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Assessing the Impact of Corn-Rind-Carrier Based Biofertilizer on the Growth and Yield of Capsicum (*Capsicum annuum* L.)

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Abstract

The production of living cells or effective microorganisms that aid in the uptake of nutrients for plant growth is referred to as a biofertilizer. In order to successfully commercialize new microbial inoculants, the formulation process is difficult and frequently success-limiting. The success of microbial inoculants is dependent on a number of variables, with carrier material playing the most significant part. The purpose of the experiment was to compare the performance of a corn-rind-carrier based biofertilizer to existing carrier material talc on the growth and production of capsicum using various application methods, including seed treatment, root dipping, and soil application. There are ten treatments with complete randomized design (CRD) design. The treatment having soil application of corn rind carrier based biofertilizer + 100% NPK had the highest beneficial microbial populations including free living N_2 fixers, PSB and KSB (49.0, 31.0, 30.66 $\times 10^5$cfu g^{-1}, respectively). Further, it had increased levels of nutrients soil *viz.*, nitrogen, phosphorus, and potassium. Greater biometric data including plant height and leaf count, yield characteristics like fruit yield per plant (1591.86) and fruit number (18). Hence, it leads to a conclusion that soil application of corn rind-carrier based biofertilizer + 100% NPK is comparable with soil application of talc carrier based biofertilizer + 100% NPK based on microbiological, nutritional, plant, and yield data. The findings of this study showed that corn rind powder can also be an alternate substrate for talc as a carrier material for the production of biofertilizers.

Keywords : Corn-rind, RDF, Phosphate solubilizing bacteria, Potassium solubilizing bacteria

The population of the globe is increasing, and by 2050, it is estimated to have grown by 9 billion people. With an emphasis on the rhizosphere's micro environment, we must double crop productivity through the adoption of new, environmentally friendly technology in order to feed this growing population (WHO, 2018). It is common knowledge that the continued and excessive use of harmful pesticides and fertilizers with petrochemical bases has had a negative impact on the land, water supplies, food, animals and even people (Laditi *et al*., 2012). The problems farmers faced when using chemical fertilizers led to the development of biofertilizer, which is safe for the environment and farmers concerned. By enhancing soil fertility, organic waste and biofertilizer can reduce the need for chemical fertilizers. The use of biofertilizers in crop cultivation will help to protect both the quality of crop products and the soil's health (Singh *et al*., 2013).

Biofertilizers are living cells or effective micro organisms that are prepared to aid in the intake of nutrients for plant growth (Abdullahi *et al*., 2012). These biofertilizers are available in different formulation like liquid, capsule and carrier-based such as granular, powder or slurry (Bhattacharjee, 2014). A difficult and frequently success-limiting stage in the successful commercialization of new microbial inoculants is formulation (Chin, 2010). Microbial inoculants' effectiveness is influenced by a number of variables, but carrier material is by far the most crucial. The bacteria attach to the carrier, which is made of inert or slowly biodegradable materials, and remain alive there for a long time (Chin, 2010). The carrier materials offer adequate microbial living space, regulate the nutrients around microorganisms, and create a favorable microenvironment for microbial growth and reproduction as well as extending the shelf life of introduced microorganisms (Chakraborty and Akhtar, 2021). When preparing biofertilizers, choosing the right carrier material is crucial, although there are no set standards for the selection of carrier materials, some general qualities should be present in the carrier material used for biofertilizer preparation are cost-effectiveness, non-toxic compounds and a high organic content, ease of processing, high water holding capacity, high buffering capacity, sticky in nature and availability in bulk quantities (Ritika and Uptal, 2014).

Presently, biofertilizers are produced in large quantities and employed for crop production using carrier materials including talc, peat, lignite, perlite, and vermiculite *etc*. However, each carrier has its own limitations, such as a short shelf life, an inability to withstand environmental stress and a high risk of contamination during bulk sterilization. Additionally, these formulations are not easily accessible globally and have a negative impact on human health, the environment and the ecosystem from which they are extracted and processed (Loyola, 2010 and Bashan, 1998).

This highlights the need of development of new formulations using alternative materials to compete with the existing inoculants. In this context, further exploration of different source of agriculture waste as a carrier which are rich in carbon content, one such waste is corn cob rind (CCR), because the CCR are rich in crude protein (5%), crude fat (5%), cellulose (36%), lignin (17%), moisture (15%), dry matter (85%) and ash content is 0.77 to 0.88 per cent (Ali & Arshad, 2014). Presently, this CCR is used as a fuel for cooking, which leads to environmental pollution. It can be used for the production of green technologies for further applications like bio fertilizers. The UASB Next generation biofertilizer unit, Department of Agricultural Microbiology, UAS, GKVK, Bangalore, has developed corn cob-rind carrier based biofertilizer.

