EFFECT OF MICROBIAL INOCULANTS ON CROP GROWTH, YIELD, BIOCHEMICAL AND PHYIOLOGICAL PARAMETERS OF BLACK GRAM (*Vigna mungo* (L.) Hepper)

ABSTRACT

A field experiment was carried out at the Department of Seed Science and Technology, S.V. Agricultural College, Tirupati during 2022**.** the field experiment was carried out in randomized block design with 10 treatments and 3 replications. The black gram variety TBG-104 differed for field, biochemical, and physiological parameters in response to different treatments of microbial inoculants. The influence of the treatments in the field was significant with respect to crop growth, phenological and yield parameters, seed quality attributes, biochemical and physiological parameters. In case of crop growth parameters which include field emergence (%), plant height (cm) highest performance was seen in T9(91.67%,27.47cm) over control and other treatments. While all the treatments recorded values that are on par with the highest performed treatment. In case of phenological parameters which include days to first flowering, 50% flowering and maturity, T9 and T8 were the best performed treatments over the other treatments and control. Similar trend was observed with respect to yield and yield parameters where T9(929.63 kg/ha) treatment showed the highest performance. Our results revealed that that the co-inoculation of 4 or 5 microbial inoculants showed better results over individual treatments during the period of storage.

INTRODUCTION

Black gram is one of the main pulse crops in India. It fixes atmospheric nitrogen into the soil, and improves soil fertility. As a complement to a diet focused on cereal and containing vegetable protein, it is a significant part of the Indian diet. It has a protein content of about 26%, which is about three times that of grains, in addition to other minerals and vitamins. Additionally, it serves as nutritious animal feed for animals.

India is the world's largest producer as well as consumer of blackgram. With an average yield of 501Kg per hectare in 2020–21, it produces roughly 23.4 lakh tonnes of blackgram yearly from 46.7 lakh hectares of land (agricoop.nic.in). About 15.7% of India's total pulse acreage and 9.09% of the nation's total pulse production are located in the Blackgram area. Blackgram was produced in Kharif 2021–22 in an area of 39.43 lakh hectares at a rate of 20.5 lakh tonnes (first advance estimates; agricoop.nic). In the years 2020–21, Andhra Pradesh produced 3.65 lakh tonnes of blackgram on a surface area of 3.93 lakh ha (des.ap.gov.in). Blackgram was cultivated on 3.93 lakh hectares with a yield of 3.65 lakh tonnes and a productivity of 929 kg/ha between 2021 and 2022, according to 2nd advance estimates.

The'quantity and quality of agricultural output can be increased by using microbial'inoculants by reducing the negative impacts of chemical input. The use of microbial inoculants, being ecofriendly provide nutrients in a more dependable manner.' Microbial inoculants can reduce the usage of chemical fertilizers. Fungi, bacteria, and algae can act as microbial inoculants. Given that it allows for the exact application of small amounts of inoculants, seed coating has been suggested as a promising method for immunising various crop seeds. (Rouphael et al., 2018b; Rocha et al., 2019a; Rocha et al., 2019b). Depending on the application goal, the type of seed, or the chosen microorganisms, the three primary types of seed coatings are seed dressing, seed filming, and seed pelleting. Therefore, it is expected in the current study that seed dressing with advantageous inoculants would discover the beneficial effects on seed quality, storability and yield.

MATERIAL AND METHODS

The variety black gram variety TBG-104 was sown and harvested during summer season inaRandomizedBlockDesign(RBD)withthreereplicationsinordertostudythecrop growth and yield parameter as per cent of mean. In each replication everytreatment was sown in five rows of 5 m length with aspacing of 30 cm between the rows and 10 cm betweenthe plants within the row. The treatments in the experiment are T1: Rhizobium,T2: Rhizobium + Phosphorous Solubilizing Bacteria (PSB),T3: Rhizobium + Potassium solubilizing Bacteria (KSB), T4: Rhizobium + Phosphorous Solubilizing Bacteria (PSB) + Potassium solubilizing Bacteria (KSB), T5: Rhizobium + Phosphorus Solubilizing Bacteria (PSB) + KSB +Pseudomonas fluorescense, T6: Rhizobium + Trichoderma viride, T7: Rhizobium + PSB + Trichoderma viride, T8: Rhizobium + Potassium solubilizing Bacteria (KSB) + Trichoderma viride, T9: Rhizobium + PSB + KSB +Trichoderma viride + Pseudomonas fluorescense.T10: Untreated Control.

