Int.J.Curr.Microbiol.App.Sci (2017) *6*(4): 987-1006

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 4 (2017) pp. 987-1006**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.604.124

Isolation and Characterization of Potassium and Phosphorus Solubilising Bacteria and Fungus (KSB, PSB, KSF, PSF) and its Effect on Cauliflower

Supriya Kumari[1], Vijay Rajwade[2], Pramod Ramteke[3], Rubina Lawrence[1] and Harison Masih[1]*

[1]Department of Microbiology and Fermentation Technology, Jacob Institute of Biotechnology and Bioengineering, Faculty of Engineering and Technology SHUATS, Allahabad 211007, India
[2]Department of Horticulture, Naini Agricultural Institute, Faculty of Agriculture, SHUATS, Allahabad-211007, India
[3]Department of Biological Sciences, Faculty of Science, SHUATS, Allahabad-211007, India
**Corresponding author*

Keywords

Potassium and Phosphorus Solubilizing Bacteria, Cauliflower.

Article Info

Accepted:
12 March 2017
Available Online:
10 April 2017

A B S T R A C T

A field experiment was performed in the agriculture field of Departmernt of Horticulture in SHUATS, Allahabad to study the effect of bacterial and fungal biofertilizers on vegetative and yield attributing parameters of Cauliflower (*Brassica oleracea botrytis*) plant under citrus orchard. Bacterial biofertilizers included phosphorus solubilising microbes (bacteria and fungus) PSB1, PSF1 and potassium solubilising microbes KSB2 and KSF2 which were isolated from the rhizospheric region of vegetable crops. The strains were screened by employing qualitative plating techniques. The isolates showing maximum zones were screened for further analysis. The microbial inoculants coated seeds were sown in fields. After 90 days of sowing, the plant growth parameters like morphological and Bio-chemical parameters were analyzed in *Brassica oleracea botrytis* plants. The morphological parameters like number of leaves, leaf spread, leaf area, shoot length, fresh plant weight, dry plant weight, phosphorus and potassium in leaves and bio-Chemical parameters like chlorophyll content, protein, carbohydrate, ascorbic acid content, were increased in combined treatment of phosphorus solubilising fungus and potassium solubilizing fungus along with recommended dose of chemical fertilizers in *Brassica oleracea* than other treatments and control plants. The present work suggests that cauliflower cultivation could be performed in the spaces between main crops and the space could be utilized giving good income for the farmers by giving increased output.

Introduction

Cauliflower (*Brassica oleracea botrytis*) is a vegetable belonging to the family of *cruciferous* and is characterized by its fleshy stem and broad leaves. It comes from the Mediterranean Sea regions, specifically the Near East (Asia Minor, Lebanon and Syria), being known and cultivated by man since ancient times. Cauliflower can be eaten raw or steamed, grilled, fried, stewed, boiled or au gratin (Zahir *et al*., 2004).

In addition to its culinary properties, its use is healthy for several reasons: first, they emphasize its anti-cancer qualities, it also has compounds called isothiocyanates, which activate enzymes (substances that speed up chemical reactions) that serve to reduce the activity of carcinogens (substances that promote the mutation of cells), so that you reduce the risk of developing prostate tumors, it facilitates the expulsion of faeces (stool), as

the "smoothing" drags cholesterol and by increasing the speed of transit of food the digestive system, helps reduce the risk of developing cancer of the large intestine. Cauliflower is of great economic importance worldwide (Turan *et al*., 2014). The results of co-inoculation of potassium and phosphorus solubilising bacteria shown that it increased P availability from 12 to 21 per cent and K availability from 13 to 15 per cent and also subsequently improved N, P and K uptake. The integration also increased plant photosynthesis by 16 per cent and leaf area by 35 per cent as compared to control and on the other hand the biomass harvest and yield of the treated plants were increased by 23 percent to 30 per cent which shows that it is sustainable alternative to the use of chemicall fertilizer (Esitken *et al*., 2005, 2006; Supanjani *et al*., 2006). Nitrogen, Phosphorus, Potassium are mobile nutrients, while the others have varying degree of mobility. K and P is costly nutrients and being used in huge quantity in India where few million tones is being imported annually to India. It was reported that inoculation of PGPR has significant increase in yield and growth of crops by different researchers (Dursun *et al*., 2010; Misra *et al*., 2010; Yildirim *et al*., 2011; Ibiene *et al*., 2012). Thus Successful identification of an elite microbial strain (Rodríguez-Díaz *et al*., 2008), capable of solubilising insoluble potassium and phosphorus mineral quickly in large quantity can conserve our existing resources and avoid environmental pollution hazards caused by heavy application of chemical fertilizers (Adesemoye and Kloepper, 2009). In the light of the above facts, an experiment involving, potassium solubilising bacteria and fungus (KSB, KSF) and phosphorus solubilising bacteria and fungus (PSB, PSF) and in combination of all (KSB, PSB, KSF, PSF) were tested on crop of cauliflower to see the effect of dual inoculation of potassium solubilising bacteria and (KSB, KSF) and phosphorus solubilising bacteria and fungus on Physico-chemical and biological properties of soil and plant samples (Kloepper *et al*., 2004). As we know that in India the rate of urbanization is so fast that availability of land is very difficult so in this experiment we have made an attempt to utilize the space between the existing lemon orchard for cultivation and results of the experiment was analysed.

