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Effect of different liquid biofertilizer on economics, yield & yield character

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Abstract
The present investigation entitled "Effect of different liquid bio fertilizers on growth and yield of black gram (*Vigna mungo* L.)" was carried out at Agronomy research farm of Rama University, Kanpur (U.P.) during *Kharif*, 2023-24. The nine treatments *viz*., T_1– Rhizobium @ 30 ml kg^{-1} seed treatments, T_2- Rhizobium + ZMB @ 30 ml kg^{-1} seed treatments each, T_3 - PSB + KMB @ 30 ml kg^{-1} seed treatments each, T_4- Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatments each, T_5 - RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1}, T_6 - NPK Consortia @ 30 ml kg^{-1} seed treatments, T_7 - Rhizobium + PSB @ 30 ml kg^{-1} seed treatments each, T_8 - Rhizobium + KMB @ 30 ml kg^{-1} seed treatments each, T_9 – Control, were comprised in Randomized Block Design with three replication. The Type-9 was taken as test crop. Spacing between row to row and plant to plant were 30 and 10 cm, respectively. The values of growth contributing characters *viz*. plant population (no.), Number of trifoliate leaves $plant^{-1}$, Leaf area index (LAI), Crop Growth rate (CGR), Plant height, Dry matter accumulation (gm^{-2}), Number of branches $plant^{-1}$, Number of nodules $plant^{-1}$, Fresh weight of nodules $plant^{-1}$, Dry weight of nodules $plant^{-1}$ and yield attributes like number of pods $plant^{-1}$, number of seed pod^{-1}, Pod length (cm), Test weight (g), Seed yield (q ha^{-1}), Biological yield (q ha^{-1}), Harvest Index (%), N, P, K contents in seed and straw, N, P, K uptake in seed and straw, Protein content in seed and straw of crop were increasing significantly with (T4) Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatment each followed by RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} seed treatment each and significantly superior over rest of the treatments. The highest gross return was recorded (Rs. ha^{-1} 84140) in *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each followed by Rs. ha^{-1} 79649 with *Rhizobium* + PSB @ 25 ml kg^{-1} seed treatments each. Maximum net return of Rs. ha^{-1} 56314 was received with the application *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each followed by *Rhizobium* + PSB @ 30 ml kg^{-1} seed treatments each. Highest benefit cost ratio (2.02) was recorded *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each followed by *Rhizobium* + PSB @ 30 ml kg^{-1} seed treatments each.

Keywords: Black gram crop, rhizobium, PSB, NPK consortia

Introduction
Pulses are a significant source of protein for humans, providing three times as much as cereals while also being high in calories, sulphur, and vitamins, particularly the B- complex. They also play a significant role in our nation's agricultural economy. They are integral component of sustainable crop production, especially in rainfed areas. Blackgram (*Vigna mungo* L.), a highly prized pulse crop of Leguminosae family, is spread in Indian subcontinent and popularly known as "Urad dal". It is cultivated in Bangladesh, Afghanistan, Myanmar and Pakistan. Most suitable climate for Blackgram is 27-30 °C, moderate rainfall and loamy soil with high water holding capability. Blackgram is third most important pulse crop grown under rainfed, rice fallow, irrigated conditions and during *kharif*, *rabi* and summer seasons, which matures in 90-100 days and it, enriches soil with nitrogen. India is major producer and consumer of Blackgram. It is used for preparation of different food preparations like *Idli*, *Dosa* and non-fermented foods (Sivasubramanian *et al*., 2015) [23], with rice flour.
It is used as a nutritive fodder specially for milch cattle. It is also used as a green manuring crop. Black gramplant possesses deep root system which binds soil particles and thus prevent soil erosion. Black gram grain contains about 24% protein, 60% carbohydrates, 1.3% fat, and is the

richest among the various pulses in phosphoric acid, being five to ten times richer than others.