The data was collected fromfive randomly selected plants of each treatment in eachreplicationfor12charactersviz., Field emergence (%), Plant height(cm), Days to first flowering, Days to 50% flowering, Days to maturity, No of branches/plant, No of pods per plant., No of seeds/pod, Seed yield per plant (g), Seed yield/plot (kg/ha), 100 seed weight(g), No of nodules per plant (effective and ineffective nodules).

RESULTS AND DISCUSSION

The influence of the treatments in the field was significant with respect to crop growth, phenological and yield parameters. In case of crop growth parameters which include field emergence (%), plant height (cm) highest performance was seen in T9(91.67%,27.47cm) over control and other treatments. While all the treatments recorded values that are on par with the highest performed treatment. In case of phenological parameters which include days to first flowering, 50% flowering and maturity, T9(24,31,60.67 days respectively) and T8(26,31.33,62 days respectively) were the best performed treatments over the other treatments and control. Similar trend was observed with respect to yield and yield parameters where T9 treatment showed the highest performance. (No of branches/plant(10.27), No of pods per plant(14.83), Seed yield per plant (4.07g), Seed yield/plot (929.63kg/ha), 100 seed weight(5.55g), No of nodules per plant(26)).

After the crop was harvested, analysis was conducted on seed quality parameters i.e., germination percentage, seedling length(cm), seedling dry weight(g), seed vigour index, and electrical conductivity (µs m-1). During the analysis of seed quality parameters of harvested seed T9 showed better results when compared to control and other treatments T5 was on par with the highest performed treatment.

'In addition to the seed quality parameters, biochemical and physiological parameters were also studied on the harvested seed. Biochemical parameters include nitrogen content (%), protein content (%), total soluble sugars (%), phenol content and chlorophyll content (SCMR Values). T9 recorded the highest mean values when compared to all the treatments except in Total soluble sugars (%) in which T4(3.04%) recorded the highest value. In case of chlorophyll content, at 40 DAS, there is no significant difference was observed among the treatments. Where as at 50 and 60 DAS, highest SCMR values were recorded in T9(50.73) and T5(43.1) respectively.

Physiological parameters analysed include the activity of reactive oxygen species (peroxidase activity and soil enzymes which include enzyme activities of dehydrogenase, acid and alkaline phosphatase, urease. The peroxidase activity was highest in T6(230 U mg-1 protein), dehydrogenase activity in T5(97.76 µg of TPF g-1 day-1), acid and alkaline phosphatase activity in T4 and T9(87.95,

112.83 µg of p-n-p g-1 hr-1 respectively). Significant enzyme activity was recorded in all the treatments which are responsible for various metabolic activities and promote plant health.

Table 1. Effect of microbial inoculants on crop growth parameters

S.No	Treatments	Field emergence (%)	Plant height(cm)
1	T1	84.33 (66.68)	27.70
2	T2	84.67 (66.94)	27.88
3	T3	85.00 (67.21)	28.00
4	T4	85.67 (67.75)	28.26
5	T5	90.33 (71.88)	29.04
6	T6	82.67 (65.39)	24.44
7	T7	85.33 (67.48)	25.76
8	T8	90.33 (71.88)	27.47
9	T9	91.67 (73.22)	29.40
10	T10	71.00 (57.42)	20.11
	Mean	85.10 (67.29)	26.81
	SEm±	2.653	1.39
	CD (5%)	7.94	4.16
	CV (1%)	5.39	8.98

*Values in the parenthesis indicate arc-sine transformed values.

