International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 3808-3816, 2023; Article no.IJECC.106288
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Microbial Inoculants on Crop Growth, Yield, Biochemical and Phyiological Parameters of Blackgram [*Vigna mungo* (L.) Hepper]

G. Lavanya [a++*], S. Vasundhara [a#], B. Rupesh Kumar Reddy [a†] and M. Raveendra Reddy [b‡]

[a] *Department of Seed Science and Technology, S.V. Agricultural College, Tirupati, India.*
[b] *Post-Harvest Engineering and Technology, RARS, Tirupati, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i103053

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106288

Original Research Article

Received: 12/07/2023
Accepted: 18/09/2023
Published: 21/09/2023

ABSTRACT

A field experiment was carried out in randomized block design with 10 treatments and 3 replications at the Department of Seed Science and Technology, S.V. Agricultural College, Tirupati during 2022. The blackgram 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

[++] *M.sc Scholar;*
[#] *Professor and Head;*
[†] *Assistant Professor;*
[‡] *Senior scientist;*
**Corresponding author: E-mail: g.lavanya412@gmail.com;*

T9(91.67%,27.47cm) over control and other treatments. While all the treatments recorded values that are at par with the highest performed treatment. In case of phenological parameters which include days to first flowering, 50% flowering and maturity, The treatment T9 and T8 were the best performed 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.

Keywords: Crop growth; biochemical; yield; blackgram.

1. INTRODUCTION

Blackgram 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 along with 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/ha in 2020–21, it produces roughly 23.4 lakh tons 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 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 tons (first advance estimates; agricoop.nic). In the years 2020–21, Andhra Pradesh produced 3.65 lakh tons of blackgram on a surface area of 3.93 lakh ha [1]. Blackgram was cultivated on 3.93 lakh hectares with a yield of 3.65 lakh tons 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 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.

2. MATERIALS AND METHODS

The blackgram variety TBG-104 was sown and harvested during summer season in a Randomized Block Design (RBD) with three replications to study the crop growth and yield parameter. The treatment details are T1: Rhizobium,T2: Rhizobium + Phosphorous Solubilizing Bacteria (PSB),T3: Rhizobium + Potassium solubilizing Bacteria (KSB), T4: Rhizobium + (PSB) + (KSB), T5: Rhizobium + (PSB) + KSB +Pseudomonas fluorescense, T6: Rhizobium + Trichoderma viride, T7: Rhizobium + PSB + Trichoderma viride, T8: Rhizobium + (KSB) + Trichoderma viride, T9: Rhizobium + PSB + KSB +Trichoderma viride + Pseudomonas fluorescense.T10: Untreated Control.

The data was collected from five randomly selected plants of each treatment in each replication for 12 characters viz., Field emergence, Plant height, Days to first flowering, Days to 50% flowering, Days to maturity, No of branches/plant, No of pods/plant., No of seeds/pod, Seed yield/plant, Seed yield/plot (kg/ha), 100 seed weight, No of nodules/plant (effective and ineffective nodules).

Biochemial analysis of Nitrogen content, Proteins content, Phenol content, and total soluble sugars was done in the harvested seeds.

Nitrogen content in blackgram seeds was analyzed by Micro-Kjeldahl method.Nitrogen content was multiplied with the factor 6.25 to obtain the crude protein content in the given sample [2]. Total Phenols were estimated by Folin-Ciocalteau Reagent method [3]. Total soluble sugar content in harvested seed samples was estimated as per method by Dubios et al. [4].

Pysiological parameters were also analysed in the harvested seeds i.e. Chlorophyll content, Reactive oxygen species (Peroxidase) and soil enzymes (Dehydrogenase, Acid and alkaline phosphatase and Urease).

Chlorophyll content in plants is estimated using SPAD (Soil Plant Analysis Development) meter. SPAD meter readings were taken in the morning hours (9-11 AM) after 40,50,60 days of sowing. Chlorophyll content of 5 plants in each plot was recorded and the average is calculated.

The activity of peroxidase enzyme in black gram seeds was determined by following the dehydrogenation of guaiacol as a substrate according to Malik and singh (1980).