Materials and Methods

Bacterial isolation

10 gm of rhizospheric soil samples were taken into a 250mL of conical flask and 90mL of sterile distilled water was added to it. The flask was shaken for 10min on a vortex machine. One milliliter of suspension was added to 10mL vial and shaken for 2min. Serial dilution technique was performed up to 10^{-8} dilution for bacteria and 10^{-4} for fungus. An aliquot (0.1mL) of this suspension was spread on the plates of Nutrient agar (NA) medium and PDA (potato dextrose agar). Plates were incubated for 24 hrs for bacteria and 4 days at 28ºC to observe fungus colonies. Bacterial colonies were streaked to other NA agar plates and fungus on PDA (potato dextrose agar) plates and were incubated at 28ºC for 24 hrs and 4 days for both cultures. Typical bacterial colonies were observed over the streak. Well isolated single colony was picked up and re-streaked to fresh NA agar plate and incubated similarly.

Identification of isolates-The bacterial strain was studied for cultural, morphological and biochemical characteristics based on Bergey's Manual of Systematic Bacteriology (Hoit *et al*., 1989).

Cultural characteristics-All the isolates were streaked on NA agar plates. After 2 days of incubation, different characteristics of colonies such as growth, form and colour.

Morphological characteristics-The suspected organisms were subjected to Gram's staining (Vincent, 1970). The bacteria which retained the primary stain called gram + ve while those that lost the crystal violet and counter stained by safranin were referred as gram – ve. Whereas for fungal strain lactophenol cotton blue staining was performed.

Biochemical characterization

Methyl Red test, Catalase test, Casein Hydrolysis test, Gelatin Hydrolysis test, Indole test, Ammonia production test (Cappuccino and Sherman, 1992).

Phosphate solubilization test

The bacterial and fungal isolates were inoculated into plates with sterilized Pikovskaya medium containing tricalcium phosphate and incubated at 30ºC for 72h. Formation of clear zone around the colony indicated the phosphate solubilizaton by the bacteria and fungus (Pikovaskya, 1948).

Potassium solubilization test

The bacterial and fungal isolates were inoculated into plates with sterilized Alexandrov medium containing potassium chloride and incubated at 30ºC for 72h. Formation of clear zone around the colony indicated the potassium solubilizaton by the bacteria and fungus (Hu *et al.*, 2006).

Plan of Experiment

Field evaluation of efficient potassium solubilising microbes (KSM) and phosphorus solubilising microbes (PSM) for growth, nutrient content and yield of vegetable crops of Cauliflower, a field experiment was conducted using two efficient each potassium solubilising bacteria two efficient phosphorus solubilising bacteria, two efficient potassium solubilising fungus and two efficient phosphorus solubilising fungus which was used as single and in combination of all to study their performance in enhancing the growth, yield, P and K content of cauliflower as detailed below.

Treatments

The experiment was laid in randomized block design in two seasons (2013-14) with treatments, each replicated three times, thus making a total 36 plots. The unit plot size was $2m^2$.The plants were spaced at rows to row spacing (60cm) and plant to plant (45cm) apart. There were total of 6 plants in each plot. The treatments were allocated randomly to a unit plot in each replication. Treatments were: T0- Control+100% RDF (without biofertilizers),T1-PSB+100% RDF (phosphorus solubilising bacteria), T2-PSF+100% RDF (phosphorus solubilising fungus), T3-KSB+100% RDF (potassium solubilising bacteria),T4-KSF+100% RDF(potassium solubilising fungus),T5-PSB+PSF+100% RDF (phosphorus solubilising bacteria and fungus),T6-PSB+KSB+100 % RDF (phosphorus and potassium solubilising bacteria),T7-PSB+KSF+100% RDF (phosphorus solubilising bacteria and potassium solubilising fungus),T8-KSB+KSF+100% RDF (potassium solubilising bacteria and fungus), T9-KSB+PSF+100% RDF (potassium solubilising bacteria and phosphorus solubilising fungus),T10-PSF+KSF+100% RDF (phosphorus and potassium solubilising fungus).

Soil type

The experimental site was fairly level land with sandy loam soil of uniform fertility status with low clay and high sand percentage.

Seed: Cauliflower seeds of hybrid obtained from alopibagh market of Allahabad, district were used in the trial.

Fertilizers

The recommended dose of fertilizers of Cauliflower was 150:80:80 kg NPK per hectare, P in the form of single super phosphate, N in the form of urea and K in the form of muriate of potash were added according to the treatment schedule.

Seed treatment and sowing

Seeds were inoculated following the method of Weller and Cook, 1983. The seeds of cauliflower were surface sterilized using tap water and then with 70% ethanol, disinfected with 0.05% $HgCl_2$ for 6 min. Again rinse with water. The strains selected for the treatments were grown on medium for 48 hours. Growth was scraped and thoroughly mixed with one percent sterile jaggery suspension. Now seeds are treated with PSM and KSM broth cultures and sown in field.