Table 2. Effect of microbial inoculants on phenological parameters

S.No	Treatments	Days to first flowering	Days to 50% flowering	Days to maturity
1	T1	28.33	36.67	71.33
2	T2	26.33	35.00	71.33
3	T3	26.33	35.00	70.67

4	T4	26.67	34.00	70.67
5	T5	26.00	31.00	60.67
6	T6	28.33	36.00	71.33
7	T7	26.67	35.00	70.67
8	T8	26.00	31.33	62.00
9	T9	24.00	31.00	60.67
10	T10	32.00	39.00	77.33
	Mean	2.56	1.86	2.47
	SEm±	0.86	0.62	0.83
	CD (5%)	0.86	0.62	0.82
	CV (%)	5.47	3.13	2.08

Table 3. Effect of microbial inoculants on yield and yield parameters

S.No	Treatments	No of branches/ plant	No of pods per plant	No of seeds /pod	Seed yield /Plant(g)	Seed yield (Kg/ha)	Test weight(g)	No of nodules /plant
1	T1	7.13	10.03	5.71	2.04	737.78	5.29	24.00

2	T2	7.73	10.93	5.25	3.29	745.19	5.22	22.33
3	T3	8.07	11.27	5.40	3.39	774.07	5.05	24.00
4	T4	8.27	13.23	5.43	3.66	890.37	5.29	23.67
5	T5	8.80	14.07	5.75	3.82	906.67	5.49	23.67
6	T6	7.67	9.60	5.60	3.00	691.11	5.09	23.67
7	T7	8.13	11.23	5.37	3.11	785.19	5.09	20.33
8	T8	8.20	12.13	5.43	3.61	905.19	5.47	21.00
9	T9	10.27	14.83	5.67	4.07	929.63	5.55	26.00
10	T10	6.80	7.67	5.09	2.62	503.45	4.6	13.33
	Mean	8.11	11.50	5.47	3.26	786.86	5.21	22.20
	SEm±	0.46	0.84	0.21	0.04	29.84	0.16	1.02
	CD (5%)	1.39	2.50	NS	0.12	89.34	0.48	3.07
	CV (%)	9.97	12.58	6.59	2.18	6.59	5.38	7.98

Table 4. Effect of microbial inoculants on seed quality parameters

S. No	Treatments	Germination (%)	Seedling length(cm)	Seedling dry weight(g)	Seedling vigour index I	Seedling vigour index II	Electrical conductivity (dsm^{-1})
1	T1	82.33 (65.14)	30.42	4.07	2504.82	554.20	233.33
2	T2	86.67 (68.58)	32.10	5.20	2782.62	551.01	203.33
3	T3	87.33	32.74	5.53	2858.92	519.43	196.67

		(69.14)					
4	T4	90.33 (71.88)	33.98	6.33	3069.51	486.87	193.33
5	T5	91.00 (72.54)	34.65	6.73	3152.98	352.59	180.00
6	T6	84.67 (66.94)	30.85	4.24	2611.81	469.92	216.67
7	T7	87.00 68.86)	32.96	4.60	2867.36	418.58	196.67
8	T8	88.00 (69.73)	33.88	5.67	2981.44	358.29	183.33
9	T9	91.67 (73.22)	34.67	7.30	3178.09	637.54	173.33
10	T10	75.37 (60.22)	27.87	3.00	2099.64	225.99	270.00
	Mean	86.43 (68.38)	32.41	5.27	2810.72	554.20	204.67
	SEm±	1.13	0.36	0.07	35.89	24.20	2.26
	CD (5%)	3.38	1.08	0.20	107.47	8.08	6.76
	CV (%)	2.26	1.93	2.29	2.22	3.06	1.91

Table 5. Effect of microbial inoculants on biochemical parameters

S.No	Treatments	Nitrogen content (%)	Protein content (%)	Total Soluble Sugars (%)	Phenol content (mg g^{-1})
1	T1	3.62	22.64	2.68	0.25
2	T2	3.67	22.94	2.99	0.26
3	T3	3.79	23.67	2.20	0.28
4	T4	3.84	24.01	3.04	0.29
5	T5	3.85	24.04	2.28	0.35
6	T6	3.64	22.77	2.81	0.25
7	T7	3.74	23.36	2.74	0.28
8	T8	3.82	23.86	2.45	0.29
9	T9	3.87	24.17	2.85	0.41
10	T10	3.66	22.89	2.45	0.24
	Mean	3.75	23.44	2.65	0.29
	SEm±	0.05	0.30	0.04	0.04
	CD (5%)	0.14	0.90	0.11	0.01
	CV (%)	2.21	2.21	2.33	2.45

Table 6. Effect of microbial inoculants on chlorophyll content (SCMR Values)