Urease activity was measured by estimating the ammonical nitrogen in soil suspension by steam distillation method. Dehydrogenase activity in the soil sample was determined by the procedure as described by Klein et al. [5]. Acid and Alkaline phosphatase was measured by the following procedure:

1. For each soil sample, take two sets of 1g (oven dry equivalent) soil (<2mm) in 50 ml conical flasks. Out of these two sets, one will be used as control.
2. Add 0.2 ml toluene and 4 ml of MUB (pH 6.5 or 11) to all flasks.
3. Add 1 ml p-nitrophenyl phosphate solution to only one set of samples.
4. Swirl the flasks of both the sets for few seconds to mix the contents. Stopper them and place in an incubator at 37^{o}C for one hour.
5. After incubation, remove the stopper and add 1 ml of 0.5 M $CaCl_2$ and 4 ml of 0.5 M NaOH. Swirl the flasks for few seconds.
6. Add 1 ml of p-nitrophenyl phosphate to the remaining set of samples.
7. Filter all the suspensions quickly through Whatman No. 2 filter paper.
8. Measure the yellow colour intensity of the filtrate with a blue filter or at 440 nm.

3. RESULTS AND DISCUSSION

The influence of the treatments in the field was significant with respect to crop growth, phenological and yield parameters. The crop growth parameters i.e. field emergence and plant height. Highest performance was seen in T9(91.67%,27.47cm) (Amruta et al. 2016, Namasivayam et al .2014) while all the treatments recorded values that are at par with the highest performed treatment. The phenological parameters which include days to first flowering, 50% flowering and maturity, T9(24,31,60.67 days) and T8 (26,31.33,62 days) 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/ plant (14.83), Seed yield/plant (4.07g), Seed yield/plot

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 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 5. 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 6. 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 7. Effect of microbial inoculants on enzyme activity in soil

S.No	Treatments	Dehydrogenase (µg of TPF g^{-1} day^{-1})	Acid phosphatase (µg of *p-n-p* g^{-1} hr^{-1})	Alkaline phosphatase (µg of *p-n-p* g^{-1} hr^{-1})	Urease (µg of NH_4-N g^{-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

(929.63kg/ha), 100 seed weight (5.55g), No of nodules/ plant (26)) [6], Dinesh kumar et al. [7], Goel et al. [8], Gomathinayagam et al. [9], Iftikhar et al. [10], Keteku et al. [11], Khan et al., [12], Navsare et al. (2018)., Nazir et al. [13], Premachandra et al. [14], Surekha et al. [15], Tagore et al. [16], Tiwari, et al. [17], Vennila et al. [18], Xu et al. (2015)., Zorawar et al. [19].

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. Whereas at 50 and 60 DAS, the highest SCMR values were recorded in T9(50.73) and T5(43.1) respectively (Abirami et al, [20], Ahmad et al. [21], Ajaykumar et al. [22], Barman et al. [23], Gomathinayagam et al. [9], Khalil et al. [24], Kaur et al. [25], Lalitha et al. [26], Li et al. [27], Mohammadi et al. [28], Nalawde, et al. [29], Palaniraja et al. [30], Ramya et al. [31], Singh et al. [32].

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 [22], Meena et al. [33], Moreno et al. [34], Sallam [35], Selvakumar et al. [36], Srivastava and singh [37,38-41],

4. 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.