In India, capsicum is grown for its mature fruits and widely used in stuffing, baking and consumed as salad, noodles and soup preparations. To meet the above requirements, elevation of capsicum yield is needed. Hence nutrient management is a crucial factor which should be considered for better growth and high yield of capsicum. There fore, the strategies like integrated nutrient management which consists of both chemical as well as biofertilizers is required. By considering the above points, the present investigation was focused on to evaluate the corn cob-rind-carrier based biofertilizer on the growth and yield of capsicum.

MATERIAL AND METHODS

Experimental Details

The pot experiment was conducted during the summer of 2023 in the Department of Agricultural Microbiology, University of Agricultural Sciences, GKVK, Bangalore, to examine the impact of corn-rind-carrier-based biofertilizer on the growth and yield of capsicum grown on sandy clay soil in polyhouse conditions. The experiment was set up in a completely randomized design with 10 treatments replicated three times, with treatment details shown in Table 1. The initial soil sample was evaluated for its physico-chemical and biological properties using conventional procedures (Table 2).

Culture Collection and Maintenance

Corn based carrier 'Jaivika Siri' Biofertilizers (GKVK Microbial consortia - GMC) was procured from UAS-B Next generation biofertilizer unit and talc

TABLE 1

The treatments details is presented

Treatments	Treatment details
T_1	Absolute Control
T_2	Corn rind carrier based biofertilizer
T_3	Talc carrier based biofertilizer
T_4	Seed treatment with Corn rind carrier based biofertilizer + RDF
T_5	Seedling root dip with Corn rind carrier based biofertilizer + RDF
T_6	Soil application of Corn rind carrier based biofertilizer + RDF
T_7	Seed treatment with Talc carrier based biofertilizer + RDF
T_8	Seedling root dip with Talc carrier based biofertilizer + RDF
T_9	Soil application of Talc carrier based biofertilizer + RDF
T_{10}	RDF

Note : RDF (150:75:50 kg NPK ha^{-1})

TABLE 2

Initial Physico-chemical and biological properties of soil

Parameter	Values
Bacteria (X 10^6 cfu g^{-1} soil)	11.00
Fungi (X 10^4 cfu g^{-1} soil)	8.66
Actinomycetes (X 10^3 cfu g^{-1} soil)	155.0
Free living N_2 fixers (X 10^5 cfu g^{-1} soil)	9.33
P Solubilizers (X 10^5 cfu g^{-1} soil)	3.33
K Solubilizers (X 10^5 cfu g^{-1} soil)	1.66
Biomass carbon (µg g^{-1} soil)	35.20
Biomass nitrogen (µg g^{-1} soil)	4.10
Biomass phosphorus (µg g^{-1} soil)	15.23
Available nitrogen (kg ha^{-1})	137.8
Available P_2O_5 (kg ha^{-1})	47.34
Available K_2O (kg ha^{-1})	205.1

based carrier biofertilizer was procured from scheme on popularization of biofertilizer, Department of Agricultural Microbiology, GKVK, Bengaluru. The consortia in both the formulations contain N fixer-NF (*Azotobacter chroococcum.*), Phosphate solubilizing bacteria-PSB (*Bacillus megaterium.*) and potassium solubilizing bacteria-KSB (*Frateuria aurantia.*)

Treatment Details:

Design : Complete randomized design (CRD)

Crop variety : Capsicum (California wonder)

Treatments : 10

Replication : 3

Enumeration of Microbial Population

The microbial population of bacteria, fungi, actinomycetes, free living N_2 fixers, PSB and KSB in capsicum rhizosphere were enumerated by the standard plate count method (Vlassak *et al.,* 1992).

Estimation of Available Nutrients in Soil

Available nutrient status was estimated by different methods like available nitrogen was estimated by alkaline permanganate method using micro-kjeldhal (Subbiah & Asija,1956), available phosphorus in soil by olsens or Brays method using spectro photometer (Bray & Kurtz, 1945) and available potassium in soil using flame photometer (Jackson, 1973) and was expressed in kg ha^{-1}.

Growth and Yield Parameters

The data pertaining to plant height number of leaves and number of branches was collected on 30, 60 and 90 Days after transplanting (DAT). Yield attributes like number of fruits, fruit yield were recorded after 50 days of transplanting. The cumulative yield was calculated considering all the pickings.

