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Agronomical performance of black gram (*Vigna mungo* L.) in the presence of organic manures and bio-fertilizers in typic haplustalf

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Abstract
During the year 2021, a field experiment was conducted at the corp research centre, School of Agriculture, ITM University, Gwalior, (M.P.) to determine the Agronomical performance of black gram in the presence of organic manures and bio fertilizers. The soil texture in the experimental field was sandy clay loam, with low organic carbon, available nitrogen, and medium available phosphorus and potash contents. With a pH of 7.35, it is slightly alkaline in reaction and has a moderate cation exchange capacity. The treatments include three replications of three types of organic manures and three types of bio fertilizers. There are ten different treatments (T1 to T10) NADEP compost - 2 t/ha + PSB - 2.5 lit/ha (T7) registered favorable plant growth and yield characteristics and yield comparable to that of the absolute control, that is, without organic manures and biofertilizer application.

Keywords: Bio fertilizers, black gram, organic manures, growth, and yield

Introduction
Black gram (*Vigna mungo* L.) is an important pulse crop grown throughout India that belongs to the "Fabaceae" family. According to reports, black gram originated in North India. Black gram is known by various names in India, including urd or urad in Hindi, Gujarati, Masakalai in Bengali, Minapa Pappu in Telugu, Ulundu in Tamil, Uddu bale in Kannada, and Uzhummu in Malayalam. Dal made from black gram is widely consumed (whole or split, husked, and unhusked). Antinutritional properties of black gramme Protein (25g/100g), potassium (983 mg/100g), calcium (138 mg/100g), iron (7.57 mg/100g), niacin (1.447 mg/100g), Thiamine (0.273 mg/100g), and riboflavin (0.254 mg/100g) are all abundant in black gramme. Black gram is beneficial in lowering cholesterol levels (Divyavani *et al.*, 2020) [5].
During *Kharif* 2021, the black gram area in India increased by 387 percent to 8.77 lakh ha (21.67 lakh acres) from 1.88 lakh ha (4.65 lakh acres) the previous year. Madhya Pradesh has 4.45 lakh ha (11.00 lakh acres), Maharashtra has 1.79 lakh ha (4.43 lakh acres), Rajasthan has 0.71 lakh ha (1.74 lakh acres), Karnataka has 0.58 lakh ha (1.43 lakh acres), Telangana has 0.11 lakh ha (0.26 lakh acres), and Andhra Pradesh has 0.04 lakh ha (0.10 lakh acres). It produces approximately 24.5 lakh tonnes of Urad per year from approximately 4.6 million hectares of land, with average productivity of 533 Kg per hectare in 2021. (agricoop.nic.in). Black gram area accounts for approximately 19% of total pulse acreage in India and contributes 23% of total pulse production.
Continuous use of chemical fertilizers increased crop yield in the early stages but had a negative impact on sustainability later on. The indiscriminate application of chemical fertilizers, particularly urea, resulted in a deficiency of nutrients other than those applied and a decrease in soil organic carbon. Furthermore, the imbalance and continuous use of synthetic chemicals harm soil's physical, chemical, and biological properties, affecting crop production sustainability while posing health and environmental risks.
The factors attributed to low yields of pulses with special reference to the black gram in India as compared to the world productivity are non-availability of quality seeds of improved and short-duration varieties, grown under marginal and less fertile soil with low inputs and without pest and disease management, growing of pulses under moisture stress, unscientific post-harvest practices, and storage under unfavorable conditions.
Among the above factors causing the low yield potential of the crop, poor fertility of the soil is one of the most important factors.

Since most of the soils in Madhya Pradesh are very poor in organic carbon which is associated with the poor supply of nitrogen, phosphorus, and micro-nutrients especially zinc to crop.

As a result, there is an urgent need to reduce the use of chemical fertilizers while increasing the use of organics in order to maintain yield and quality levels. Due to their low nutrient status, organics alone do not result in a dramatic increase in crop yields. As an outcome, there is conceivability for increasing this crop's production potential through organic manures and bio-fertilizers. Bio-fertilizers can hasten the conversion of a fixed form of nutrient into a soluble form, improving nutrient availability and crop yield.

