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Effect of microbial inoculants on the yield of beet-root (*Beta vulgaris*)

J. AJAY KUMAR[1], K.R. SREERAMULU[2] **AND** G. KUSHALA[3]

[1]Department of Agricultural Microbiology, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARNATAKA) INDIA
[2]Department of Horticulture, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARNATAKA) INDIA
[3]Department of Plant Pathology, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARNATAKA) INDIA
Email: ajaymic01@rediffmail.com

Comparative performance of *Azotobacter chroococcum, Glucanobacter diazotrophicus* tested both at 50 per cent and 75 per cent recommended N showed that *Glucanobacter diazotrophicus* was more effective than *Azotobacter chroococcum* in improving the tuber yield. The total tuber yield per plot and per hectare in plants was maximum in combined inoculation of microbial inoculants *viz., Azotobacter chroococcum, Glucanobacter diazotrophicus, Bacillus megaterium* and *Trichoderma harzianum,* with 75 per cent N, P with full dose of K compared to control plants (FYM alone T_{14}).

Key words : Microbial inoculants, Yield, Beet-root

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INTRODUCTION

Nutrient management is most important in beet-root to obtain good growth and higher yield of root crops. The crop benefiting microbial inoculants generally called as biofertilizers, help in augmenting the crop productivity through effective mobilization of major plant nutrients like N, P and K and other minor nutrients needed by the crop. These beneficial microorganisms are also known to secrete plant growth promoting substances like IAA, GA, cytokinins, vitamins for the improvement of crop growth, yield and for quality produce.

India is the leading vegetable producing country in the world. Presently vegetable cultivation occupies an area of 6.09 million hectares with an annual production of 84.8 million tons accounting to a productivity of 13.90 tons per hectare (The Hindu Survey of Indian Agriculture 2004). India being blessed with the unique gift of nature with diverse climates and distinct seasons, it makes it possible to grow an array of vegetables whose number exceeds more than hundred types.

Beet-root or garden beet (*Beta vulgaris* L.) is an important root vegetable crop (root modification) belonging to the botanical family Chenopodiaceae. It is indigenous to Southern Europe. The chromosome number of cultivated beet-root types is 2n=2x=18. It is a popular root vegetable grown mainly for its fleshy enlarged roots in almost all the states of India but not as common as radish, carrot and turnip. The garden beet is eaten boiled or as salad, cooked with other vegetables and it is also used in pickles, chutneys and in canned food products. The garden beet is rich in proteins, carbohydrates, calcium, phosphorus, iron and vitamin C (Aykroyd, 1963). The beet tops are also rich in iron, vitamin A, vitamin C and protein. Apart from these, it also contains traces of minerals, fat, potassium, vitamin B_1 and B_2. The red colour of beet-root is due to β-cyanin, a nitrogen containing compound, with chemical properties similar to anthocyanin. Beet-root also contains a yellow pigment *viz.*, β- xanthin. The ratio of these two pigments varies with cultivation and changes during the growth and environmental conditions (Nilsson, 1973).

The area under beet-root in India is about 5000 ha with an annual production of 90,000 tons (Anonymous, 2001). It is essentially a cool weather crop. It grows best in winter with bit warm climate in the plains of India. Good quality roots, rich in sugar and intense red colour are obtained always in cool weather with a temperature range between 18.3^{0}C to 21.1^{0}C. At a temperature range below 10^{0}C, plants start wilting before

attaining marketable root size (Sadhu, 1986). Under warm condition, beet-root shows alternate white and colour circles when sliced called zoning.

Beet-root grows best on fairly deep, friable loam, moist and well drained soils. Heavy yields are obtained from deep rich alluvial or silt loams. It is sensitive to soil acidity and yields are adversely affected as the soil pH goes below 5.8. But it thrives well in alkaline soils with a pH as high as 9.0 to 10.0. Soil with a pH of 6.0-7.0 is considered as ideal for beet-root cultivation. About 25-30 tons of roots could be expected from one hectare area (Kale and Masalkar, 1993).