Dry Matter Accumulation Estimation

The sample collected from the three replications of each treatment was used to record the dry matter accumulation. The plant was uprooted and roots and shoot separated. Then it was dried in an oven at 60 °C till the sample was dried to constant weight and recorded.

Results and Discussion

Effect on Soil Bacterial, Fungal and Actinomycetes Population in Capsicum Rhizosphere

Bacterial, fungal and actinomycetes population in soil differed significantly with the application of corn rind carrier based biofertilizer (Table 3).

The bacterial population was significantly higher in treatment T_6 at all stages of crop growth *i.e.*, 30 (27.00 × 10^6 cfu g^{-1}), 60 (41.67×10^6 cfu g^{-1}) and 90 DAT, (44.33×10^6 cfu g^{-1}) which was on par with T_9, T_5, T_8, T_4 and T_7. The fungal population was significantly higher in T_6 at all stages of crop growth *i.e.*, 30 (21.00 × 10^4 cfu g^{-1}), 60 (34.67 × 10^4 cfu $g^{-1)}$ and 90 DAT, (37.33 × 10^4 cfu g^{-1}) which was on par with T_9, T_5 and T_8. Similarly actinomycetes population was found higher in treatment T_6 at all stages of crop growth *i.e.*, 30 (189.33× 10^3 cfu g^{-1}), 60 (201.00× 10^3 cfu g^{-1}) and 90 DAT, (204.00 × 10^3 cfu g^{-1}) which was on par with T_9. The highest population of bacteria, fungi and actinomycetes was found in the treatment T_6 might be due to the application of corn rind carrier based biofertilizers that contained beneficial microorganisms. Generally soil microorganisms population is influenced by soil carbon content with the addition of exogenous carbon through corn rind carrier based biofertilizer gradually increased the carbon availability and this could have stimulated microbial population in soil (Wei *et al.*, 2017). The Plant growth releases root exudate into the soil which serves as carbon and nitrogen source for the growth and proliferation of bacteria, fungi and actinomycetes cells (Badri & vivanco, 2009).

Effect of Corn-Rind-Carrier based Biofertilizer on Free Living N_2 Fixers, PSB and KSB Population in Capsicum Rhizosphere at different Stages of Crop Growth

The population of free living N_2 fixers, PSB and KSB in soil upon application of corn-rind-carrier based biofertilizer differed significantly at different intervals of the crop as shown in Fig. 1.

The free living N_2 fixers population was significantly higher in treatment T_6 (33.33 × 10^5 cfu g^{-1}) and T_9 (33.33 × 10^5 cfu g^{-1}) at 30 DAT whereas at 60 DAT, (46.33 × 10^5 cfu g^{-1}) and 90 DAT, (49.00 × 10^5

Table 3

Effect of corn rind carrier based biofertilizer on soil bacterial, fungal and actinomycetes population in capsicum rhizosphere at different stages of crop growth

Treatments	Bacteria (× 10^6 cfu g^{-1})			Fungal (× 10^4 cfu g^{-1})			Actinomycetes (× 10^3 cfu g^{-1})		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	15.33 ^{d}	19.67 ^{c}	19.67 ^{c}	11.67 ^{e}	19.67 ^{f}	19.00 ^{f}	175.33 ^{d}	182.67 ^{d}	181.33 ^{e}
T_2	16.66 ^{d}	28.00 ^{b}	29.67 ^{b}	13.33 ^{de}	24.00 ^{e}	25.33 ^{e}	178.67 ^{bcd}	188.67 ^{cd}	190.33 ^{cd}
T_3	16.33 ^{d}	26.33 ^{bc}	28.00 ^{b}	14.00 ^{cde}	23.33 ^{ef}	24.67 ^{e}	178.00 ^{cd}	187.33 ^{cd}	189.00 ^{d}
T_4	24.67 ^{ab}	36.00 ^{a}	37.67 ^{a}	16.67 ^{bcd}	28.67 ^{cd}	30.33 ^{cd}	181.00 ^{bc}	193.00 ^{bc}	195.00 ^{cd}
T_5	25.33 ^{ab}	37.67 ^{a}	39.67 ^{a}	17.33 ^{abcd}	30.67 ^{bcd}	32.67 ^{bc}	177.00 ^{cd}	194.00 ^{abc}	196.33 ^{bc}
T_6	27.00 ^{a}	41.67 ^{a}	44.33 ^{a}	21.00 ^{a}	34.67 ^{a}	37.33 ^{a}	189.33 ^{a}	201.00 ^{a}	204.00 ^{a}
T_7	23.00 ^{bc}	37.00 ^{a}	38.67 ^{a}	17.67 ^{abc}	28.33 ^{cd}	30.00 ^{cd}	187.00 ^{a}	191.67 ^{c}	193.67 ^{cd}
T_8	24.33 ^{ab}	37.67 ^{a}	39.67 ^{a}	18.67 ^{ab}	31.00 ^{abc}	33.00 ^{bc}	186.67 ^{a}	192.33 ^{c}	194.67 ^{cd}
T_9	25.67 ^{ab}	40.33 ^{a}	43.00 ^{a}	19.33 ^{ab}	33.67 ^{ab}	36.00 ^{ab}	187.67 ^{a}	199.67 ^{ab}	202.00 ^{ab}
T_{10}	20.67 ^{c}	29.33 ^{b}	30.00 ^{b}	14.33 ^{cde}	27.00 ^{de}	27.33 ^{de}	182.33 ^{b}	191.67 ^{c}	192.67 ^{cd}