Therefore, the consequences as mentioned earlier have paved the way to grow black gram using organic manures along with bio-fertilizers. The use of organics plays a major role in maintaining soil health due to the build-up of soil organic matter, and beneficial microbes. The organic fertilizers in addition to nutrients contain microbial load and growth-promoting substances which help in improving the plant growth, metabolic activity, and resistance to pests and diseases. (Shukla *et al.*, 2015).

Organic manures, particularly FYM, Vermicompost, and NADEP compost, not only provide macronutrients but also meet micronutrient requirements while improving soil health. Farmyard manure has a nitrogen content of 0.5 percent, a phosphorus content of 0.2 percent, and potassium content of 0.5 percent. It is remedies for maintaining soil health and crop plant productivity. Vermicompost is the result of a decomposition process in which various species of worms, typically red wigglers, white earthworms, and other earthworms, decompose decomposing vegetables or food waste, bedding materials, and vermicast. This is known as vermicomposting. Vermicompost has a nitrogen content of 0.6 percent, a phosphorus content of 1.34 percent, and potassium content of 0.4 percent. Narayan Deotao Pandharipande of Maharashtra developed the NADEP composting method of organic composting. It is accomplished by combining crop residues, weeds, forest litter, and kitchen waste to produce a fertilizer that is a viable alternative to FYM. NADEP Compost contains 0.9 percent nitrogen, 0.5 percent phosphorus, and 0.7 percent potassium.

Biofertilizers are selected strains of beneficial soil microorganisms cultured in the laboratory and packaged in an appropriate carrier. They help to generate solubilized plants' essential nutrients like nitrogen and phosphorus through their activities in the soil or rhizosphere and gradually make them available to plants (Prajapati. 2014). The phosphorus solubilizing bacteria (PSB) aids in the conversion of insoluble phosphate that is chemically fixed into the available form, resulting in higher crop yields (Gull *et al*., 2004), just as the Potassium and Zinc solubilizing bacteria mobilize potassium and zinc in the soil for the black gram crop to produce more yields.

Materials and methods

The current research, entitled "Response of Organic manures and Bio fertilizers on growth, yield, and quality of Black gram (*Vigna mungo* L)," was conducted in 2021 at the Agriculture Research Farm, School of Agriculture, ITM University, Gwalior, India (M.P.). The experimental site, climatic conditions, materials used, procedures, and techniques employed throughout the experiment. The research farm is located at 26°14 N, 78° 14 E, and 206 m above mean sea level. The experimental field's soil texture was sandy clay loam. Before sowing, a few surface soil samples were taken at random up to 15 cm in-depth, and a composite sample was created by combining all of these. It had low levels of organic carbon (0.12 percent), nitrogen (67 kgs/ha), phosphorus (14.5 kgs/ha), and potassium (238.4 kgs/ha).The field was levelled, with even topography and an effective drainage system. The study used a randomized block design with nine treatments replicated three times. When used in conjunction (T1) 2t/ha VC + 2.5 L/ha PSB (T2) 2t/ha VC + 2.5 lit/ha KSB (T3) 2t/ha VC + 2.5 lit/ha ZSB (T4) 4t/ha FYM + 2.5lit/ha PSB (T5) 4t/ha FYM + 2.5lit/ha KSB (T6) 4t/ha FYM + 2.5lit/ha ZSB (T7) 2t/ha NADEP + 2.5lit/ha PSB (T8) NADEP-2.5lit/ha + KSB-2.5lit/ha (T9) NADEP-2.5lit/ha + ZSB-2.5lit/ha (T10) Complete control. A combination of organic manures like FYM, Vermicompost, and NADEP compost along with bio-fertilizers *viz* Phosphorus solubilizing bacteria(PSB), Potassium solubilizing bacteria (KSB), Zinc solubilizing bacteria (ZSB) were applied prior to 10 days of sowing as per treatment at the time of sowing. To control insect pests, such as white fly and pod-borer, neem oil (5%) and botanicals such as datura leaf extract and Ipomea leaf extract were sprayed. All three sprays were applied as soon as early insect symptoms were detected. When the crop reached physiological maturity, it was harvested. After proper sun drying, the crop was threshed, and the statistics were calculated and analyzed using Gomez and Gomez's statistical approach.