RESEARCH METHODOLOGY

A study on the effect of microbial inoculants on the growth and yield of beet-root (*Beta vulgaris*) was carried out in the biofertilizer scheme of the Department of Agricultural Microbiology, with a field experiment at the Olericulture Section, in the Department of Horticulture, University of Agricultural Sciences, G.K.V.K., Bengaluru, during *Rabi* season 2005-2006. The details of the experiment are presented below:

Mass production of microbial inoculants:

The microbial cultures used in the experiment were obtained from the biofertilizer scheme of the Department of Agricultural Microbiology, University of Agricultural Sciences, G.K.V.K., Bengaluru.

The microbial inoculants used in the study are as fallows:

N fixing microbial inoculants:

Glucanobacter diazotrophicus:

It was grown on *Glucanobacter diazotrophicus* broth for 8-10 days and after attaining sufficient microbial population, it was mixed in presterilized lignite powder neutralized with $CaCO_3$. The final product had a population of 9×10^7 cfu. g^{-1} carrier and was applied to the field at the rate of 10 kg/ha.

Azotobacter chroococcum:

It was grown on Ashby's broth for 8-10 days and after attaining the desired population the culture was mixed aseptically in presterilized lignite powder neutralized with calcium carbonate. The final product had a population of 8×10^7 cfu. g^{-1} carrier and was applied as soil application at the rate of 10 kg/ha.

P solubilizers:

Bacillus megaterium:

Bacillus megaterium was mass multiplied on Pikovaskaya's broth for 8-10 days and after attaining sufficient microbial population, it was mixed in presterilized lignite powder neutralized with $CaCO_3$. The final product had a population of 8×10^8 cfu. g^{-1} carrier and was applied to the field at the rate of 10 kg/ha.

Trichoderma harzianum:

It was grown on Trichoderma specific broth for 10 days on a mechanical shaker with frequent agitation. After sufficient growth, the mycelial mat formed at the scum was macerated along with the broth using a homogenizer. Fully grown broth culture was mixed with presterilized lignite powder earlier neutralized with $CaCO_3$. The final product had a population of 4×10^6 cfu. g^{-1} and the inoculum was added at the rate of 5 kg/ha.

Details of the field experiment:

Location of the field experimental site:

The field experiment was conducted during the *Rabi* season of 2005-2006 in the month of Nov.-Dec. at the Horticulture research station, University of Agricultural Sciences, GKVK, Bengaluru under protective irrigated conditions. The study site was located at $12^0\ 58^1$ north latitude and $77^0\ 35^1$ east longitude with an elevation of 930m above the mean sea level.

Land preparation:

The experimental area was ploughed and harrowed to bring to a fine tilth. The experimental plot was divided in to plots of size 1.7m × 1.3m with 20 cm bunds between the plots.

Weather parameters:

Weather data prevailed during the cropping season (Nov.-Dec.) *viz.*, temperature, rainfall, mean relative humidity are given in appendix I.

The weather data were collected from the Meteorological observatory of the University of Agricultural Sciences, G.K.V.K., Bengaluru (Karnataka) India.

Design and layout of the experiment:

The experiment was laid out in Randomized Complete Block Design (RCBD), with 14 treatments and three replications.

–	Gross plot size	:	92.82 square meters
–	Net plot size	:	1.7m × 1.3m
–	Beet-root variety used	:	Ruby Queen
–	Recommended seed rate	:	7.5 kg/ha
–	Recommended FYM	:	25 tons/ha
–	Recommended fertilizer dose	:	100: 50: 70 kg NPK/ha
–	Spacing followed	:	30cm × 22.5cm

Treatments details of the field experiment:

