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Effect of biofertilizers on germination and seedling growth of radish, beet root, carrot and lettuce under greenhouse condition

Sanjukta Biswas* and M.K.Shivaprakash
Department of Agricultural Micrbiology, University of Agricultural Sciences, GKVK Campus, Bengaluru-560065, Karnataka, India
sanjuktaa2004@gmail.com

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Abstract

Radish, beet root and carrot three tuber vegetables and lettuce green leafy vegetable was grown in seedling trays under greenhouse condition to evaluate the effect of different bio fertilizers on germination percentage and seedling growth parameters. All the crops were grown in seedling trays containing coco pith and vermicompost at 2:1 ratio. Biofertilizers applied were broth cultures of phosphorus solubilizing bacteria (PSB), potassium mobilizing bacteria (KMB) and potassium solubilizing bacterial isolates (KSB), isolated from different potassium containing minerals. Among the three biofertilizers, T_9 and T_3 recorded significant results and the other treatments are on par with each other. Highest germination percentage and seedling vigour was recorded in T_9 and T_3 respectively in radish. In case of carrot, maximum fresh weight and seedling vigour was observed in T_9 and number of leaves observed highest in T_3 and T_6. Germination percentage was also recorded highest in T_6. Beet root growth was also highly influenced by the application of biofertilizers and (KMB) T_9 recorded significantly highest growth. Root length, shoot length, number of leaves and seedling vigour was recorded highest in T_9, whereas, fresh weight and dry weight was observed highest in T_7. In lettuce all the treatments showed different results. T_3 recorded maximum seedling vigour highest shoot length and fresh weight was observed in T_6 and maximum number of leaves was recorded in T_8. In all the crops, control showed least growth and germination percentage.

Keywords: Biofertilizers, greenhouse, seedling tray, growth, germination.

Introduction

Carrot (*Daucuscarota* L) belongs to the family Apiaceae, is a rich source of antioxidants, vitamins, minerals and fiber. It is considered as a highly nutritious and tasty root vegetable through worldwide. It has become a part of everyday diet in different forms like salads, soups, curry, halwa, jam etc. Due to its high content in beta carotene, vitamins, potassium and fiber; it helps in reducing different health issues like cancer, diabetes, blood pressure and many more.

Beet root (*Beta vulgaris*) a tap root vegetable belongs to the family Amaranthaceae, is a highly nutritious and very rich source of betalain pigments which exhibit potent antioxidants, anti-inflammatory and chemo-preventive activity *in vitro* and *in vivo*[1]. Beet root also contains several bioactive compounds which have health benefits like reducing blood pressure, limits the diabetes risk Due to the presence of high levels of nitrate, which significantly lowers blood pressure thus reducing the risk factor of cardio vascular disease. Likewise carrot, beet root is also consumed in daily diet in various forms as salads, juice, curry etc.

Radish (*Raphanus sativus*), a cruciferous root vegetable is an excellent source of antioxidants, dietary fiber, minerals and vitamins. It is a low calorie vegetable with numerous health benefits. Sulforaphane an isothiocyanate antioxidant compound which is abundent in radish is known to have properties of antiproliferative activity against breast cancer[2].

Lettuce (*Lactuca sativa*), a leafy vegetable belongs to the family Asteraceae considered to be a highly beneficial and healthy due to its different nutritional properties. Lettuce plays crucial role in improving body metabolism.

It contains potassium, magnesium and iron which stimulates in body metabolism; in one word it is a rich source of energy. It is also a very good source of several Vitamins and B-carotene which lowers the cholesterol quantity in blood. It also lowers the risk of heart diseases due to the presence of fiber & vitamin C. It also possess anti inflammation properties and antioxidants activities.

Microbial bioinoculants in the form of potassium and phosphorus solubilizers, mobilizers have enormous abilities to enhance crop growth and increase soil fertility. These beneficial microbes by their microbial activity accelerates the process which elevates the growth promotion in plants. These rhizospheric microorganisms applied as biofertilizers can be the replacement of chemical fertilizers in the sustainable agriculture.

By applying these Phosphorus and Potassium mobilizers and solubilizers farmers can reduce the expenses of demand of P and K fertilization.

The inorganic form of phosphorus compounds *viz.,* tri calcium phosphate, di calcium phosphate, rock phosphate etc and inorganic potassium forms like, muscovite mica, orthoclase feldspar, illiteetc which are found naturally and cannot be directly absorbed by plants for their growth and nutrition.