S.No	Treatments	40 DAS	50 DAS	60 DAS
1	T1	41.31	42.60	38.27
2	T2	46.29	42.97	38.50
3	T3	45.02	44.67	41.13
4	T4	44.34	44.93	42.50

5	T5	46.29	47.13	42.60
6	T6	44.45	43.57	38.77
7	T7	43.86	44.23	40.30
8	T8	42.87	45.10	41.83
9	T9	43.10	50.73	43.10
10	T10	41.60	38.90	35.57
	Mean	43.91	44.48	40.26
	SEm±	1.99	1.30	0.53
	CD (5%)	NS	3.90	1.59
	CV (%)	7.84	5.08	2.28

Table 7. Effect of microbial inoculants on peroxidase activity in harvested black gram seed (U mg^{-1} protein)

S.No	Treatments	Peroxidase (U mg^{-1} protein)
1	T1	212.47
2	T2	213.73
3	T3	220.31
4	T4	214.22
5	T5	222.51
6	T6	218.47
7	T7	214.51
8	T8	218.30
9	T9	230.96
10	T10	205.72
	Mean	217.13
	SEm±	1.29
	CD (5%)	3.85
	CV (%)	1.02

Table 8. Effect of microbial inoculants on enzyme activity in soil

S.No	Treatments	Dehydrogenase (µg of TPF g^{-}	Acid phosphatase	Alkaline phosphatase	Urease (µg of NH_4-N g^{-}

		$^{1}day^{-1}$)	(µg of *p-n-p* g^{-1} hr^{-1})	(µg of *p-n-p* g^{-1} hr^{-1})	^{1} 2 hr^{-1})
1	T1	85.69	76.37	96.37	70.97
2	T2	85.17	87.01	96.30	74.62
3	T3	81.50	80.83	111.2	75.84
4	T4	82.59	87.95	92.15	84.15
5	T5	97.76	87.66	102.28	86.93
6	T6	87.36	82.59	107.31	90.11
7	T7	83.52	79.30	97.77	91.5
8	T8	80.77	75.97	102.76	82.64
9	T9	68.77	85.69	112.83	70.57
10	T10	70.75	76.92	99.90	86.02
	Mean	82.39	82.03	101.89	81.34
	SEm±	1.17	1.43	2.58	5.15
	CD (5%)	3.51	4.29	7.71	NS
	CV (%)	6.46	7.57	4.38	10.97

CONCLUSION

Further from this study, the treatment T9(Rhizobium + PSB + KSB +Trichoderma viride + Pseudomonas fluorescens) has'emerged as an ideal treatment with superior morphological, physiological, biochemical and yield parameters. Hence T9(Rhizobium + PSB + KSB +Trichoderma viride + Pseudomonas fluorescens) can be recommended for enhanced seed quality, seed yields and productivity. Our results revealed that that the co-inoculation of 4 or 5 microbial inoculants showed better results over individual treatments during the period of storage.

References

Abirami, S., Nagarajan, D., and Rodrigo, B. C. P. 2018. Enhancement of Black Gram (Phaseolus mungo L.) growth by dual inoculation with Pseudomonas fluorescens and Rhizobium leguminosarum. *Journal of Pharmacognosy Phytochemistry.* 2018.7(5S):01-07.

Ahmad, E., Zaidi, A. and Khan, M.S., 2016. Effects of Plant Growth Promoting Rhizobacteria on the Performance of Greengram under Field Conditions. *Jordan Journal of Biological Sciences*. *9*(2).

Ajaykumar, R., Harishankar, K., Chandrasekaran, P., Kumaresan, P., Sivasabari, K., Rajeshkumar, P. and Kumaresan, S., 2023. Physiological and biochemical characters of blackgram as influenced by liquid rhizobium with organic biostimulants. Legume Research-An International Journal. 46(2): 60-165.

Alori, E.T., Babalola, O.O. and Prigent-Combaret, C., 2019. Impacts of microbial inoculants on the growth and yield of maize plant. *The Open Agriculture Journal*. *13*(1).

Amruta, N., Devaraju, P.J., Mangalagowri, M., Kiran, S.P., Ranjitha, H.P. and Teli, K., 2016. Effect of integrated nutrient management and spacing on seed quality parameters of black gram cv. Lbg-625 (rashmi). Journal of Applied and Natural Science. 8(1):340-345.