T_1 - 50% NP + 100% K + *Azotobacter chroococcum*

T_2 - 50% NP+100% K+*Glucanobacter diazotrophicus*
T_3 - 50% NP + 100% K + *Azotobacter chroococcum + Gluconobacter diazotrophicus*
T_4 - 50% NP + 100% K + *Azotobacter chroococcum* + *Gluconobacter diazotrophicus + Bacillus megaterium* (PSB).
T_5 - 50% NP + 100% K + *Azotobacter chroococcum* + *Glucanobacter diazotrophicus + Bacillus megaterium + Trichoderma harzianum*
T_6 - 75% NP + 100% K + *Azotobacter chroococcum*
T_7 - 75% NP+100% K+ *Glucanobacter diazotrophicus*
T_8 - 75% NP + 100% K + *Azotobacter chroococcum* + *Glucanobacter diazotrophicus*
T_9 - 75% NP + 100% K + *Azotobacter chroococcum* + *Glucanobacter diazotrophicu + Bacillus megaterium*
T_{10} - 75% NP + 100% K + *Azotobacter chroococcum* + *Glucanobacter diazotrophicus + Bacillus megaterium + Trichoderma harzianum*
T_{11} - 50% NP + 100% K
T_{12} - 75% NP + 100% K
T_{13} - 100% NPK (Reccommended dose)
T_{14} - FYM alone

Note: (FYM was common to all the treatments)

Cultural operations:

Seeds and sowing:

Beet-root variety Ruby Queen seeds were sown directly on main experimental plot at the rate of 7.5 kg/ha, at a spacing of 22.5 cm between plants and 30 cm between rows.

Fertilizer application:

The recommended dose of fertilizer 100 kg nitrogen, 50 kg phosphorus and 70 kg potassium per hectare (UAS package of practice for vegetable cultivation) was applied in the form of urea, single super phosphate and muriate of potash, respectively as per the treatments requirement. Half of the nitrogen and entire dosage of P and K were applied as basal dose while the remaining half of the nitrogen was applied 30 days after sowing. FYM was applied uniformly to all the treatments at the rate 25 tons/ha, 15 days prior to seed sowing and mixed well with the soil.

Weeding and irrigation:

Periodic hand weeding was done to keep the plots free from weeds. Irrigation was given at an interval of 3 to 4 days depending on the soil moisture condition.

Yield parameters:

Yield of tuber per plant (g):

Fresh tuber weight per plant was recorded at harvest and expressed in grams.

Yield of beet-root (kg/plot):

The plants were uprooted from each plot at harvest and fresh weight of tubers were recorded after cleaning the adhering soil and expressed as kg per plot.

Yield tons/ha:

Root yield per hectare was computed from the net plot yield and expressed as tons per hectare.

Statistical analysis:

The experimental data obtained were subjected to statistical analysis as per Fischer's method of variance as given by Panse and Sukhatme (1967).

RESEARCH FINDINGS AND ANALYSIS

The results pertaining to the field study "Effect of microbial inoculants on growth and yield of beet-root (*Beta vulgaris*) conducted during *Rabi* season 2005-06 are presented below:

Yield parameters:

Yield of tuber per plant (g):

Fresh tuber weight per plant was recorded at harvest (Table 1). The highest tuber yield per plant (302 g/plant) was recorded in the treatment of 75 per cent N, P plus full dose of K with *Azotobacter chroococcum, Glucanobacter diazotrophicus, Bacillus megaterium* and *Trichoderma harzianum.* The lowest tuber yield per hectare was recorded in the treatment of un inoculated control (100.33 g/plant).

Tuber yield per plot (kg):

Treatments differed significantly with respect to tuber yield per plot and the results are presented in Table 1. Maximum tuber yield was in the treatment of 75 per cent N, P plus full dose of K with *Azotobacter chroococcum, Glucanobacter diazotrophicus Bacillus megaterium* and *Trichoderma harzianum* (8.53 kg/plot). The lowest tuber yield per plot (1.90 kg/plot) was recorded in uninoculated control treatment.

Tuber yield per hectare:

Based on tuber yield per plot, the tuber yield per hectare was computed (Table 1). The highest tuber yield per hectare (38.61 t/ha) was recorded in the treatment of 75 per cent N, P plus full dose of K with *Azotobacter chroococcum, Glucanobacter diazotrophicus, Bacillus megaterium* and *Trichoderma harzianum.* The lowest tuber yield per hectare was recorded in the treatment of uninoculated control (8.60 t/ha).