Plant growth parameters

Plant height (cm)

Mean height of the five plants selected randomly and tagged in the net plot was recorded for these plant in centimeter at different growth stages of wheat. The height was measured from the ground surface to the base of the fully opened leaf before heading and to the tip of ear head of the main shoot after heading. The plant height was measured at 30, 60 and 90 days after sowing from the base of the plant to the base of fully opened top leaf and expressed in centimeters.

Number of leaves per plant

Number of leaves per plant were counted and recorded at 30, 60, and 90 DAS

Root growth: Root length was recorded at 90 DAS by uprooting the plant the neck and measuring the length from tip of the longest root to region and expressed in centimeters.

Dry matter content

The dry matter content of cauliflower plant was recorded at 30, 60 days after sowing and at harvesting. The uprooted plant, root and shoot portions were separated and air dried separately in an oven at 60°C to constant weight. The shoot and root dry weight were recorded and expressed in g/ plant

Fresh and dry weight of root and shoot

Plants were removed from soil and washed off any loose soil then blotted for removing any free surface moisture. Plant was dry in an oven at 37^{o}C for 16 hours.

Root was separated from the top (cut at soil line) and separately weigh and record the root and top for plant. Dry weight of root was measured in gram and dry weight of top of plant (shoot weight) was also measured in gram.

Chlorophyll content

Chlorophyll contents were estimated according to the method by Arnon. Fresh leaves were taken from five selected plants and cut into 0.5 cm segments and extracted overnight with 80% acetone (10 ml pure acetone solution + 2.5 ml distilled water) at 40^{o}C. The extract was centrifuged at 10000 rpm for 5 minutes and absorbance of the supernatant was taken at 645 and 663 nm.

Leaf area index

Leaf area was calculated using graph paper method (Sestak *et al*., 1971) at 30, 60, 90 and 120 days of transplanting by selecting one fully opened mature leaf from each replication.

Physio-Chemical analysis of collected soil samples

Soil texture analysis was done by using John *et al*., (2001) method. All soil samples were analyzed for their pH and EC by using 1:1(w/v) with the help of method described by McLean (1982) and Rhoades (1982) respectively. The organic matter of all the soil samples was determined by Walkley-Blake method (1934), organic carbon and protein content of soil was also calculated. AB-DTPA extraction: AB-DTPA method (Soltanpour and Workman, 1979) was used for the determination of macronutrients. Available phosphorus was measured by Olsen and Sommers (1982). Extractable potassium was determined directly from the filtrate by using a flame photometer at 404 nm wavelengths. Standard solutions were made in the extraction with KCl. Available nitrogen was measured by Microkjeldhal method.

Biochemical properties of plant samples

Biochemical properties of plant samples were analyzed like protein, carbohydrate and Ascorbic acid content. The protein content of the sample was measured by Lowry's method (Lowry, 1951). Carbohydrates content was measured using anthrone's method. Ascorbic acid of the curd was determined titrimetrically, using 2, 6 dichlorophenol indophenols dye as per method suggested by Ranganna (1986).

Statistical Analysis

The data obtained during the course of investigation will be statistically analyzed using tukey's HSD test which is an appropriate methodology for knowing the comparison among readings and will be interpreted accordingly.

Results and Discussion

In this study, potassium and phosphorus solubilising bacteria were isolated from rhizosphere soil of vegetable grown in Horticulture field of Shiats, Allahabad agriculture institute, Allahabad in both the years. Bacterial isolates were examined for their ability to solubilise insoluble potassic and phosphatic mineral. The efficient P and K solubilizers were further subjected to incubation condition to understand the release of K from potassic minerals. Among the 380 rhizobacterial isolates/strains tested in this study, only 27.7% strains showed K solubilization on modified Aleksandrov medium plates supplemented with KCl. Fungal strain KSF 2 is black colonies on potato dextrose agar and characterized as *Aspergillus spp*. whereas potassium solubilising bacteria was Gram-positive rod KSB2 and 30% of them showed potassium solubilization. The bacteria having maximum phosphorus solubilization was Gram-negative rod-shaped strain (PSB1) and fungus was having green colonies (*Trichoderma spp.*) PSF1. Liu *et al.*, (2001) isolated silicate dissolving bacteria *B. mucilaginosus* CS1 and CS2 from soil. The present study was well correlated with the previous reports by Prabha *et al.*, (2014). They studied the combined and dual inoculations of *Rhizobium, Phosphobacteria* and *Azospirillum* sp. inoculated plants showed increase in the growth of *Cajanus cajan* L. when compared with control plants.

Qualitative screening method (solubilization index (si) and associated characters)

According to plate screening for clear zone formation, all selected strains, gave clear zone formation around the spot inoculated culture. Similar observation has been reported by several workers (Kim *et al.*, 1997; Kumar *et al.*, 1999; Gupta *et al.*, 2007; Rashid *et al.*, 2004). Index for clear zone formation of these strains has been shown in table 2. During several days of incubation, clear zone formation of all these strains where larger.

Solubilization index (SI) of PSM isolates ranged from 8 to 13 (mm) in the present work, and KSM ranged from 9.4 to 15(mm).

