompost + *Rhizobium*

Table 2: Effect of combined application of nitrogenous fertilizers and organic adjuvants on yield attributes and yield of green gram (*Vigna radiata* L.)

Yield attributes							
Treatments	**Number of pods plant^{-1}**	**Number of seeds pods^{-1}**	**Test weight (g)**	**Grain yield (q ha^{-1})**	**Stover yield (q ha^{-1})**	**Biological yield (q ha^{-1})**	**Harvest Index (%)**
Varieties							
V_1: PDM-139	18.44	8.88	4.60	7.93	22.24	30.18	25.97
V_2: SML-668	19.25	9.18	4.77	8.93	23.55	32.48	27.36
S.EM±	0.23	0.08	0.01	0.17	0.28	0.42	0.37
C.D. at 5%	0.71	0.24	0.03	0.52	0.84	1.26	1.11
Fertilizer levels							
T_1	15.93	7.04	4.55	5.10	15.42	20.52	24.91
T_2	18.10	8.69	4.62	8.06	22.60	30.67	26.14
T_3	19.64	9.52	4.70	9.06	24.32	33.38	27.00
T_4	19.71	9.75	4.73	9.49	25.08	34.58	27.41
T_5	20.84	10.14	4.82	10.43	27.06	37.49	27.85
S.EM±	0.37	0.12	0.01	0.27	0.44	0.66	0.58
C.D. at 5%	1.12	0.38	0.05	0.82	1.33	1.99	1.76
V×F Interaction							
S.EM±	0.53	0.18	0.04	0.39	0.62	0.94	0.83
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS

Note:
T_1: Control
T_2: 100% RDF (N-20 Kg through urea, P2O5-40 Kg through SSP, K2O-20 Kg through MOP, 25 Kg Zn through ZnSo4)
T_3: 100% RDF + 25% Higher Nitrogen
T_4: 100% RDF + 25% Nitrogen through Vermicompost
T_5**:** 100% RDF + 25% Nitrogen through Vermicompost + *Rhizobium*

Table 3: Effect of combined application of nitrogenous fertilizers and organic adjuvants on economics of green gram (*Vigna radiata* L.)

Treatments	Cost of Cultivation (₹ ha^{-1})	Gross Returns (₹ ha^{-1})	Net Returns (₹ ha^{-1})	B:C
Varieties				
PDM-139	31135	63721	32586	2.05
SML-668	31135	71607	40472	2.30
Fertilizer Levels				
T_1	31135	41093	9958	1.32
T_2	35630	64765	29135	1.82
T_3	35691	72692	37001	2.04
T_4	36524	76103	39579	2.08
T_5	36631	83591	46960	2.28

Note:
T_1: Control
T_2: 100% RDF (N-20 Kg through urea, P2O5-40 Kg through SSP, K2O-20 Kg through MOP, 25 Kg Zn through ZnSo4)
T_3: 100% RDF + 25% Higher Nitrogen
T_4: 100% RDF + 25% Nitrogen through Vermicompost
T_5: 100% RDF + 25% Nitrogen through Vermicompost + *Rhizobium*

Conclusion

Among the two varieties *i.e.* PDM-139 and SML-668, higher growth parameters, yield, and yield attributes were recorded in SML-668. Among treatments, Treatment T_5 (100% RDF + 25% N through Vermicompost + *Rhizobium*) recorded the highest values of growth parameters, yield attributes, and yield. In the economics of treatments, treatment T_5, consisting of 100% RDF + 25% N through vermicompost + *Rhizobium*, recorded highest gross, net return, and B:C. Therefore, 100% RDF + 25% N through Vermicompost + *Rhizobium*) can be recommended to the mung bean growers to attain sustainable and economically viable yield levels.

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