The tuber yield per plot and per hectare was significantly influenced due to biofertilizers application in conjunction with different levels of nitrogen and phosphorus. Maximum tuber yield per plot and per hectare was recorded in the plots treated with 75 per cent N, P plus full dose of K. Similar findings of

Table 1: Influence of microbial inoculants on yield of beet-root

Treatments	Tuber yield/plant (g)	Tuber yield/plot (kg)	Tuber yield (t/ha)
T_1 – *A. chroococcum* + 50% N, P	122.67	2.82	12.74
T_2 – *G. diazotrophicus* + 50% N, P	128.33	3.38	15.31
T_3 – *A. chroococcum* + *G. diazotrophicus* + 50% N, P	139.00	3.63	16.44
T_4 – *A. chroococcum* +*G. diazotrophicus* +*B. megaterrium* + 50% N, P	180.67	5.30	23.98
T_5 – *A. chroococcum* + *G. diazotrophicus* + *B. megaterium* + *T. harzianum* + 50% N, P	194.00	5.83	26.39
T_6 – *A. chroococcum* + 75% N, P	150.67	4.07	18.40
T_7 – *G. diazotrophicus* + 75% N, P	163.00	4.53	20.51
T_8 – *A . chroococcum* + *G. diazotrophicus* + 75% N, P	174.33	4.83	21.87
T_9 – *A. chroococcum* + *G. diazotrophicus* + *B. megaterium* + 75% N, P	205.67	6.33	28.66
T_{10} – *A. chroococcum* + *G. diazotrophicus* + *B. megaterium* + *T. harzianum* + 75% N, P	302.00	8.53	38.61
T_{11} - 50% N, P	114.33	2.47	11.16
T_{12} - 75% N, P	143.00	3.92	17.72
T_{13} - 100% N, P	215.00	6.92	31.30
T_{14} - FYM alone	100.33	1.90	8.60
F-test	*	*	*
S.E. ±	9.47	0.23	1.05
C.D. (P=0.05)	30.03	0.70	3.19

Note: Recommended K is common to all the treatments except T_{14}.
FYM is common to all the treatments at recommended dose.

improvement in yield of potato due to triple inoculation of *Azospirillum brasilense, Bacillus megaterium,* and *Glomus fasciculatum* was earlier reported by Thamiz vendan and Nanjan (1998). Maximum yield of sugar in beet-root was recorded due to inoculation of *Azotobacter chroococcum,* plus *Glucanobacter diazotrophicus* with 75 kg N per hectare (Jambukar and Wange, 2005).

Basavaraju (1999) observed significant increase in fresh weight and dry weight of radish due to inoculation of *Azotobacter.* Similarly Wange (1995) reported maximum bulb yield in garlic due to inoculation of *Azotobacter.*

Similarly maximum yield of sugarcane with increase in sugar recovery from 0.5 to 1 per cent was recorded due to inoculation of *Glucanobacter diazotrophicus* with 50 per cent saving in the application of chemical nitrogen fertilizers was reported by Muthukumarasamy *et al*. (1994).

Plants treated with 75 per cent N, P with full dose of K and combined inoculation of *Azotobacter chroococcum, Glucanobacter diazotrophicus, Bacillus megaterium* and *Trichoderma harzianum* recorded highest amount of dry matter in both leaves and tubers, while the minimum dry matter was recorded in plants treated with FYM alone. Higher dry weight of beet-root in combined microbial inoculation could be attributed to higher nutrient uptake due to effective mobilization of nutrients by synergistic action of microorganisms. These results are in conformity with the findings of Sundaravelu and Muthukrishnan (1993) on radish when seeds were inoculated with *Azospirillum.* Similar increase in plant dry weight due to microbial inoculation was also earlier reported by other workers in tapioca and ginger (Sucheeta, 1989; Sharma *et al.,* 1997).

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