Note : Numerical values are mean of three replicates. The treatment means with the different letters as superscript in the same columns as determined by DMRT (p≤ 0.05).

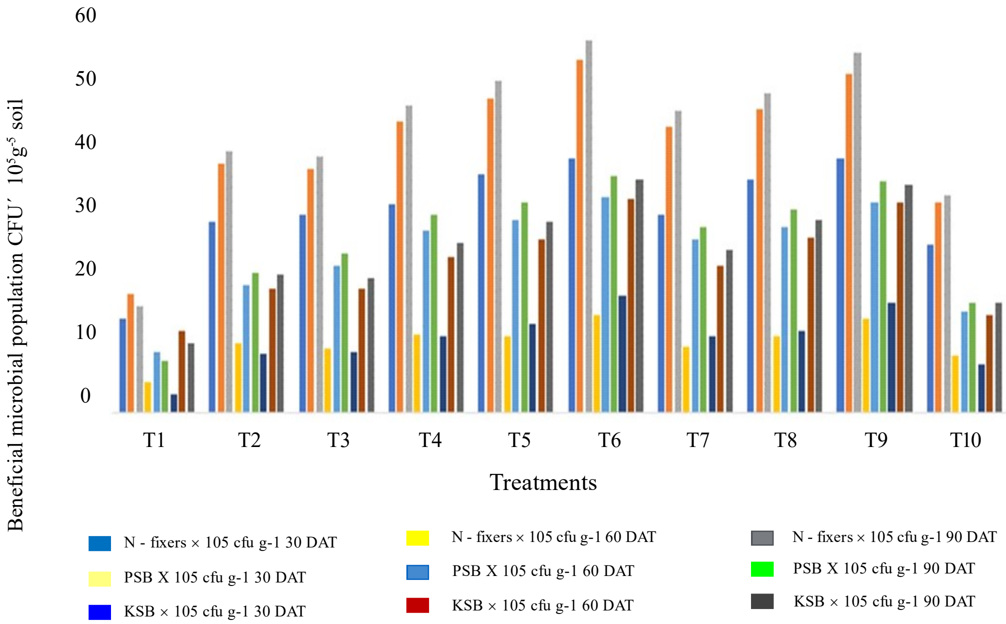

Fig. 1 : Influence of corn rind carrier based biofertilizer on beneficial microbial population in capsicum rhizosphere

cfu g^{-1}) was found higher in T_6 which is on par with T_9 and T_5. The highest population of nitrogen fixers in treatment T_6 is due application of biofertilizer consortium had a stimulating effect on the population of rhizospheric diazotrophs. The application of corn-rind-carrier material along with the recommended amount of mineral fertilizers must have led to better plant growth and a well-developed root system, which released higher levels of root exudates and resulted in a high amount of organic matter, increasing the amount of carbon and energy sources for rapid growth of diazotrophs (Pratheep and Kanchana, 2018).

The population of PSB in capsicum rhizosphere was recorded significantly higher in treatment T_6 at all stages of crop growth *i.e.*, 30 (12.66×10^5 cfu g^{-1}), 60 (28.33×10^5 cfu g^{-1}) and 90 DAT, (31.0×10^5 cfu g^{-1}) which was on par with T_9, T_4, T_5 and T_8. Similarly the treatment T6 out performed than other treatments in terms of the population of KSB at all stages of crop growth *i.e.*, 30 (15.33×10^5cfu g^{-1}), 60 (28.0×10^5 cfu g^{-1}) and 90 DAT, (30.66×10^5cfu g^{-1}) which was on par with T_9. The higher phosphate and potassium solubilizing bacteria recorded with soil application of corn-rind-carrier based biofertilizer which was on par with soil application of talc carrier based biofertilizer in capsicum rhizosphere which may be due to inoculation of PSB. The phosphate solubilizing bacteria could have solubilized the insoluble P into usable form by production of organic acids. Hence on application of biofertilizers it directly increased the number of PSB in soil by utilizing the organic matter present in soil (Shrivastava *et al.*, 2018 and Choudhary *et al.*, 2018). KSB can dissolve silicate minerals and release K through the production of organic and inorganic acids, acidolysis, upon addition into the soil as biofertilizers and it enhanced the number of KSB in the soil (Zhang *et al.*, 2004 and Subhashini, 2015).