Arif, M.S., Shahzad, S.M., Riaz, M., Yasmeen, T., Shahzad, T., Akhtar, M.J., Bragazza, L. and Buttler, A., 2017. Nitrogen- enriched compost application combined with plant growth- promoting rhizobacteria (PGPR) improves seed quality and nutrient use efficiency of sunflower. *Journal of Plant Nutrition and Soil Science*. *180*(4):464-473.

Barman, P., Rekha, A. and Pannerselvan, P., 2016. Effect of microbial inoculants on physiological and biochemical characteristics in jamun (Syzygiumcumini L. Skeels) under different propagation substrates. *International Journal of Minor Fruits, Medicinal and Aromatic Plants (IJMFM&AP)*.

BOIU-SICUIA, O.A., CONSTANTINESCU, F., URSAN, M.D. and CORNEA, C.P., 2020. Microbial inoculants applied as seed treatments and their effect on common wheat Triticum aestivum L. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*. *49*(2):38-43.

Chennakesavulu, M., Reddikumar, M and Eswarareddy, N.P. 2013. Mass multiplication and shelf life studies of Pseudomonas fluorescens against pigeon pea wilt. Indian Journal of plant Protection. 41(1): 45-49.

Dineshkumar, R., M. Duraimurugan, N. Sharmiladevi, L. Priya Lakshmi, A. Ahamed Rasheeq, A. Arumugam, and P. Sampathkumar. "Microalgal liquid biofertilizer and biostimulant effect on green gram (Vigna radiata L) an experimental cultivation." Biomass Conversion and Biorefinery. 2020: 1-21.

Erdemci, İ., 2021. Effects of seed microbial Inoculant on growth, yield, and nutrition of durum wheat (Triticum Durum L.). *Communications in Soil Science and Plant Analysis*. *52*(7):792-801.

Goel, S. and Bano, Y., Effect of microbial inoculants on soil quality, growth and yield of pea plant.

Gomathinayagam, R., Subramanian, G., Persaud, M., Persaud, R. and Velusamy, S., 2021. The Studies of Effect of Bio Fertilizers Rhizobium, Phosphobacteria, and Root Nodule Extract (R. PB, R+ PB & RNE) on the Growth and Certain Biochemical Changes in the Seedlings of Black Gram & Maize. *Asian Journal of Applied Science and Technology (AJAST)*. *5*(4):01-15.

Harireddy, Y. V., and Dawson, J. 2021 Effect of biofertilizers and levels of vermicompost ongrowth and yield of cowpea (*Vigna unguiculata L.*) *The Pharma Innovation Journal*. 2021. 10(6): 985-988.

Hoque, S., Sultana, N., Faruq, A.N., Bhuiyan, M.Z.R and Islam, N. 2014. In-vitro evaluation of selected bio-control agents against foot and root rot pathogens of lentil. *Scholorly Journal of Agricultural Sciences.* 5 (1):8-15.

Iftikhar, A., Muhammad, J.A., Hafiz, N.A and Muhammad, K. 2013. Influence of Rhizobium applied in combination with micronutrients on mung bean. Pakistan Journal of Life and Social Sciences.11(1): 53-59.

Keteku, A.K., Yeboah, S., Agyemang, K., Amegbor, I., Danquah, E.O., Amankwaa-Yeboah, P., Dormatey, R., Brempong, M.B. and Frimpong, F., 2022. Evaluation of Carrier- and Liquid-Based Bioinoculant as a Promising Approach to Sustain Black Gram (*Vigna mungo L.)* Productivity. *International Journal of Plant Production*. 1-14.

https://agricoop.nic.in/

http://des.ap.gov.in/MainPage.do;jsessionid=D0E49AFAC4DA26B42F2A05C3D631C775

Karnwal, A. and Kumar, V., 2012. Influence of plant growth promoting rhizobacteria

(PGPR) on the growth of chickpea (Cicer arietinum L.). *Annal Review of Food Science and Technology*. *13*(2):1-6.

Khalil, M.K., Taha, K.F., Nesem, M.A. and Sallam, S.S., 2019. Phytochemical studies on celery (apium graveolens l.) Plant under using chemical fertilization, biofertilizer and thidiazuron treatments. AI-Azhar journal of Pharmaceutical Sciences. 59.