ACKNOWLEDGEMENT

The authors thank Acharya N.G. Ranga Agricultural University for providing financial assistance and support in the conduct of experiment at RARS, Tirupati, A.P.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Available:http://des.ap.gov.in/MainPage.do;jsessionid=D0E49AFAC4DA26B42F2A05C3D631C775
2. Doubetz S, Wells SA. Relation of barley varieties to nitrogen fertilization. Journal of Agricultural Science. Cambridge. 1968; 70(1):253-256.
3. Swain T, Hillis WE. The phenolic constituents of Prunus domestica. I.—The quantitative analysis of phenolic constituents. Journal of the Science of Food and Agriculture. 1959;10(1):63-68.
4. Dubios M, Gilles K, Hamilton JK, Rebers PA, Smith F. Phenol sulphuric acid calorimetric estimation of carbohydrates. Annal Review of Analytical Chemistry. 1956;28(3):350-356.
5. Klein DA, Loh TC, Goulding RL. A rapid procedure to evaluate the dehydrogenase activity of soils low in organic matter. Soil Biology and Biochemistry. 1971;3(4):385-387.
6. Alori ET, Babalola OO, Prigent-Combaret C. Impacts of microbial inoculants on the growth and yield of maize plant. The Open Agriculture Journal. 2019;13(1).
Available:https://agricoop.nic.in/
7. Dineshkumar R, Duraimurugan M, Sharmiladevi N, Priya Lakshmi L, Ahamed Rasheeq A, Arumugam A, Sampathkumar P. "Microalgal liquid biofertilizer and biostimulant effect on green gram (*Vigna radiata* L) an experimental cultivation." Biomass Conversion and Biorefinery. 2020;1-21.
8. Goel S, Bano Y, Effect of microbial inoculants on soil quality, growth and yield of pea plant; 2020.
9. Gomathinayagam R, Subramanian G, Persaud M, Persaud R, Velusamy S. 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). 2021;5(4):01-15.

10. Iftikhar A, Muhammad JA, Hafiz NA, Muhammad K. Influence of Rhizobium applied in combination with micronutrients on mung bean. Pakistan Journal of Life and Social Sciences. 2013;11(1):53-59.
11. Keteku AK, Yeboah S, Agyemang K, Amegbor I, Danquah EO, Amankwaa-Yeboah P, Dormatey R, Brempong MB, Frimpong F. Evaluation of Carrier-and Liquid-Based Bioinoculant as a Promising Approach to Sustain Black Gram (*Vigna mungo L.)* Productivity. International Journal of Plant Production. 2022;1-14.
12. Khan M, Zaidi A, Rizvi A, Saif S. Inoculation effects of associative plant growth-promoting Rhizobacteria on the performance of legumes. In Microbes for Legume Improvement. Springer,Cham. 2017;(261-276).
13. Nazir H, Badrul H, Rehana H, Lekh C, Abid Ali, Anwar H. Response of bio fertilizers on growth and yield attributes of black gram (*Vigna mungo*.L).International Journal of Current Research. 2010;2(1):148-150.
14. Premachandra D, Hudek L, Enez A, Ballard R, Barnett S, Franco CM, Brau L. Assessment of the capacity of beneficial bacterial inoculants to enhance canola (Brassica napus L.) growth under low water activity. Agronomy. 2020;10(9). 1449.
15. Surekha CH, Neelapu NRR, Kamala G, Siva prasad B, Sankar Ganesh P. 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. 2013;3(2):285-294.
16. Tagore GS, Namdeo SL, Sharma SK, Kumar N. Effect of Rhizobium and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghemoglobin, and yield of chickpea genotypes. International Journal of Agronomy; 2013.
17. Tiwari S, Chauhan RK, Singh R, Shukla R, Gaur R. Integrated effect of rhizobium and azotobacter cultures on the leguminous crop black gram (Vigna mungo). Advances in Crop Science and Technology. 2017;5 (3):1–9.
18. Vennila S. Effect of microbial inoculants on biometrical traits of black gram (*Vigna mungo* l. Hepper). International Journal of Current Research in Life Sciences. 2018;7(04):1487-1488.
19. Zorawar S, Guriqbal S, Navneet A. 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. 2017;9(3): 1422-1428.
20. Abirami S, Nagarajan D, Rodrigo BCP. 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.
21. Ahmad E, Zaidi A, Khan MS. Effects of plant growth promoting rhizobacteria on the performance of greengram under field conditions. Jordan Journal of Biological Sciences. 2016;9(2).
22. Ajaykumar R, Harishankar K, Chandrasekaran P, Kumaresan P, Sivasabari K, Rajeshkumar P, Kumaresan S. Physiological and biochemical characters of blackgram as influenced by liquid rhizobium with organic biostimulants. Legume Research-An International Journal. 2023;46(2):60-165.
23. Barman P, Rekha A, Pannerselvan P. Effect of microbial inoculants on physiological and biochemical characteristics in jamun (*Syzygium cumini* L. Skeels) under different propagation substrates. *International Journal of Minor Fruits,* Medicinal and Aromatic Plants (IJMFM&AP); 2016.
24. Khalil MK, Taha KF, Nesem MA, Sallam, SS. Phytochemical studies on celery (*Apium graveolens* l.) Plant under using chemical fertilization, biofertilizer and thidiazuron treatments. AI-Azhar journal of Pharmaceutical Sciences. 2019;59.
25. Kaur H, Gosal SK, Walia SS. Synergistic effect of organic, inorganic and biofertilizers on soil microbial activities in rhizospheric soil of green pea. Annual Research & Review in Biology. 2017; 12(4):1-11.
26. Lalitha S, Santhakumari R. 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. 2020;11:1-10.