Effect of Corn Rind Carrier Based Biofertilizer on Microbial Biomass Carbon, Nitrogen and Phosphorus in Capsicum at Different Stages of the Crop Growth

The impact of corn rind carrier based biofertilizer on biomass carbon, nitrogen, and phosphorus at different intervals of the crop is presented in Table 4. With the exception of T_1 (Absolute control), there was no discernible variation in soil microbial biomass carbon and nitrogen among the treatments. At all stages of crop growth, including 30 DAT (70.26 g g^{-1} soil and

TABLE 4

Effect of corn rind carrier based biofertilizer on microbial biomass carbon, nitrogen and phosphorus

Treatments	Biomass Carbon µg g-1			Biomass Nitrogen µg g-1			Biomass Phosphorous(µg g-1 soil)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	39.20 ^{b}	42.13 ^{b}	41.86 ^{b}	4.57 ^{b}	4.91 ^{b}	4.88 ^{b}	19.23 ^{d}	22.39 ^{c}	18.95 ^{c}
T_2	65.33 ^{a}	69.33 ^{a}	69.33 ^{a}	7.62 ^{a}	8.08 ^{a}	8.08 ^{a}	53.31 ^{bcd}	57.56 ^{bc}	58.31 ^{bc}
T_3	65.33 ^{a}	69.20 ^{a}	69.20 ^{a}	7.62 ^{a}	8.07 ^{a}	8.07 ^{a}	43.45 ^{cd}	53.58 ^{bc}	52.15 ^{bc}
T_4	67.33 ^{a}	71.60 ^{a}	71.60 ^{a}	7.85 ^{a}	8.35 ^{a}	8.35 ^{a}	62.81 ^{bcd}	66.34 ^{bc}	66.21 ^{bc}
T_5	69.60 ^{a}	75.20 ^{a}	75.20 ^{a}	8.12 ^{a}	8.77 ^{a}	8.77 ^{a}	69.63 ^{bcd}	118.64 ^{ab}	118.64 ^{ab}
T_6	70.26 ^{a}	76.93 ^{a}	76.93 ^{a}	8.19 ^{a}	8.97 ^{a}	8.97 ^{a}	162.35 ^{a}	165.02 ^{a}	165.50 ^{a}
T_7	64.53 ^{a}	68.67 ^{a}	72.53 ^{a}	7.52 ^{a}	8.01 ^{a}	8.46 ^{a}	74.00 ^{bcd}	75.32 ^{bc}	74.55 ^{bc}
T_8	69.73 ^{a}	73.60 ^{a}	73.46 ^{a}	8.13 ^{a}	8.58 ^{a}	8.57 ^{a}	112.67 ^{ab}	114.46 ^{ab}	161.72 ^{a}
T_9	70.13 ^{a}	75.20 ^{a}	75.20 ^{a}	8.18 ^{a}	8.77 ^{a}	8.77 ^{a}	89.60 ^{bc}	128.26 ^{ab}	128.44 ^{ab}
T_{10}	66.13 ^{a}	68.67 ^{a}	68.53 ^{a}	7.71 ^{a}	8.01 ^{a}	7.99 ^{a}	64.90 ^{bcd}	68.22 ^{bc}	67.79 ^{bc}

Note : Numerical values are mean of three replicates. The treatment means with the different letters as superscript in the same columns as determined by DMRT ($p \leq 0.05$).

8.19 g g^{-1} soil), 60 DAT (76.93 g g^{-1} soil and 8.97 g g^{-1} soil) and 90 DAT (76.93 g g^{-1} soil and 8.97 g g^{-1} soil), higher biomass carbon and nitrogen content was found in treatment T_6, but biomass phosphorus was significantly higher in the treatment T_6 at all stages of crop growth *i.e.*, 30 (162.35 µg g^{-1} soil), 60 (165.02 µg g^{-1} soil) and 90 DAT, (165.50 µg g-1 soil) were on par with T_9, T_5 and T_8.