Field experiment for growth of (*Brassica oleracea* var. Italica l) plant

P solubilising bacteria and silicate bacteria play an important role in plant nutrition through the increase in P and K uptake by the plant (Lian *et al.*, 2002; Liu *et al.*, 2001). Application of Phosphate solubilising microorganisms (Goenadi *et al.*, 2000) have been used as P-biofertilizer for crop cultivation (Sindhu *et al.*, 2009). Silcate bacteria provided less polluting and less energy-consuming approaches widely used in improvement of available K for assimilation by plants, and removal of impurities from minerals (Xiufang *et al.*, 2006). The morphological parameters like Shoot length, number of leaves, spread of leaves, root length, total length of plants were increased in combined inoculation of phosphorus and potassium solubilising fungus (T10-PSF1+KSF2+100% RDF) plants than other dual inoculations and control plants. The shoot length of *Brassica oleracea* var. italica L. Plant was highest in combined inoculation of (PSF+KSF+100% RDF), Number of leaves, plant spread and was also highest in combined inoculation (PSF1+KSF2+100% RDF) compared to control for both the seasons (Tables 1–6).

The fresh plant weight, dry plant weight, of cauliflower plant was highest in combined inoculation of (PSF1+KSF2+100% RDF) compared to control (Table 5) for both the seasons. Phosphorus in leaves and Potassium in leaves of cauliflower plant was highest in combined inoculation of (PSF1+KSF2+100% RDF) compared to control (Table 6) for both the seasons (Table 7). These findings have also been reported by many researchers while investigating the inoculation effect of different species of phosphate solubilising bacteria and AM fungi on a variety of crop plants (Zaidi *et al.*, 2005; Zaidi *et al.*, 2003). Bio-Chemical parameters like chlorophyll content, protein, carbohydrate, ascorbic acid, were also increased in combined treatment of phosphorus and potassium solubilising fungus (T10-PSF1+KSF2+100% RDF) in both seasons (Tables 9). The leaf area, (protein, carbohydrate and ascorbic acid content of curd), chlorophyll of cauliflower leaf was highest in combined inoculation of (PSF1+KSF2+100% RDF) compared to control (Table 7 and 8 in both the seasons). This might be due to production of plant growth hormones and organic acids secreted by them in the medium (Tables 10–12).

Growth attributes

All the nutrient management treatments had resulted into statistically significant effects. Increase in root length was due to adding organic matter which enhances the soil structure conditions, creates conducive conditions for good root development (Arisha *et al*., 2003; Togun and Akanbi, 2003) and mineralization by microorganisms (Table 13). Hence, plants are able to get nutrients for higher yield (Wong *et al*., 1999; Al-Nasir, 2002) upon application of organic manures. Pandey *et al.*, (2008) also highlighted the positive effects of azotobactor on growth and yield of broccoli. Bashyal (2011) pointed that biofertilizer inoculation enhances phytohormone production, nitrogen fixation, phosphate solubilization and specific activities of enzymes involved in the metabolic pathway might be the reason behind growth and yield improvement in cauliflower. Sharma and Sharma (2010) also reported significant improvement in plant height, number of leaves per plant, curd diameter, curd depth, gross weight/plant and marketable curd yield when cauliflower was treated with inorganic fertilizers in presence of biofertilizers. The results on quality attributes indicated that vitamin A as well as

ascorbic acid content of curd for all the cauliflower varieties were increased in presence of biofertilizer however the differences were statistically non significant. The experimental findings showed that seedling root dipping with bio-inoculants offers great potential as organic amendment for cauliflower cultivation.

Growth and yield attributes were significantly influenced by interactions of bio-inoculation and varieties. Seedling root dipping with *Azotobacter chroococcum* and Phosphate solubilising bacteria (*Acinetobacter sp*) containing bio-inoculants proved its superiority in enhancing the growth, yield and quality attributes of cauliflower. The practice will help to achieve desired yield, augment nutrient efficiency and will sustain the fertility and productivity of soil under terai zone of West Bengal in long run.

Biofertilizer enhances phytohormone production, nitrate reduction, nitrogen fixation, phosphate solubilization, specific activities of enzymes involved in the tricarboxylic acid cycle and the glycolysis pathway might be the reason behind yield increase.

Hormone induced modification in root morphology leads to enhanced uptake of mineral nutrients like NO_3^-, NH_4^+, $H_2PO_4^+$, K^+, Rb^+ and Fe^{2+}might help increasing yield. Curd height and curd diameter increased with biofertilizer is not just related to the capacity to fix atmospheric nitrogen but also, due to the production of plant growth promoting substances. These phytohormones promote root growth of the plants, consequently increasing nutrients and water absorption areas.