Results and discussion

Effect of organic manures and bio fertilizers on growth attributes of black gram

Plant height

The highest plant height at harvest was 52.80 cm with the combined application of organic manures and Bio-fertilizers in the treatment (T7) NADEP compost - 2 t/ ha + Phosphorous Solubilizing Bacteria (PSB) - 2.5 lit/ ha, which is comparable to VC- 2t/ ha + PSB-2.5 l/ ha (T1) (52.40 cm). The treatment (T10) had the shortest plant height (48.0 cm), which was inferior to the other treatments.

Plant dry weight

At harvest, the treatment (T7) NADEP compost - 2 t/ ha + PSB- 2.5 lit/ ha had the highest plant dry weight of 11.25, which was comparable to the treatment (T1) (11.03). The treatment (T10) had the lowest plant dry weight of 4.3, which was inferior to the other treatments. This is due to the more efficient use of phosphorous. Phosphorus is known to promote extensive root development and nodulation in legumes, increasing the supply of nutrients to growing parts of the plant and resulting in the increased photosynthetic area and dry matter accumulation. These findings are consistent with previous reports by Dhewa *et al.*, (2015) and Das *et al.*, (2015).

The number of leaves per plant

At harvest, NADEP compost - 2t/ha + PSB- 2.5 lit/ha (T7) had the highest number of leaves (16), while Absolute control (T10) had the lowest number of leaves (7 leaves) and was significantly inferior to the other treatments.

The number of branches per plant

The organic manure and bio-fertilizer treatments increased the total number of branches. The treatment involving NADEP compost- 2t/ ha + PSB- 2.5 lit/ ha (T7) recorded the highest number of branches at harvest, 49.61, which was comparable to the treatments involving VC- 2t/ ha + PSB-2.5 lit/ha (T1) and NADEP compost- 2t/ ha + ZSB-2.5lit/ha (T9), which registered 48.09 and 47.65, respectively. The absolute control (T10) had the fewest branches (41.78), which was lower than the rest of the treatments.

The number of root nodules per plant

At harvest, NADEP compost- 2t/ ha + PSB- 2.5 lit/ ha (T7) had the highest number of root nodules (18.09), while Absolute control (T10) had the lowest number of root nodules (11.99) and was significantly inferior to the other treatments. Seed inoculation with PSB increased total and active nodule plant-1 significantly more than uninoculated treatments. This increase is due to PSB releasing growth-promoting substances, which provide a favorable environment for rhizobium and promote root nodulation (Rathour *et al.*, 2014). PSB also solubilizes native P and increases its availability to plants. The increased availability may have contributed to improved nodulation. These findings are similar to those of Kumawat *et al*., 2010.

Effect of Organic manures and Bio-fertilizers on Yield attributes of a Black gram

Pod length

The application of NADEP compost - 2 t/ ha + Phosphorous Solubilizing Bacteria (PSB) - 2.5 lit/ ha (T7) resulted in a longer pod length of 5.3 cm, which was comparable to the application of VC- 2 t/ ha + PSB-2.5 lit/ ha (T1), which resulted in 5.2 cm, and the treatments were statistically comparable. T10, the absolute control, had a significantly shorter pod length of 4.2 cm and was found to be inferior to the other treatments.