The treatment T_6 had higher soil microbial biomass than the other treatments which may be related to the use of carrier based biofertilizers. The treatments that received no biofertilizers, had significantly lower soil microbial biomass carbon, nitrogen and phosphorus compared to the carrier-based biofertilizer treatments due to the presence of more organic substances in microorganisms than in the treatment that used inorganic fertilizer to provide nutrients. This, in turn, increased the rate of humification of fresh organic matter incorporated into soil (Balasubramanian *et al.*, 2002 & Piotrowska *et al.*, 2012).

Effect of Corn Rind Carrier Based Biofertilizer on Available NPK in Capsicum Rhizosphere at Different Stages of Crop Growth

The available nitrogen, phosphorus and potassium in the soil varied significantly during the progression of the crop as shown in Table 5.

The highest available nitrogen content was recorded in the treatment T_6 at all the stages of crop growth *i.e.,* 30 (201.51 kg ha^{-1}), 60 (210.73 kg ha^{-1}) and 90 DAT, (214.08 kg ha^{-1}) was on par with T_9. The highest available nitrogen status of the soil was found in treatment T_6 might be due to increased multiplication of rhizo microorganism due to addition of biofertilizers, which converted atmospheric nitrogen or organically bound nitrogen into inorganic form, as well as the efficient rhizomicroorganism colonization of the roots, may both contribute to the higher nitrogen status of soil. The favourable soil condition under the application of organic sources like biofertilizers may have encouraged soil N_2 mineralization leading to the enhancement of higher-available N_2 (Chesti *et al.*, 2013: Muthuvel *et al.*, 2003).

Available phosphorus varied significantly and the highest was observed in the treatment T_6 at all stages of crop growth *i.e.*, 30 (75.39 kg ha^{-1}), 60 (80.41 kg ha^{-1}) and 90 DAT, (80.93kg ha^{-1}) which was on par with T_9, T_5 and T_8. The highest amount of phosphorus that is readily available in treatment T_6 comes from biofertilizers that contain PSB, which solubilize native phosphate molecules by transforming insoluble or bound phosphorus into an accessible form through

TABLE 5

Effect of corn rind carrier based biofertilizer on available nitrogen, phosphorus and potassium in capsicum rhizosphere at different stages of crop growth

Treatments	Nitrogen kg/ha			Phosphorus kg/ha			Potassium kg/ha		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	135.07 ^{e}	140.49 ^{e}	134.22 ^{f}	43.10 ^{e}	43.27 ^{e}	42.07 ^{e}	198.10 ^{d}	202.44 ^{e}	185.60 ^{e}
T_2	163.56 ^{d}	171.01 ^{d}	173.52 ^{de}	50.23 ^{de}	53.39 ^{de}	53.67 ^{de}	210.40 ^{c}	215.52 ^{d}	222.28 ^{c}
T_3	164.82 ^{d}	170.59 ^{d}	172.68 ^{e}	50.57 ^{de}	53.11 ^{de}	53.49 ^{de}	208.56 ^{c}	215.00 ^{d}	220.96 ^{c}
T_4	180.45 ^{bc}	185.23 ^{bc}	187.74 ^{bc}	60.40 ^{abcd}	65.24 ^{bcd}	65.60 ^{bcd}	224.67 ^{ab}	229.48 ^{c}	238.68 ^{b}
T_5	185.88 ^{b}	190.25 ^{b}	192.76 ^{b}	71.55 ^{ab}	74.52 ^{abc}	74.92 ^{abc}	228.70 ^{a}	232.16 ^{bc}	242.24 ^{b}
T_6	201.51 ^{a}	210.73 ^{a}	214.08 ^{a}	75.39 ^{a}	80.41 ^{a}	80.93 ^{a}	233.13 ^{a}	241.96 ^{a}	258.20 ^{a}
T_7	178.88 ^{c}	183.56 ^{bc}	185.65 ^{bc}	59.30 ^{bcd}	62.38 ^{cd}	62.80 ^{cd}	230.17 ^{a}	230.96 ^{bc}	238.48 ^{b}
T_8	186.90 ^{b}	190.66 ^{b}	193.17 ^{b}	68.94 ^{abc}	72.72 ^{abc}	73.17 ^{abc}	230.23 ^{a}	234.80 ^{abc}	241.28 ^{b}
T_9	198.43 ^{a}	207.81 ^{a}	210.73 ^{a}	72.11 ^{ab}	78.45 ^{ab}	78.91 ^{ab}	233.78 ^{a}	238.32 ^{ab}	246.88 ^{b}
T_{10}	175.06 ^{c}	179.79 ^{cd}	181.47 ^{cd}	55.45 ^{cde}	59.00 ^{d}	58.62 ^{d}	217.33 ^{bc}	221.00 ^{d}	209.28 ^{d}

Note : Numerical values are mean of three replicates. The treatment means with the different letters as superscript in the same columns as determined by DMRT ($p \leq 0.05$).

particular processes. PSB play a significant role in P nutrition by increasing phosphorus availability. (Sundaram *et al*., 2016).