Table.1 Number of leaves (First year)

Treatments	Number of Leaves (First Year)		
	30	60	90
	DAYS OF SOWING		
T0-CONTROL+100%RDF	8.17±0.14^{cd}	11.20±0.10^{f}	14.23±0.15^{f}
T1-PSB1****+100%RDF	8.30±0.10^{cd}	11.60±0.20^{ef}	15.60±0.10^{de}
T2-PSF1*****+100%RDF	9.50±0.10^{a}	12.60±0.20^{bc}	16.60±0.20^{c}
T3-KSB2$^{\#}$+100%RDF	9.00±0.10^{ab}	12.03±0.15^{de}	16.60±0.20^{c}
T4-KSF2$^{\#\#}$+100%RDF	8.40±0.20^{cd}	11.60±0.20^{ef}	15.40±0.20^{e}
T5-PSB1+PSF1+100%RDF	9.30±0.20^{a}	12.40±0.20^{bcd}	16.60±0.20^{c}
T6-PSB1+KSB2+100%RDF	8.50±0.20^{bcd}	12.07±0.11^{cde}	16.20±0.20^{cd}
T7-PSB1+KSF2+100%RDF	8.60±0.30^{bc}	11.60±0.20^{ef}	15.50±0.20^{e}
T8- KSB2+KSF2+100%RDF	8.06±0.20^{d}	11.70±0.20^{ef}	15.33±0.49^{e}
T9- KSB2+PSF1+100%RDF	8.30±0.20^{cd}	12.70±0.20^{b}	17.70±0.20^{b}
T10- SF1+KSF2+100%RDF***	9.40±0.10^{a}	13.33±0.25^{a}	18.40±0.20^{a}
F-test	S	S	S
F-Tab	2.07	2.07	2.07
F-cal	25.28	33.39	75.65
S.Ed(±)	0.69	0.72	0.89
CD at 5%	1.42	1.48	1.85

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "cd, f," is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bcd, def, fg etc.

Table.2 Number of leaves (cauliflower second year)

Treatments	Number of Leaves (Cauliflower Second Year)		
	30	60	90
	Days of Sowing		
T0-CONTROL+100%RDF	8.10±0.10^{b}	8.23±0.15^{b}	10.20±0.10^{g}
T1-PSB1****+100%RDF	8.43±0.32^{ab}	8.70±0.35^{ab}	10.83±0.05^{de}
T2-PSF1*****+100%RDF	9.00±0.43^{ab}	8.93±0.98^{ab}	11.40±0.10^{bc}
T3-KSB2$^{\#}$+100%RDF	8.63±0.51^{ab}	8.90±0.50^{ab}	10.66±0.15^{ef}
T4-KSF2$^{\#\#}$+100%RDF	8.43±0.32^{ab}	9.30±0.62^{ab}	10.36±0.15^{fg}
T5-PSB1+PSF1+100%RDF	8.93±0.60^{ab}	8.96±0.42^{ab}	11.06±0.20^{cd}
T6-PSB1+KSB2+100%RDF	8.23±0.95^{b}	8.53±0.95^{b}	10.60±0.10^{ef}
T7-PSB1+KSF2+100%RDF	8.96±0.64^{ab}	9.23±0.67^{ab}	10.80±0.10^{de}
T8 KSB2+KSF2+100%RDF	9.03±0.38^{ab}	9.33±0.38^{ab}	11.60±0.10^{b}
T9-KSB2+PSF1+100%RDF	8.23±0.40^{b}	8.53±0.40^{b}	10.40±0.10^{fg}
T10-PSF1+KSF2+100%RDF***	9.89±0.86^{a}	10.30±0.44^{a}	12.40±0.10^{a}
F-test	S	S	S
F-Tab	2.07	2.07	2.07
F-cal	2.60	2.70	84.53
S.Ed(±)	2.13	2.23	0.47
CD at 5%	4.41	4.63	0.97

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "b, g" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* a, b, c, d, e, f, g, h, i, etc.

Table.3 Height (cauliflower first year)

TREATMENTS	HEIGHT (CAULIFLOWER FIRST YEAR)		
	30	60	90
	DAYS OF SOWING		
T0-CONTROL+100%RDF	8.43±0.02^{d}	14.21±0.01^{i}	18.41±0.01^{h}
T1-PSB1****+100%RDF	14.23±0.02^{abc}	21.42±0.02^{e}	25.24±0.01^{e}
T2-PSF1*****+100%RDF	9.42±0.03^{cd}	12.27±0.01^{k}	16.45±0.02^{k}
T3-KSB2$^{\#}$+100%RDF	9.53±0.03^{cd}	12.42±0.02^{j}	16.73±0.03^{j}
T4-KSF2$^{\#\#}$+100%RDF	15.32±0.025^{ab}	23.11±0.01^{c}	28.93±0.01^{b}
T5-PSB1+PSF1+100%RDF	12.23±0.62^{bcd}	17.52±0.02^{f}	22.43±0.02^{f}
T6-PSB1+KSB2+100%RDF	11.44±0.01^{bcd}	16.64±0.02^{g}	21.63±0.02^{g}
T7-PSB1+KSF2+100%RDF	7.13±0.02^{d}	15.82±0.02^{h}	17.75±0.01^{i}
T8 KSB2+KSF2+100%RDF	9.87±0.02^{cd}	21.93±0.03^{d}	26.14±0.02^{d}
T9-KSB2+PSF1+100%RDF	16.32±0.02^{ab}	24.83±0.03^{b}	28.40±0.10^{C}
T10-PSF1+KSF2+100%RDF***	18.64±0.02^{a}	25.32±0.02^{a}	38.43±0.01^{a}
F-test	S	S	S
F-Tab	2.07	2.07	2.07
F-cal	13.09	142672.59	105920.33
S.Ed(±)	6.68	0.09	0.14
CD at 5%	13.83	0.17	0.29

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "d, i, j" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bcd, def, gh, fg etc.