Black gram includes roughly 24% protein, 60% carbohydrates, 10.9% moisture, 1.4% fat, 0.9% fibre, and 3.2% minerals and vitamins, including calcium 154 mg, phosphorus 385 mg, iron 9.1 mg, and a minor amount of vitamin B complex. Black grama has mostly been found in tropical and subtropical regions of the world. In India, Pakistan, Sri Lanka, Burma, and some other East Asian nations, it is grown during the Kharif, Rabi, and summer seasons. Black gram is a crop that is widely grown throughout India, particularly in the states of Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana, Tamil Nadu, and Karnataka. It is grown on an area of about 35.53 lakh ha^{-1}, producing a total of 24 lakh tonnes annually with an average productivity of 533 kg ha^{-1}. Utter Pradesh, it is farmed over a 5.19 lakh ha^{-1} area, producing 2.19 lakh tonnes and productivity 500 kg ha^{-1}, respectively.

Material and Methods

The experiment was conducted at Rama University, Kanpur, which is situated in the alluvial tract of Indo - Gangetic plains in central part of Uttar Pradesh between 26° 34' to 26° 56' North latitude and 80° 13' to 80° 21'East longitude at an elevation of 125.9 metres from the sea level. This region falls under agro-climatic zone V (Central Plain Zone) of Uttar Pradesh. The irrigation facilities are adequately available on this farm. This zone has semi-arid climatic conditions having alluvial fertile soil. The normal rainfall of the area is about 890 mm per annum. Most of the rains are received from mid-June to the end of the September. The winter months are cooler with occasional rain and frost during last week of December to mid-January. The temperature in the month of May and June may go up to 44-47 °C or beyond and during winter go down to 2-3 °C. Mean relative humidity (7AM) remains nearly constant at about 80-90% from July to end of the March and after March slowly decline to about 40-50% by the end of April and remains 80% up to May. The weekly distribution of maximum and minimum temperature (°C), relative humidity (%), wind velocity (km hr-1), evaporation rate (mm day-1) and total rainfall (mm) recorded during the crop growth period).

Results and Discussion

Yield and Yield Component

Number of Pod plant^{-1}: The data recorded on number of pods plant^{-1} clearly indicated in table no:1 that various liquid biofertilizers had a significant effect on the number of pods/plant. The *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each produced a significantly higher number of pods per plant than closer RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} during field experimentation in *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each recorded maximum (64.00) number of pods which was at par with Rhizobium + PSB @ 30 ml kg^{-1} seed treatments each, NPK Consortia @ 30 ml kg^{-1} seed treatment. during field experimentation.

It is also clear from the result presented in the forgoing chapter that *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each was considerably better than other treatments in respect of total number of pods plant^{-1} because more availability of nutrients which helped increase in the number of pods per plant.

Number of seeds pod^{-1}: The data recorded on Number of seed pod^{-1} clearly indicated in table no: 1 that various liquid biofertilizers had a significant effect on the number of seed pod^{-1}. The *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each produced a significantly higher number of seed per pod than closer RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} during field experimentation in *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each recorded maximum (8.20) number of pods which was at par with treatment *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each, NPK Consortia @ 30 ml kg^{-1} seed treatments, *Rhizobium* + KMB @ 30 ml kg^{-1} seed treatments each. during field experimentation. It is also clear from the result presented in the forgoing chapter that *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each was considerably better than other treatments in respect of total number of seed pod^{-1} because more availability of nutrients which helped increase in the number of seed per pod.

Length of pods (cm): The data recorded on Length of pods clearly indicated in table no: 1 that various liquid biofertilizers had a significant effect on the Length of pods. The *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each produced a significantly higher Length of pods than closer T2 during field experimentation in *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each recorded maximum (6.20) length of pod which was at par with treatment *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each, NPK Consortia @ 30 ml kg^{-1} seed treatments, *Rhizobium* + KMB @ 30 ml kg^{-1} seed treatments each, *Rhizobium* + ZMB @ 30 ml kg^{-1} seed treatments each, PSB + KMB @ 30 ml kg^{-1} seed treatments each during field experimentation. It is also clear from the result presented in the forgoing chapter that *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each was considerably better than other treatments in respect of total number of seed pod^{-1} because more availability of nutrients which helped increase in the length of pod.