Available potassium content in the soil at 30 DAT, was the highest in treatment T_9 (233.78kg ha^{-1}) which was on par with T_6, T_8, T_7, T_5 and T_4. Where as at 60 DAT, higher potassium content was found in treatment T_6 (241.96 kg ha^{-1}) which is comparable with T_9 and T_8. Similarly at 90 DAT, maximum potassium content was recorded in treatment T_6 (258.20 kg ha^{-1}). The biofertilizers containing KSB, which convert fixed forms of potassium into soluble form through a number of mechanisms, such as acidolysis, chelation, exchange reactions, and the production of organic

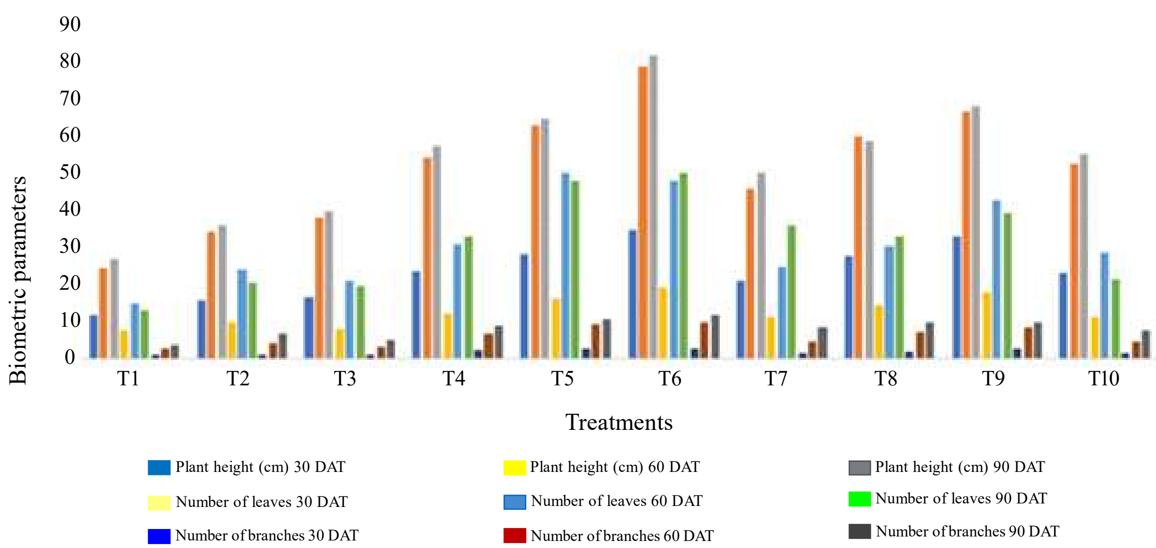

Fig. 2 : Influence of corn rind carrier based biofertilizer on biometric parameters of capsicum at different stages of crop growth

acids, are to be claimed for the increased potassium levels. (Mazid & Khan 2014 and Saha *et al.*, 2016).

Effect of Corn Rind Carrier Based Biofertilizer on Plant Growth Parameters at Different Intervals of Crop Growth in Capsicum

The results on effect of corn rind carrier based biofertilizer on biometric parameters is represented in Fig. 2.

The plant height was significantly higher in treatment T_6 at all stages of crop growth *i.e.*, 30 (32.66 cm), 60 (74.0 cm) and 90 DAT, (77.0 cm) which was on par with T_9. The number of leaves in a plant indicate about its vegetative growth. The higher number of leaves at 30 DAT, was observed in treatment T_6 (18), is comparable with T_9 and T_5 but, at 60 DAT maximum number of leaves was recorded in treatment T_5 (47) which is on par with T_6 and T_5. At 90 DAT, the higher number leaves was found in T_6 (47) which is on par with T_5, T_9 and T_7. The higher number of branches were noticed in the treatment T_9 (2.66) at 30 DAT, whereas at 60 (9.0) and 90 DAT, (9.66) maximum branches were observed in treatment T6 which is on par with T_9, T_8, T_5 and T_4. These all parameters were on higher side which may be due to the availability of nutrients to its full potential because of combined application of inorganics and corn rind carrier based biofertilizer that improved soil properties, increased nutrient availability through mineralization, phosphate solubilization, potassium solubilization, induced the production of growth promoting substances which could have caused cell elongation and expansion, culminating in a taller crop and more leaves (Nalini *et al.*, 2017; Abhik *et al.*, 2020 and Divya *et al.*, 2017).