Khan, M., Zaidi, A., Rizvi, A. and Saif, S., 2017. Inoculation effects of associative plant growth-promoting Rhizobacteria on the performance of legumes. In *Microbes for Legume Improvement.* (261-276). Springer, Cham.

Kaur, H., Gosal, S. K., & Walia, S. S. (2017). Synergistic Effect of Organic, Inorganic and Biofertilizers on Soil Microbial Activities in Rhizospheric Soil of Green Pea. *Annual Research & Review in Biology*. *12*(4):1-11.

Lalitha, S. and Santhakumari, R., 2020. Improving and effect of bio fertilizer on enhancement of the growth and bio chemical characteristic of photosynthesis on the Blackgram (Vigna mungo L.). *Journal of Biological Chemistry*. *11*:1-10

Li, H., Qiu, Y., Yao, T., Ma, Y., Zhang, H. and Yang, X., 2020. Effects of PGPR microbial inoculants on the growth and soil properties of Avena sativa, Medicago sativa, and Cucumis sativus seedlings. *Soil and Tillage Research*. *199*:104577.

Manojkumar, M.K., Ramji, S and Ajay, T. 2014. In vitro evaluation of antagonistic activity of Pseudomonas fluorescens against fungal pathogen. *Journal of Bio Pesticides.* 7 (1): 43-46.

Meena, G.N., Kurdiya, K., Sharma, K.C. and Sharma, M., 2021. Effect of Different Fertilizers on Biochemical Characteristics of Leaf of Groundnut (Arachis hypogaea L.). *Turkish Online Journal of Qualitative Inquiry*. 12(10).

Mohammadi, M., Safikhani, S., Esmaeili, A., Reza, C.M and Mohammad, D. 2013. Effects of seed inoculation by Rhizobium strains on yield and yield components of common bean (Phaseolus vulgaris. L). *International Journal of Bio Sciences. 3 (3): 134 – 141.*

Moreno-Lora, A., Sousa-Ortega, C., Recena, R., Perea-Torres, F. and Delgado, A., 2022. Microbial inoculants improve nutrients uptake and yield of durum wheat in calcareous soils under drought stress in the Mediterranean region. *Archives of Agronomy and Soil Science*. 1-15.

Nalawde Amit, A. and Bhalerao Satish, A., 2015. Response of Black gram Vigna mungo (L. Hepper) to Biofertilizer. *International journal of Life Sciences*. *3*(1):81-84.

Naragund, R., Singh, Y.V., Jaiswal, P., Bana, R.S. and Choudhary, A.K., 2022. Influence of crop establishment practices and microbial inoculants on nodulation of summer green gram (Vigna radiata) and soil quality parameters. *Legume Research-An International Journal*. *45*(5):646-651.

Navsare, R.I., Mane, S.S. and Supekar, S.J., 2018. Effect of potassium and zinc solubilizing microorganism on growth, yield and quality of mungbean. *International Journal of Chemical Studies*. *6*(1):1996-2000.

Nazir, H., Badrul, H., Rehana, H., Lekh, C., Abid Ali and Anwar, H. 2010. Response of bio fertilizers on growth and yield attributes of black gram (Vigna mungo.L).*International Journal of Current Research.* 2 (1): 148-150.

Palaniraja, K. 2018. "Response of biofertilizers on growth attributes of black *gram* vigna mungo (L.) hepper" *International Journal of Current Research in Life Sciences*. 7(04):1495-1496.

Prasad, S., 2016. Impact of Different Microbial Cultures on Nutrient Uptake and Quality of

Groundnut. International Journal of Agriculture Sciences, ISSN, pp.0975-3710.

Premachandra, D., Hudek, L., Enez, A., Ballard, R., Barnett, S., Franco, C.M. and Brau, L., 2020. Assessment of the capacity of beneficial bacterial inoculants to enhance canola (Brassica napus L.) growth under low water activity. *Agronomy*, *10*(9). 1449.

Ramya, S., Gulab, P., Oberoi, H., Kaur, S. and Kalia, A., 2022. Improvement in the Quality Attributes of Forage Cowpea by Use of Liquid Microbial Inoculants. *Indian Journal of Animal Research*. *56*(8):959-965.