Table.4 Height (cauliflower second year)

TREATMENTS	HEIGHT (CAULIFLOWER SECOND YEAR)		
	30	60	90
	DAYS OF SOWING		
T0-CONTROL+100%RDF	12.67±0.21^{h}	18.20±0.10^{h}	23.80±5.63^{a}
T1-PSB1****+100%RDF	19.61±0.03^{c}	25.30±0.10^{d}	29.49±1.00^{a}
T2-PSF1*****+100%RDF	10.44±0.02^{i}	16.50±0.01^{j}	26.74±5.34^{a}
T3-KSB2$^{\#}$+100%RDF	10.56±0.04^{i}	16.94±0.02^{i}	27.94±5.43^{a}
T4-KSF2$^{\#\#}$+100%RDF	17.63±0.04^{d}	27.40±0.10^{c}	30.70±7.23^{a}
T5-PSB1+PSF1+100%RDF	16.26±0.15^{e}	21.70±0.10^{e}	31.70±4.61^{a}
T6-PSB1+KSB2+100%RDF	15.70±0.20^{f}	20.80±0.10^{f}	28.91±3.13^{a}
T7-PSB1+KSF2+100%RDF	13.40±0.20^{g}	19.60±0.10^{g}	28.70±4.41^{a}
T8 KSB2+KSF2+100%RDF	19.40±0.09^{c}	25.30±0.17^{d}	27.83±4.23^{a}
T9-KSB2+PSF1+100%RDF	21.13±0.15^{a}	28.42±0.19^{b}	31.70±1.44^{a}
T10-PSF1+KSF2+100%RDF***	20.70±0.20^{b}	30.40±0.10^{a}	28.78±4.59^{a}
F-test	S	S	S
F-Tab	2.07	2.07	2.07
F-cal	2272.40	5532.56	0.73
S.Ed(±)	0.55	0.43	17.68
CD at 5%	1.13	0.89	36.6

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "h, a" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* a, b, c, d, e, f, g, h, i, etc.

Table.5 Plant spread (cauliflower first year)

TREATMENTS	PLANT SPREAD (CAULIFLOWER FIRST YEAR)		
	30	60	90
	DAYS OF SOWING		
T0-CONTROL+100%RDF	9.20±0.09^{j}	15.21±0.02^{j}	20.42±0.01^{j}
T1-PSB1****+100%RDF	18.40±0.02^{c}	24.47±0.06^{c}	29.31±0.07^{c}
T2-PSF1*****+100%RDF	8.30±0.05^{k}	14.86±0.01^{k}	19.31±0.02^{k}
T3-KSB2$^{\#}$+100%RDF	9.45±0.02^{i}	15.96±0.02^{i}	20.56±0.02^{i}
T4-KSF2$^{\#\#}$+100%RDF	14.53±0.03^{e}	20.45±0.01^{e}	25.84±0.03^{e}
T5-PSB1+PSF1+100%RDF	16.59±0.01^{d}	22.32±0.03^{d}	27.87±0.07^{d}
T6-PSB1+KSB2+100%RDF	13.33±0.03^{f}	19.14±0.03^{f}	24.39±0.08^{f}
T7-PSB1+KSF2+100%RDF	11.90±0.01^{g}	17.20±0.02^{g}	22.23±0.03^{g}
T8 KSB2+KSF2+100%RDF	11.44±0.01^{h}	16.42±0.02^{h}	21.75±0.04^{h}
T9-KSB2+PSF1+100%RDF	20.47±0.02^{b}	26.34±0.03^{b}	31.14±0.02^{b}
T10-PSF1+KSF2+100%RDF***	21.72±0.04^{a}	28.71±0.02^{a}	34.13±0.02^{a}
F-test	S	S	S
F-Tab	2.07	2.07	2.07
F-cal	38829.46	71417.76	32343.73
S.Ed(±)	0.16	0.12	0.18
CD at 5%	0.33	0.24	0.37

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "j" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bcd, def, gh, fg etc.

Table.6 Plant spread (cauliflower second year)