These rhizospheric microorganisms have the potential to solubilize and mobilize the inorganic forms of P and K which can be obtained easily by the plants[3-5]. Moreover, the application and use of biofertilizers are environment friendly, reasonably cheaper than chemical fertilizers, very potential and it also maintains the soil fertility. PSB (Phosphorus solubilizing Bacteria) solubilizes soil organic P by the production of acid phosphatses which results in releasing of organic anions and siderophore production leads to mineralize soil organic P into available form of P[6].

During solubilization process PSB produces several organic acids viz., carboxylic, malic, succinic, fumaric, and alpha-ketoglutaric acid which leads the lowering the pH and breaks down the organic P into soluble form by making readily available to the plants[7,8]. PSB promotes plant growth by producing gibberellins, auxins and cytokinins[9-11].

To achieve healthy, potential and high yielding seedlings under greenhouse condition factors involved are growth medium and good quality seeds. Growth medium to grow seedlings under green house should have certain properties which will allow the seed to germinate faster and grow well, *viz*., water holding capacity, proper aeration with adequate nutrition supply[12,13] when applied in soil less substrates. Seed germination and seedling growth was significantly influenced by different treatments. Germination percentage was highly influenced by the application of KSB isolates and PSB respectively. Therefore, the present study has taken up to evaluate the effect of both PSB and KSB isolates on seed germination and seedling growth of radish, beet root, carrot and lettuce under greenhouse condition.

Materials and methods

The experiments were carried out at Department of Agricultural Microbiology, UAS, GKVK, Bengaluru, under greenhouse condition.

Seedling tray preparation for green house experiment: Seedling tray containing 18 cavity of dimension measured 49cm x 25.5cm x 8cm was selected for the experiment. Well decomposed coir pith and vermicompost @ 2:1 ratio was used as a growing medium for both the crops. Two third of each cavity of the tray were filled with the growing medium and watered before sowing the seeds.

Sowing of seeds: Seeds of radish, carrot, beet root and lettuce were soaked overnight in a petri plate containing filter paper before sowing to the seedling trays. 4-5 seeds were placed in each cavity. During sowing, broth cultures of PSB, KMB and KSB isolates were applied @ 10 ml per cavity. After 4-5 days of sowing, seeds were found sprouted with two leaf stage. All the seeds were sown individually seven days interval of each other.

Seedlings were watered in regular intervals depending upon the moisture content in the trays .Germination percentage of seedlings were calculated by using the following formula[14]. Once the seedlings were in four to five leaf stages, thinning was done in each cavity retaining single seedling in each cavity.

Broth Culture Preparation: All the cultures were maintained in regular intervals in their respective media. Bacterial culture of *Bacillus megaterium* as Phosphorus solubilizing bacteria (PSB) was selected and grown on Pikovskaya media, whereas, *Frateuria aurentia* was selected as Potassium mobilizing bacteria (KMB) was grown and maintained on GYCA (Glucose yeast extract calcium carbonate agar) media. Potassium solubilizing bacterial (KSB) isolates were isolated from two different potassium bearing minerals on Aleksandrov medium and maintained on the same.

PSB, KMB and KSB bacterial isolates were applied individually and in consortia. Four replications were kept for each treatments. Control has been kept as uninoculated.

Seed variety selected for the experiment: The seed varieties of all the crops were selected for the experiment are as follows: Carrot variety "Early Nantes", beet root variety "Early Wonder", leaf lettuce variety "Grand Rapids" and radish variety "Arka Nishanth" were selected for the pot trial experiments under greenhouse condition.

Treatment details of seedling tray experiment under greenhouse condition: The treatments have been selected in individual as well as in consortia for the seedling tray experiment under house condition. The treatments are follows as: i. T_1: Cocopith + Vermicompost + SAF (KSB isolates), ii.T_2: Cocopith + Vermicompost + SBF (KSB isolates), iii.T_3:Cocopith + Vermicompost + SDM (KSB isolates), iv.T_4:Cocopith + Vermicompost + SAF + SBF, v. T_5: Cocopith + Vermicompost + SAF+SDM, vi. T_6: Cocopith + Vermicompost +SBF+SDM, vii. T_7: Cocopith + Vermicompost +SAF+SBF+SDM, viii. T_8: Cocopith + Vermicompost +PSB (*Bacillus megaterium*), ix. T_9: Cocopith + Vermicompost + KMB (*Frateuria aurentia*), x. Control: Cocopith + Vermicompost.