Test weight (g): The data related from test weight (g.) is clearly indicated in table no:1 that non-significantly maximum data recorded with *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each (38.70) and RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} (38.70). The result revealed that the combination of liquid biofertilizers was found statistically better over the single biofertilizers treatments in respect to test weight due to the fact that in better nutrient management and mobilization. Due to application of different liquid biofertilizers no. of nodule and seed/pod, pod length and test weight in Black gram was found significant due to better nutrient availability and nutrient mobility, similarly reported by Yadav *et al*. (2017) [25].

Seed yield (q ha^{-1}): The data pertaining to seed yield is clearly indicated in table no:2 as influenced by different liquid biofertilizers. The result revealed that seed yield was significantly increased at *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each (11.20 q ha^{-1}) which was significantly higher in present field experimentation. The yield increments with *Rhizobium* + PSB + KMB @ 30 ml kg^{-1}seed treatments each (11.20 q ha^{-1}) on at par with RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} (10.95 q ha^{-1}), *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each (10.60 q ha^{-1}), NPK Consortia @ 30 ml kg^{-1} seed treatments (10.10 q ha^{-1}) in seed yield, respectively in present field experiment.

Biological yield (q ha^{-1}): The data on Biological yield (q ha^{-1}) is clearly indicated in table no: 2 as influenced significantly due to different liquid biofertilizers seed treatments. Here the significantly higher value was observed among *Rhizobium* +

PSB + KMB @ 30 ml kg^{-1} seed treatments each (35.45 q ha^{-1}) that is on at par with RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1}, *Rhizobium* + PSB @ 30 ml kg^{-1} seed treatments each, NPK Consortia @ 30 ml kg^{-1} seed treatments.

Stover yield (q ha^{-1}): The result indicated in table no:2 depicted that stover yield enhanced significantly upto *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each (24.25 q ha^{-1}) treatment that is on at par with RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1}, *Rhizobium* + PSB @ 30 ml kg^{-1} seed treatments each, NPK Consortia @ 30 ml kg^{-1} seed treatments, *Rhizobium* + KMB @ 30 ml kg^{-1} seed treatments each. The minimum yield was recorded with control.

Harvest Index (%): The data pertaining to harvest index indicated in table no: 2 recorded and found that non-significant under various liquid biofertilizers (nutrient management) practices. Harvest index varied from 30.90 percent under control to 31.96 percent under treatment T1 (*Rhizobium* + PSB + KMB @ 30 ml Kg^{-1} seed treatments each). Such differences were however non-significant and varied from 30.90 to 31.96.
Application of different liquid biofertilizers on yield attributes in Black gram was found significant except harvest index due higher nutrient availability and mobility by various biofertilizers, similarly reported by Yadav *et al*. (2017) [25].

Table 1: The data recorded on Number of seed pod^{-1} clearly indicated

Symbols	Treatments	Number of Pod plant^{-1}	Number of seeds pod^{-1}	Length of pods (cm)	Test weight (g)
T_1	Rhizobium @ 30 ml kg^{-1} seed treatments	54.00	7.20	5.50	38.35
T_2	Rhizobium + ZMB @ 30 ml kg^{-1} seed treatments each	54.60	7.30	5.60	38.40
T_3	PSB + KMB @ 30 ml kg^{-1} seed treatments each	55.40	7.40	5.70	38.45
T_4	Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatments each	64.00	8.20	6.20	38.70
T_5	RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1}	62.80	8.00	6.10	38.70
T_6	NPK Consortia @ 30 ml kg^{-1} seed treatments	58.80	7.60	5.80	38.55
T_7	Rhizobium + PSB @ 30 ml kg^{-1} seed treatments each	60.60	7.80	5.90	38.60
T_8	Rhizobium + KMB @ 30 ml kg^{-1} seed treatments each	56.00	7.40	5.70	38.50
T_9	Control	42.00	6.20	4.80	38.00
SEm ±		1.92	0.30	0.23	1.34
C.D. at 5%		5.64	0.89	0.69	3.92