Effect of Corn Rind Carrier Based Biofertilizer on Yield Attributes and dry Matter Accumulation in Capsicum

The results on effect of corn-rind-carrier based biofertilizer on yield attributes and dry matter accumulation is represented in Table 6

The treatment T_6 produced a higher number of fruits (18), compared to other treatments, while treatment T_1 produced less fruits (3). The treatment T_6 (1591g) reported significantly higher fruit production than the other treatments. The enhanced nutrient availability, particularly in the form of phosphate and potassium, is the cause for enhanced fruit quantity and yield under the treatment

TABLE 6

. Effect of corn rind carrier based biofertilizer on yield attributes and dry matter accumulation in capsicum

Treatments	Number of fruits plant-1	Fruit yield plant-1 (g)	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)
T_1	3 ^{h}	107.29 ^{i}	40.67 ^{c}	5.71 ^{f}	0.77 ^{c}	0.66 ^{d}
T_2	9 ^{f}	505.15 ^{g}	63.46 ^{bc}	8.54 ^{ef}	1.30 ^{c}	1.18 ^{d}
T_3	7 ^{g}	358.02 ^{h}	68.01 ^{bc}	10.02 ^{def}	1.28 ^{c}	1.15 ^{d}
T_4	14 ^{c}	991.97 ^{cd}	89.48 ^{ab}	16.87 ^{abcde}	3.08 ^{b}	2.67 ^{bc}
T_5	14 ^{c}	1032.59 ^{c}	117.90 ^{a}	18.30 ^{abcd}	3.13 ^{b}	2.70 ^{bc}
T_6	18 ^{a}	1591.86 ^{a}	125.48 ^{a}	23.58 ^{ab}	4.19 ^{a}	3.77 ^{a}
T_7	13 ^{d}	958.97 ^{d}	104.91 ^{ab}	15.46 ^{bcde}	2.57 ^{b}	2.24 ^{c}
T_8	13 ^{d}	897.36 ^{e}	104.13 ^{ab}	25.43 ^{a}	4.12 ^{a}	3.47 ^{ab}
T_9	16 ^{b}	1341.50 ^{b}	123.90 ^{a}	22.72 ^{abc}	3.43 ^{ab}	2.54 ^{bc}
T_{10}	11 ^{e}	717.08 ^{f}	89.12 ^{ab}	14.77 ^{cde}	2.88 ^{b}	2.45 ^{bc}

Note : Numerical values are mean of three replicates. The treatment means with the different letters as superscript in the same columns as determined by DMRT (p≤0.05).

T_6 (Olaniyi & Ojetayo, 2010). According to Boraste *et al*. (2009), the PSB and KSB were part of a consortium that solubilized the insoluble P and K elements and made them accessible to plants. Then, it was combined with chemical fertilizer that already included phosphorus and potassium, making the P and K content readily available to plants and improving fruit yield (Singh *et al*., 2022).

The treatment T_6 shoot fresh weight (125.48gm) was greater than that of the other treatments and comparable to those of T_9, T_5, T_7, T_8, T_4 and T_{10}. The treatment T_8 had the highest shoot dry weight (25.43g), which was higher than any other treatment and comparable to treatments T_6, T_9, T_5 and T_4. The treatment T_6 also reported the highest root fresh weight (4.19 g), which is comparable to treatments T_8 and T_9. The treatment T_6 had a higher root dry weight than the other treatments (3.77 g), and was comparable to T_8. The plants inoculated with corn rind-carrier-based biofertilizer showed higher fresh and dry weight of the shoot and root, which was significantly higher than control and on par with talc carrier based biofertilizer. This may be because the plant was inoculated with beneficial microorganism at an early stage of development, which had a positive impact on biomass through direct effect on root growth, production of phytohormones by bacteria, mineral enhancement uptake and an increase in biomass. (Cleyet-Marel *et al*., 2001).

The efficacy of the corn rind carrier based biofertilizer was comparable to that of the currently used carrier material *i.e*., talc, in terms of microbial population, enzyme activity, available nutrient status, growth and yield parameters of capsicum and both are on par. Among treatments w.r.t. application, the soil application of corn rind based biofertilizer + RDF is more effective. There fore, this corn rind can also be employed as a carrier material for the formulations of biofertilizers. Additionally, as corn-rind-carrier is organic in nature, it may enhance soil microbiological and chemical properties which in turn enhance soil fertility, structure and texture over a course of time.

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