Results and discussion

Germination Percentage and Seedling Vigour: Different treatments has influenced in percentage germination and seedling vigour of carrot, beet root, radish and lettuce represented in Table-1.

Table-1: Germination percentage and seedling vigour index in seedling tray experiment influenced by PSB, KMB and KSB isolates under green house condition.

	Germination percentage				Seedling Vigour Index			
Treatment	Carrot	Beet root	Radish	Lettuce	Carrot	Beet root	Radish	Lettuce
T_1	98.36^{bc}	96.36^{c}	98.30^{b}	98.46^{c}	1541.1^{bcd}	2536.81^{c}	4439.78^{b}	2263.93^{cd}
T_2	99.13^{a}	98.30^{b}	98.10^{b}	98.30^{c}	1470.36^{cd}	2310.15^{c}	3825.83^{cd}	3086.98^{b}
T_3	99.23^{a}	99.43^{a}	99.05^{a}	97.40^{d}	1372.38^{d}	2452.33^{c}	5035.00^{a}	4092.28^{a}
T_4	96.53^{d}	95.33^{d}	97.21^{c}	98.53^{c}	1560.83^{bcd}	2685.31^{abc}	4099.38^{bc}	2793.26^{bcd}
T_5	98.53^{b}	94.23^{e}	98.05^{b}	99.03^{ab}	1740.78^{abcd}	2418.85^{c}	3823.98^{bc}	3042.20^{bc}
T_6	99.43^{a}	99.63^{a}	98.10^{b}	99.36^{a}	1786.65^{abc}	2657.06^{abc}	3972.93^{cd}	3353.60^{b}
T_7	90.03^{e}	91.20^{f}	98.33^{b}	$98.66b^{c}$	1470.58^{cd}	2599.23^{bc}	3539.93^{bcd}	2239.00^{d}
T_8	98.10^{c}	98.60^{b}	99.03^{a}	99.06^{ab}	1890.00^{ab}	3056.63^{ab}	3812.76^{cd}	2627.20^{bcd}
T_9	99.03^{a}	99.56^{a}	99.16^{a}	99.10^{ab}	2114.42^{a}	3136.01^{a}	4379.90^{b}	2705.90^{bcd}
Control	70.10^{f}	70.10^{g}	80.03^{d}	84.76^{e}	677.633^{e}	1411.26^{d}	2067.58^{e}	1215.18^{e}
SEM	9.24	0.15	6.56	0.10	87.75	115.53	113.39	177.35
LSD ($p< 0.05$)	0.27	0.45	0.19	0.31	258.87	340.82	334.52	523.18

The values with different superscript are significantly different ($p<0.05$).

In case of carrot, highest germination percentage was recorded in T_2,T_3,T_6 and T_9 whereas, highest seedling vigour index was observed in T_9 and lowest in T_3.

Highest germination percentage was observed in T_6 and seedling vigour was recorded highest in T_9 and other treatments are on par with each other, except T_7 has recorded lowest germination percentage in beet root. The least was observed in control.

In radish, significantly highest germination percentage was recorded in T_9, T_8 and T_3, seedling vigour was observed in T_3.

Lettuce seedlings was also influenced significantly by different treatments. T_3 showed highest seedling vigour and germination percentage was recorded highest in T_6

Germination percentage of seedlings were calculated followed by the formula given by Atif *et. al.*[14].

Germination (%) can be calculated as:

$$= \frac{\text{Seeds germinated}}{\text{Total no. of seeds}} \times 100$$

Seedling vigour index was calculated by following the formula:
Germination (%) X (Shootlength + Rootlength)

Growth parameters: Application of different biofertilizers has influenced the growth attributes of carrot, beet root, radish and lettuce. Carrot and beet root both recorded significant growth in seedling tray experiments (Table-2). Potassium solubilizing isolates, phosphorus solubilizers has significantly influenced the seedling growth of carrot, whereas, potassium mobilizer and phosphorus solubilizing bacteria recorded maximum shoot length, root length number of leaves in beet root. Similar results was observed in carrot where phospho bacteria has influenced the growth and yield by Singh *et. al.*[15] and similar reports also recorded by Ahmed *et. al.*[16] showed that PSB has significantly increased plant height, no of leaves, K uptake by potato tubers in potato.