Pod weight

Combined effect of organic manures and Bio-fertilizers increased the pod weight. The application of NADEP compost - 2 t/ ha + PSB- 2.5 lit/ ha (T7) recorded higher pod weight (0.54 gm) and this was on par with VC- 2t/ ha + PSB-2.5 l/ ha (T1) by registering 0.53 grams. This is closely followed by NADEP-compost 2t/ ha + ZSB-2.5lit/ha (T9) with 0.51 grams. These were comparatively superior to the rest of the treatments. The less pod weight was registered under absolute control (T10) with a value of 0.42 grams.

The number of seeds per pod

The highest number of seeds (6) was registered in (T7) NADEP compost - 2 t/ ha + PSB- 2.5 lit/ ha which was on par with VC- 2t/ ha + PSB-2.5 l/ ha (T1) and NADEP- 2t/ ha + ZSB-2.5lit/ha (T9) by registering 6 seeds per pod in both treatments. The lower number of seeds was registered under absolute control (T10) the value is 4.

The number of seeds per plant

Application of NADEP compost - 2 t/ ha + PSB-2.5 lit/ ha (T7) recorded a higher number of seeds per plant (150 seeds), which was comparable to VC- 2t/ ha + PSB-2.5 l/ ha (T1), which registered 144 seeds. This is followed by NADEP compost- 2t/ha + ZSB-2.5 lit/ha (T9), which has 132 seeds. These were significantly better than the other treatments. The absolute control (T10) yielded the fewest seeds per plant, with a value of 48.

Interaction effect of Organic manures and Bio-fertilizers on Yield of a Black gram

Grain yield

The higher grain yield of 2128.50 kg ha^{-1} was registered under the application of NADEP- 2 t/ ha + PSB- 2.5 lit/ ha (T_7). This was followed by VC- 2t/ ha + PSB-2.5 l/ ha (T_1) with a grain yield of 2043.36 kg ha^{-1}. The absolute control (T_{10}) recorded the lower grain yield of 1520 kg ha^{-1} and was significantly inferior to the rest of the treatments**.** Increased grain yield might be attributed to increased availability of nitrogen and phosphorus in soil resulting in higher growth and development and finally the yield (Tagore *et al.*, 2013).

Stover yield

The highest stover yield was recorded under the application of Vermicompost – 2 t/ha + PSB – 2.5lit/ ha (T_1) by registering 2860.7 kg which is on par with the application of NADEP compost -2t/ha + Zinc solubilizing bacteria – 2.5lit/ha (T_9). The least stover yield was recorded in the absolute control (T_{10}) with 1520.64 kg and was significantly inferior to the rest of the treatments.

Biological yield

The result shows that biological yield per hectare was influenced significantly due to different levels of organic fertilizers and bio fertilizers. The application of VC- 2t/ ha + PSB-2.5 l/ ha (T_1) registered a higher biological yield of 4904.06 kg ha^{-1}, however, this was comparable with NADEP-2 t/ ha + PSB- 2.5 lit/ ha (T_7) was 4682.70 kg ha^{-1} and NADEP- 2t/ ha + ZSB-2.5lit/ha (T_9) with 4628. 70 kg ha^{-1}. The lowest biological yield of 2026.88 kg ha^{-1} was recorded under Absolute (T_{10}) which was significantly inferior to other treatments. Application of Vermicompost and PSB gave luxuriant growth rather than yield these findings are similar to the results of Amit *et al*., 2021.

Harvesting Index

The highest harvest index was noticed in the treatment with the application of NADEP compost– 2t/ha + phosphorous solubilizing bacteria – 2.5lit/ ha (T_7) by registered 45.45. The least harvest index was recorded in the absolute control (T_{10}) with 25.05 and was significantly inferior to the rest of the treatments.

The findings of this research show similar results to Kumawat *et al*. (2017) revealed that NADEP Compost has been considered a valuable soil amendment for centuries. Most people are aware that using compost is an effective way to increase healthy plant production, help save money, reduce the use of chemical fertilizers, and conserve natural resources. Compost provides a stable organic matter that improves the physical, chemical, and biological properties of soils, thereby enhancing soil quality and crop production as well as farm productivity on a sustainable basis.