27. Li H, Qiu Y, Yao T, Ma Y, Zhang H, Yang X. Effects of PGPR microbial inoculants on the growth and soil properties of Avena sativa, Medicago sativa, and Cucumis sativus seedlings. Soil and Tillage Research. 2020;199:104577.
28. Mohammadi M, Safikhani S, Esmaeili A, Reza CM, Mohammad D. Effects of seed inoculation by Rhizobium strains on yield and yield components of common bean (*Phaseolus vulgaris*. L). International Journal of Bio Sciences. 2013;3(3):134 – 141.
29. Nalawde Amit A, Bhalerao Satish A. Response of Black gram *Vigna mungo* (L. Hepper) to Biofertilizer. International journal of Life Sciences. 2015;3(1): 81-84.
30. Palaniraja K. Response of biofertilizers on growth attributes of black *gram Vigna mungo* (L.) hepper. International Journal of Current Research in Life Sciences. 2018;7(04):1495-1496.
31. Ramya S, Gulab P, Oberoi H, Kaur S, Kalia A. Improvement in the quality attributes of forage cowpea by use of liquid microbial inoculants. Indian Journal of Animal Research. 2022;56(8):959-965.
32. Singh UB, Malviya D, Singh S, Singh P, Ghatak A, Imran M, Rai JP, Singh RK, Manna MC, Sharma AK, Saxena AK. 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. 2021; 18(18):9936.
33. Meena GN, Kurdiya K, Sharma KC, Sharma M. Effect of Different Fertilizers on Biochemical Characteristics of Leaf of Groundnut (*Arachis hypogaea* L.). Turkish Online Journal of Qualitative Inquiry. 2021;12(10).
34. Moreno-Lora A, Sousa-Ortega C, Recena, R, Perea-Torres F, Delgado A. 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. 2022;1-15.
35. Sallam s. Phytochemical studies on celery (*Apium graveolens* l.) Plant under using chemical fertilization, biofertilizer and thidiazuron treatments. Al-azhar journal of Pharmaceutical Sciences. 2019;59(1):54-65.
36. Selvakumar G, Reetha S, Thamizhiniyan, P. Response of biofertilizers on growth, yield attributes and associated protein profiling changes of blackgram (*Vigna mungo* L. Hepper). World Applied Sciences Journal. 2012;16(10):1368-1374.
37. Srivastava P, Singh N. 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. 2022;33(2):308-323.
38. Harireddy YV, Dawson J. Effect of biofertilizers and levels of vermicompost on growth and yield of cowpea (*Vigna unguiculata L.*) The Pharma Innovation Journal. 2021;10(6):985-988.
39. Malik, C.P. and Singh, M.B., 1980. Plant enzymology and histo-enzymology.
40. Navsare RI, Mane SS, Supekar SJ. Effect of potassium and zinc solubilizing microorganism on growth, yield and quality of mungbean. International Journal of Chemical Studies. 2018;6(1):1996-2000.
41. Xu HL. Effects of a microbial inoculant and organic fertilizers on the growth, photosynthesis and yield of sweet corn. Journal of crop production. 2001;3(1):183-214.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/106288