Rao, D., Sachan, C.P., Pashwan, V.R. and Sakpal, A.V., 2021. Effect of organic manure, biofertilizer, phosphorus and nitrogen on growth, seed yield, seed quality attributes of green gram (Vigna radiata L.). The Pharma Innovation Journal. 10(11):197-204.N

Sallam, s., 2019. Phytochemical studies on celery (apium graveolens l.) Plant under using chemical fertilization, biofertilizer and thidiazuron treatments. Al-azhar journal of Pharmaceutical Sciences. 59(1):54-65.

Selvakumar, G., Reetha, S. and Thamizhiniyan, P., 2012. Response of biofertilizers on growth, yield attributes and associated protein profiling changes of blackgram (Vigna mungo L. Hepper). World Applied Sciences Journal. 16(10):1368-1374.

Singh, R., Arora, N.K., Preeti, G and Shattarohan, L. 2013. Enhancement of plant growth of Trigonella foenum-graecum by coinoculation of fluorescent Pseudomonas and Rhizobium for the sustainability of agriculture. *Asian Journal of Plant Science and Research.* 3 (3):74-79

Singh, U.B., Malviya, D., Singh, S., Singh, P., Ghatak, A., Imran, M., Rai, J.P., Singh, R.K., Manna, M.C., Sharma, A.K. and Saxena, A.K., 2021. Salt-tolerant compatible microbial inoculants modulate physio-biochemical responses enhance plant growth, Zn biofortification and yield of wheat grown in saline-sodic soil. *International Journal of Environmental Research and Public Health*. *18*(18):9936.

Shafi, S., Asif, M., Zargar, M.Y., Maqbool, S., Mir, S.A., Baba, Z.A. and Dar, Z.M., 2019. Impact of microbial inoculants on growth and yield of tomato (Solanum lycopersicon L.) under temperate conditions. *Journal of Pharmacognosy and Phytochemistry*. *8*(1):1261-1264.

Srivastava, P. and Singh, N., 2022. Effects of microbial inoculants on soil carbon stock, enzymatic activity, and above ground and belowground biomass in marginal lands of Northern India. Land Degradation & Development. 33(2): 308-323.

Surekha, C.H., Neelapu, N.R.R., Kamala, G., Siva prasad, B and Sankar Ganesh, P. 2013. efficacy of Trichoderma viride to induce disease resistance and antioxidant responses in legume Vigna mungo infested by Fusarium oxysporum and Alternaria alternate. *International Journal of agricultural Science.* 3 (2): 285-294.

Tagore, G.S., Namdeo, S.L., Sharma, S.K. and Kumar, N., 2013. Effect of Rhizobium and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghemoglobin, and yield of chickpea genotypes. *International Journal of Agronomy*, *2013*.

Tiwari, S., Chauhan, R.K., Singh, R., Shukla, R. and Gaur, R., 2017. Integrated effect of rhizobium and azotobacter cultures on the leguminous crop black gram (Vigna mungo). *Advances in Crop Science and Technology.* 5 (3): 1–9.

Vennila, S. 2018. "Effect of microbial inoculants on biometrical traits of black gram (Vigna Mungo l. Hepper)" *International Journal of Current Research in Life Sciences.* 7(04):1487-1488.

Xu, H.L., 2001. Effects of a microbial inoculant and organic fertilizers on the growth, photosynthesis and yield of sweet corn. *Journal of crop production*. *3*(1):183-214.

Yilmaz, A., 2022. Mixed consortium of microbial inoculants improves yield and essential oil

profile of coriander. *Journal of Bioscience and Bioengineering*. *134*(5):462-470.
Zhou, W., Zhang, M., Tao, K. and Zhu, X., 2022. Effects of arbuscular mycorrhizal fungi and plant growth-promoting rhizobacteria on growth and reactive oxygen metabolism of tomato fruits under low saline conditions. *Biocell*. *46*(12):2575-2582.
Zorawar, S., Guriqbal, S. and Navneet, A., 2017. Effect of Mesorhizobium, plant growth promoting rhizobacteria and phosphorus on plant biometry and growth indices of desi chickpea (Cicer arietinum L.). *Journal of Applied and Natural Science.* 9(3):1422-1428.