Table 2: The data pertaining to seed yield is clearly indicated

Symbols	Treatments	Seed yield (q ha^{-1})	Biological yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%):
T_1	Rhizobium @ 30 ml kg^{-1} seed treatments	9.00	19.62	28.62	31.44
T_2	Rhizobium + ZMB @ 30 ml kg^{-1} seed treatments each	9.50	20.68	30.18	31.47
T_3	PSB + KMB @ 30 ml kg^{-1} seed treatments each	9.70	21.10	30.80	31.49
T_4	Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatments each	11.20	24.25	35.45	31.59
T_5	RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1}	10.95	23.73	34.68	31.57
T_6	NPK Consortia @ 30 ml kg^{-1} seed treatments	10.10	21.90	32.00	31.56
T_7	Rhizobium + PSB @ 30 ml kg^{-1} seed treatments each	10.60	22.98	33.58	31.56
T_8	Rhizobium + KMB @ 30 ml kg^{-1} seed treatments each	9.85	21.41	31.26	31.50
T_9	Control	7.00	15.65	22.65	30.90
SEm ±		0.45	1.01	1.20	1.35
C.D. at 5%		1.32	2.96	3.51	NS

Economics

Cost of Cultivation (Rs. ha^{-1}): The data on cost of cultivation (Rs. ha^{-1}) is indicated in table no: 3 that evaluation of different liquid biofertilizers, maximum cost of cultivation (Rs.29530 ha^{-1}) recorded with RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} which was higher than rest of the evaluation of different liquid biofertilizers.

Gross return (Rs. ha^{-1}): The data on gross return (Rs. ha$^{-1)}$ indicated in table no: 3 that highest gross return was recorded (Rs. 84140) in *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each followed by Rs. 79649 with *Rhizobium* + PSB @ 30 ml kg^{-1} seed treatments each. Similar result also found by Philip *et al*. (2021) [5].

Net return (Rs. ha^{-1}): The data on net return are presented in table no: 3 that all evaluation of different liquid biofertilizers gave higher net return than control treatment. Maximum net return of Rs 56314 was received with the application *Rhizobium* + PSB + KMB @ 25 ml kg^{-1} seed treatments each fallowed by *Rhizobium* + PSB @ 25 ml kg^{-1} seed treatments each. Similar result was also found by Gohain *et al*. (2022) [7] due to dual inoculation of seed with rhizobium and PSB.

Benefit: Cost Ratio (B:C Ratio): The data on benefit: cost ratio indicated in table no:3 among evaluation of different liquid biofertilizers, *Rhizobium* + PSB + KMB @ 30 ml kg^{-1} seed treatments each followed by *Rhizobium* + PSB @ 30 ml kg^{-1} seed treatments each. registered maximum benefit: cost ratio (2.02). Similarly reported by Philip *et al*. (2021) [5].

Table 3: Economics

Symbols	Treatments	Cost of Cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
T_1	Rhizobium @ 30 ml kg^{-1} seed treatments	27626	67687	40061	1.45
T_2	Rhizobium + ZMB @ 30 ml kg^{-1} seed treatments each	27726	71431	43705	1.58
T_3	PSB + KMB @ 30 ml kg^{-1} seed treatments each	27726	72926	45200	1.63
T_4	Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatments each	27826	84140	84140	2.02
T_5	RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1}	29530	82274	52744	1.79
T_6	NPK Consortia @ 30 ml kg^{-1} seed treatments	27626	75894	48268	1.75
T_7	Rhizobium + PSB @ 30 ml kg^{-1} seed treatments each	27726	79649	51923	1.87
T_8	Rhizobium + KMB @ 30 ml kg^{-1} seed treatments each	27726	74045	46319	1.67
T_9	Control	27526	52864	25864	0.92

Conclusions

It may be concluded that application of Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatments may be recommended to obtain the high values of growth, yield attributes and yields of Black gram followed by RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} and Rhizobium + PSB @ 30 ml kg-1 seed treatments. Liquid biofertilizers application was recorded non-significant in nutrient content while nutrients uptake was recorded higher in Rhizobium + PSB + KMB @ 30 ml kg^{-1} seed treatments followed by RDF N-25 Kg ha^{-1}, P-45 Kg ha^{-1}, K-0 Kg ha^{-1} treatment. Highest net return (Rs. 56314 ha^{-1}) and benefit cost ratio (2.02) was obtained per rupees invested with Rhizobium + PSB + KMB @ 25 ml kg^{-1} seed treatments.

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