TREATMENTS	PLANT SPREAD (CAULIFLOWER SECOND YEAR)		
	30	60	90
	DAYS OF SOWING		
T0-CONTROL+100%RDF	10.60±0.10^{j}	14.50±0.01^{k}	30.79±0.60^{a}
T1-PSB1****+100%RDF	20.20±0.17^{c}	25.14±0.02^{d}	32.14±4.01^{a}
T2-PSF1*****+100%RDF	10.41±0.015^{k}	16.34±0.04^{j}	30.04±7.27^{a}
T3-KSB2$^{\#}$+100%RDF	11.67±0.03^{i}	17.47±0.01^{i}	28.20±4.10^{a}
T4-KSF2$^{\#\#}$+100%RDF	16.36±0.04^{e}	26.52±0.02^{b}	31.05±5.14^{a}
T5-PSB1+PSF1+100%RDF	18.91±0.01^{d}	24.36±0.02^{e}	34.74±4.38^{a}
T6-PSB1+KSB2+100%RDF	15.15±0.01^{f}	21.44±0.03^{f}	30.17±2.80^{a}
T7-PSB1+KSF2+100%RDF	13.61±0.01^{g}	19.93±0.03^{g}	31.60±5.74^{a}
T8 KSB2+KSF2+100%RDF	12.44±0.01^{h}	18.87±0.02^{h}	30.23±4.88^{a}
T9-KSB2+PSF1+100%RDF	22.74±0.03^{b}	25.61±0.015^{c}	32.25±1.59^{a}
T10-PSF1+KSF2+100%RDF***	24.52±0.02^{a}	30.44±0.01^{a}	36.16±1.13^{a}
F-test	S	S	S
F-Tab	2.07	2.07	2.07
F-cal	17996.18	139032.96	0.83
S.Ed(±)	0.24	0.089	16.33
CD at 5%	0.50	0.19	33.8

Different letters in each column denote significant difference (p>0.005,n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "j, k " is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* a, b, c, d, e, f, g, h, i, etc.

Table.7 Phosphorus and potassium in cauliflower leaf

TREATMENTS	Phosphorus leaf (Cauliflower)		Potassium leaf (Cauliflower)	
	First year	second year	First year	second year
T0-CONTROL+100%RDF	10.62±0.01^{j}	12.61±0.04^{i}	123.13±0.015^{k}	100.23±0.02^{k}
T1-PSB1****+100%RDF	25.41±0.06^{a}	27.42±0.06^{a}	351.68±1.19^{b}	334.61±0.09^{b}
T2-PSF1*****+100%RDF	23.75±0.04^{b}	25.77±0.02^{b}	337.50±0.10^{c}	317.20±0.26^{c}
T3-KSB2$^{\#}$+100%RDF	14.20±0.10^{g}	16.37±0.2^{f}	225.92±0.06^{g}	205.39±0.64^{g}
T4-KSF2$^{\#\#}$+100%RDF	12.05±0.04^{h}	14.07±0.01^{g}	129.58±0.02^{j}	109.09±0.60^{j}
T5-PSB1+PSF1+100%RDF	21.88±0.01^{d}	23.87±0.02^{cd}	293.52±0.04^{e}	275.47±0.42^{e}
T6 PSB1+KSB2+100%RDF	11.20±0.01^{i}	13.22±0.02^{h}	148.73±0.03^{i}	128.42±0.08^{i}
T7-PSB1+KSF2+100%RDF	15.66±0.02^{f}	17.68±0.01^{e}	175.32±0.31^{h}	153.20±0.42^{h}
T8 KSB2+KSF2+100%RDF	21.54±0.02^{e}	23.58±0.01^{d}	255.17±0.02^{f}	234.56±0.08^{f}
T9-KSB2+PSF1+100%RDF	22.96±0.02^{c}	24.34±0.5^{c}	315.59±0.06^{d}	301.23±0.02^{d}
T10-PSF1+KSF2+100%RDF***	25.46±0.02^{a}	27.49±0.01^{a}	388.28±0.17^{a}	358.04±0.48^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	59052.5	3080.66	187725.83	203743.64
S.Ed(±)	0.16	0.69	1.41	1.41
CD at 5%	0.34	1.44	2.92	2.92

Different letters in each column denote significant difference (p>0.005,n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "j, I, k" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* a, b, c, d, e, f, g, h, i, etc.

Table.8 Diameter of curd and ascorbic acid in cauliflower leaf

TREATMENTS	DIAMETER OF CURD (CAULIFLOWER)	DIAMETER OF CURD (CAULIFLOWER)	ASCORBIC ACID LEAF CAULIFLOWER	ASCORBIC ACID LEAF CAULIFLOWER
	First year	second year	First year	second year
T0-CONTROL+100%RDF	11.30±0.20^{f}	12.60±0.20^{g}	58.60±0.20^{k}	54.75±0.03^{j}
T1-PSB1****+100%RDF	16.53±0.35^{a}	16.70±0.20^{b}	61.86±0.15^{j}	73.26±0.02^{g}
T2-PSF1*****+100%RDF	13.70±0.20^{d}	14.66±0.40^{de}	66.70±0.20^{h}	58.08±0.02^{i}
T3-KSB2$^{\#}$+100%RDF	14.50±0.20^{c}	16.50±0.20^{b}	70.40±0.20^{f}	96.36±0.02^{f}
T4-KSF2$^{\#\#}$+100%RDF	14.10±0.20^{cd}	15.30±0.20^{cd}	68.30±0.20^{g}	62.04±0.02^{h}
T5-PSB1+PSF1+100%RDF	13.56±0.30^{d}	14.50±0.20^{e}	73.60±0.20^{e}	102.03±0.02^{e}
T6-PSB1+KSB2+100%RDF	12.70±0.20^{e}	13.60±0.20^{f}	75.50±0.20^{d}	106.92±0.02^{d}
T7-PSB1+KSF2+100%RDF	14.60±0.20^{c}	15.20±0.20^{cd}	62.50±0.20^{i}	52.14±0.02^{k}
T8 KSB2+KSF2+100%RDF	15.60±0.20^{b}	16.50±0.20^{b}	79.60±0.20^{c}	115.50±0.20^{c}
T9-KSB2+PSF1+100%RDF	14.60±0.20^{c}	15.40±0.20^{c}	98.33±0.30^{b}	122.20±0.10^{b}
T10-PSF1+KSF2+100%RDF***	16.80±0.10^{a}	17.40±0.20^{a}	108.53±0.25^{a}	134.64±0.02^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	154.54	120.03	16003.88	542220.0
S.Ed(±)	0.85	0.86	0.82	0.26
CD at 5%	1.76	1.78	1.69	0.53

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "f, g, k, j" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bcd, def, gh, fg etc.