Table-2: Growth of carrot and beet root seedlings influenced by biofertilizers under green house condition.

	Carrot					Beet Root				
Treatment	Shoot length	Root length	No of Leaves	Fresh weight	Dry weight	Shoot length	Root length	No of Leaves	Fresh weight	Dry weight
T_1	11.25^{a}	10.1^{a}	2.66^{a}	0.26^{bccd}	0.18^{a}	17.16^{abcd}	9.16^{ab}	4.00^{abc}	1.48^{cd}	0.35^{cd}
T_2	10.93^{ab}	8.33^{ab}	2.66^{a}	0.29^{bcd}	0.33^{a}	14.33^{de}	9.16^{ab}	4.00^{abc}	1.08^{cd}	0.26^{def}
T_3	10.66^{ab}	7.46^{ab}	2.33^{a}	0.13^{d}	0.06^{a}	15.66^{cde}	9.00^{ab}	3.33^{bc}	1.02^{cd}	0.22^{ef}
T_4	10.50^{ab}	7.33^{abc}	2.33^{a}	0.28^{bcd}	0.10^{a}	17.50^{abc}	10.66^{a}	3.66^{bc}	1.25^{cd}	0.22^{ef}
T_5	9.50^{ab}	7.16^{abc}	3.00^{a}	0.32^{abc}	0.11^{a}	15.83^{bcde}	9.83^{ab}	3.66^{bc}	1.40^{cd}	0.29^{de}
T_6	9.16^{ab}	7.00^{abc}	3.00^{a}	0.28^{bcd}	0.08^{a}	16.16^{bcde}	10.50^{a}	4.33^{abc}	1.87^{bc}	0.45^{bc}
T_7	9.16^{ab}	6.50^{bc}	2.66^{a}	0.36^{ab}	0.12^{a}	18.83^{ab}	9.66^{ab}	4.66^{ab}	2.87^{a}	0.59^{a}
T_8	8.83^{ab}	5.66^{bc}	2.33^{a}	0.36^{ab}	0.11^{a}	19.66^{a}	11.33^{a}	4.66^{ab}	2.56^{ab}	0.52^{ab}
T_9	8.16^{bc}	5.33^{bc}	2.66^{a}	0.48^{a}	0.07^{a}	20.00^{a}	11.50^{a}	5.33^{a}	2.63^{ab}	0.52^{ab}
Control	5.50^{c}	4.16c	2.00^{a}	0.15^{cd}	0.02^{a}	13.63^{e}	6.50^{b}	3.00^{c}	0.68^{d}	0.16^{f}
SEM	0.63	0.70	0.38	3.97	7.88	0.70	0.82	0.33	0.21	2.56
LSD($p<0.05$)	1.86	2.06	1.12	0.11	0.11	2.07	1.16	0.98	0.64	7.56

The values with different superscript are significantly different ($p<0.05$).

In case of beet root, significant increase in seedling growth parameters was observed in T_9 and T_8, i.e. seedlings treated with phosphorus solubilizing and potassium solubilizing bacteria. The similar results were reported by Mahmoud[17] phosphate dissolving bacteria and potassium solubilizing bacteria in conjunction highly influenced the growth of beet root.

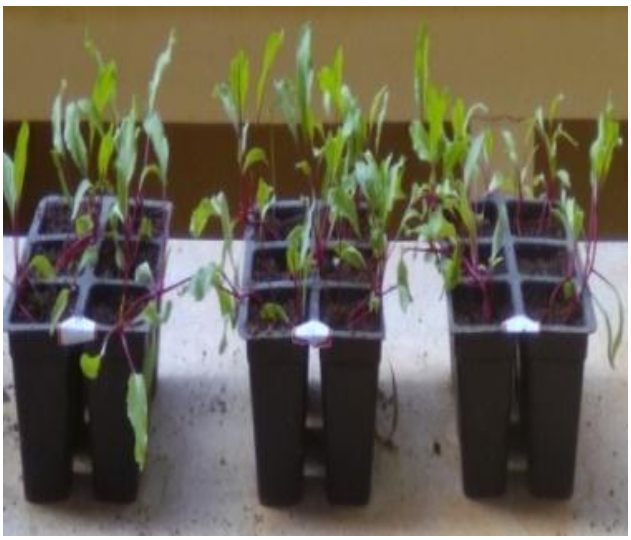

Figure-1: Beet root seedling

Figure-2: Carrot seedling.