Table 1: Effect of Organic manures and Bio-fertilizers on growth attributes of a Black gram.

T. No.	Treatments	Plant height	Plant dry matter	Number of leaves/plant	Number of Branches/plant	Number of nodules/plant
T_1	VC + PSB	52.4	11.03	15	48.09	17.39
T_2	VC + KSB	51.8	8.45	12	45.85	13.59
T_3	VC + ZSB	51.1	8.23	12	45.55	12.99
T_4	FYM + PSB	52.1	9.56	13	47.24	14.69
T_5	FYM + KSB	48.9	6.55	10	42.8	13.39
T_6	FYM + ZSB	50.9	7.91	11	44.11	12.29
T_7	NADEP + PSB	52.8	11.25	16	49.61	18.09
T_8	NADEP + KSB	49.2	7.25	11	43.82	12.89
T_9	NADEP + ZSB	52.4	9.98	13	47.65	15.19
T_{10}	CONTROL	48	4.3	7	41.78	11.89
	SEM +/-	0.83	0.10	0.19	0.71	0.24
	CD (P=0.05)	2.47	0.29	0.55	2.10	0.70

Table 2: Effect of Organic manures and Bio-fertilizers on yield attributes of black gram.

T. No.	Treatment	Pod length	Number of pods/plant	Number of seeds/pod	Number of seeds/plant	Pod weight
T1	VC + PSB	5.2	24	6	144	0.53
T2	VC + KSB	4.6	20	5	100	0.48
T3	VC + ZSB	4.6	20	4	80	0.46
T4	FYM + PSB	4.9	20	5	100	0.49
T5	FYM + KSB	4.3	15	4	60	0.43
T6	FYM + ZSB	4.5	18	4	72	0.45
T7	NADEP + PSB	5.3	25	6	150	0.54
T8	NADEP + KSB	4.4	17	4	68	0.44
T9	NADEP + ZSB	5	22	6	132	0.51
T10	CONTROL	4.2	12	4	48	0.42
	SEM +/-	0.70	0.31	0.06	1.70	0.01
	CD (P=0.05)	0.21	0.91	0.19	5.06	0.02

Table 3: Effect of Organic manures and Bio-fertilizers on yield of black gram.

T. No	Treatment	Grain Yield	Straw Yield	Biological Yield	Harvest Index
T1	VC + PSB	2043.36	2860.70	4904.06	41.6
T2	VC + KSB	1320	2640	3960	33.3
T3	VC + ZSB	1029.6	2162.16	3191.76	32.2
T4	FYM + PSB	1353	2706	4059	33.3
T5	FYM + KSB	732.6	2051.28	2783.88	26.3
T6	FYM + ZSB	902.88	2528.06	3430.94	26.3
T7	NADEP + PSB	2128.5	2554.2	4682.7	45.4
T8	NADEP + KSB	830.28	2324.78	3155.06	26.3
T9	NADEP + ZSB	1873.08	2809.62	4682.7	40
T10	CONTROL	506.88	1520.64	2026.88	25
	SEM +/-	21.75	39.20	55.60	0.60
	CD(P=0.05)	64.62	116.46	165.18	1.76

VC = Vermicompost, FYM = Farmyard manure, NADEP = NADEP compost,
PSB = Phosphorous Solubilizing Bacteria, KSB = Potassium Solubilizing Bacteria.

Conclusion

According to the findings of this study, using a combination of organic manures and bio-fertilizers as a soil amendment increased black gram yield. The plant height, the number of leaves, and the number of branches increased when NADEP compost was used in conjunction with Phosphorous Solubilizing Bacteria (PSB), resulting in a higher yield of a black gram over the control treatment, despite the fact that no chemical fertilizer was applied. Farmers are advised to use a combination of organic manures and biofertilizers instead of synthetic fertilizers since they are less expensive and plentiful, and they have a significant impact on the yield of a Black gram.

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