Table-3: Growth of radish and lettuce seedlings influenced by biofertilizers under green house condition

	Radish					Lettuce				
Treatment	Shoot length	Root length	No of Leaves	Fresh weight	Dry weight	Shoot length	Root length	No of Leaves	Fresh weight	Dry weight
T_1	23.83^{ab}	26.66^{a}	3.66^{a}	2.43^{d}	0.89^{d}	10.16^{d}	12.83^{cd}	3.66^{ab}	0.79^{cd}	0.22^{f}
T_2	21.83^{ab}	21.33^{b}	4.00^{a}	3.30^{c}	1.12^{c}	11.50^{cd}	20.00^{b}	5.00^{ab}	1.47^{abcd}	0.41^{d}
T_3	24.16^{ab}	20.66^{bc}	4.33^{a}	5.16^{a}	1.53^{a}	14.83^{b}	27.00^{a}	5.66^{a}	2.41^{ab}	0.84^{a}
T_4	22.83^{ab}	19.33^{bcd}	4.33^{a}	4.20^{b}	1.06^{c}	14.00^{bc}	14.33^{bc}	4.66^{ab}	2.11^{abcd}	0.53^{c}
T_5	18.33^{ab}	18.16^{bcde}	4.33^{a}	2.33^{d}	0.85^{d}	15.83^{b}	14.83^{bc}	4.66^{ab}	2.27^{ab}	0.52^{c}
T_6	24.83^{a}	17.16^{bcde}	3.66^{a}	2.83^{cd}	1.06^{c}	20.16^{a}	13.66^{c}	5.00^{ab}	2.88^{a}	0.70^{b}
T_7	22.66^{ab}	15.66^{cde}	4.00^{a}	3.16^{c}	1.30^{b}	10.66^{d}	12.00^{cd}	4.33^{ab}	1.07^{bcd}	0.32^{e}
T_8	24.00^{ab}	14.50^{def}	4.00^{a}	3.16^{c}	0.74^{e}	11.83^{cd}	14.66^{bc}	5.33^{ab}	1.72^{abcd}	0.53^{c}
T_9	26.00^{a}	13.33^{ef}	4.00^{a}	2.66^{cd}	0.85^{d}	14.83^{b}	13.66^{c}	4.33^{ab}	2.15^{abc}	0.71^{b}
Control	16.66^{b}	9.16^{f}	3.33^{a}	0.90^{e}	0.25^{f}	7.16^{e}	7.16^{d}	3.33^{b}	0.62^{d}	0.20^{f}
SEM	0.16	1.23	0.36	0.16	1.65	0.63	1.38	0.43	0.32	9.74
LSD(p< 0.05)	0.47	3.65	1.07	0.47	4.87	1.87	4.09	1.28	0.96	2.87

The values with different superscript are significantly different ($p<0.05$).

Growth of radish seedlings were highly influenced by the application of PSB, KMB and KSB isolates. Potassium mobilizing bacteria recorded maximum growth in seedling tray experiments under greenhouse condition. Seed inoculation with KSB biofertilizer improved crop growth, productivity by enhancing K assimilation was reported in maize wheat system by Madar *et. al.*[18]. Phosphorus solubilizing bacteria also recorded good yield parameters. Similar results were observed by Mali *et al.*[19] where phospho bacteria along with vermicompost recorded higher yield. In lettuce, K solubilizing isolates in combination has recorded highest growth under greenhouse condition. Other treatments are par with each other. Similar results were studied by Chatterjee[20] showed phospho bacteria has influenced significant growth attributes and green biomass yield.

Figure-3: Radish seedling.

Figure-4: Lettuce seedling.

Conclusion

Data pertaining to growth parameters of three different tuber vegetables showed contrasting figures in growth attributes like shoot length, root length, number of leaves, fresh weight and dry weight. This is may be due to the application of the biofertilizers which has significantly influenced the growth parameters of seedlings under greenhouse condition. Both, potassium and phosphorus solubilizing bacteria both are considered as potential biofertilizers. The availability of the nutrients obtained by the application of potassium and phosphorus solubilizing and mobilizing bacteria induced the growth of the seedlings.

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