Table.9 Protein content in leaf and carbohydrate in fruit (cauliflower)

TREATMENTS	PROTEIN LEAF (CAULIFLOWER)	PROTEIN LEAF (CAULIFLOWER)	CARBOHYDRATE FRUIT CAULIFLOWER	CARBOHYDRATE FRUIT CAULIFLOWER
	First year	second year	First year	second year
T0-CONTROL+100%RDF	0.16 ± 0.02^{g}	0.17 ± 0.02^{h}	0.07 ± 0.02^{f}	0.10 ± 0.05^{f}
T1-PSB1****+100%RDF	0.31 ± 0.015^{cd}	0.34 ± 0.02^{bcd}	0.15 ± 0.02^{cde}	0.17 ± 0.02^{cde}
T2-PSF1*****+100%RDF	0.35 ± 0.02^{bc}	0.36 ± 0.02^{bc}	0.19 ± 0.015^{abc}	0.22 ± 0.02^{abc}
T3-KSB2$^{\#}$+100%RDF	0.32 ± 0.02^{bcd}	0.35 ± 0.02^{bc}	0.19 ± 0.02^{abc}	0.20 ± 0.02^{abcd}
T4-KSF2$^{\#\#}$+100%RDF	0.17 ± 0.02^{g}	0.21 ± 0.02^{gh}	0.13 ± 0.02^{de}	0.14 ± 0.02^{ef}
T5-PSB1+PSF1+100%RDF	0.28 ± 0.02^{de}	0.32 ± 0.02^{cde}	0.18 ± 0.02^{bcd}	0.18 ± 0.02^{bcde}
T6-PSB1+KSB2+100%RDF	0.21 ± 0.02^{fg}	0.25 ± 0.02^{fg}	0.15 ± 0.02^{cde}	0.13 ± 0.02^{ef}
T7-PSB1+KSF2+100%RDF	0.24 ± 0.01^{ef}	0.28 ± 0.02^{ef}	0.12 ± 0.02^{ef}	0.15 ± 0.02^{def}
T8 KSB2+KSF2+100%RDF	0.37 ± 0.02^{b}	0.39 ± 0.02^{b}	0.23 ± 0.02^{ab}	0.23 ± 0.02^{ab}
T9-KSB2+PSF1+100%RDF	0.26 ± 0.02^{ef}	0.29 ± 0.02^{def}	0.17 ± 0.02^{cde}	0.17 ± 0.02^{cde}
T10-PSF1+KSF2+100%RDF***	0.49 ± 0.01^{a}	0.52 ± 0.02^{a}	0.23 ± 0.015^{a}	0.24 ± 0.01^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	84.09	67.24	19.28	17.00
S.Ed(±)	0.068	0.073	0.073	0.068
CD at 5%	0.14	0.15	0.15	0.14

Different letters in each column denote significant difference ($p>0.005$,n=3) according to a tukey's HSD test. Each letter shows relative degree of significance(a=most significant whereas "i" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, abcd, bcd, cde, def, de, bc, cd, ef, fg, a, b, etc.

Table.10 Protein content and ascorbic acid in fruit (cauliflower)

TREATMENTS	PROTEIN FRUIT (CAULIFLOWER)	PROTEIN FRUIT (CAULIFLOWER)	ASCORBIC ACID FRUIT CAULIFLOWER	ASCORBIC ACID FRUIT CAULIFLOWER
	First year	second year	First year	second year
T0-CONTROL+100%RDF	0.55±0.02^{f}	0.55±0.02^{f}	60.50±0.20^{i}	54.13±2.0^{f}
T1-PSB1****+100%RDF	0.71±0.02^{c}	0.72±0.02^{c}	73.40±0.20^{e}	71.48±2.01^{cd}
T2-PSF1*****+100%RDF	0.78±0.01^{b}	0.78±0.01^{b}	71.50±0.20^{g}	67.13±2.0^{de}
T3-KSB2$^{\#}$+100%RDF	0.76±0.02^{b}	0.76±0.02^{bc}	71.56±0.25^{g}	68.64±2.0^{cde}
T4-KSF2$^{\#\#}$+100%RDF	0.58±0.01^{ef}	0.58±0.01^{ef}	77.10±0.10^{c}	78.95±2.0^{b}
T5-PSB1+PSF1+100%RDF	0.67±0.005^{cd}	0.67±0.00^{d}	69.20±0.20^{h}	64.49±2.0^{e}
T6-PSB1+KSB2+100%RDF	0.61±0.015^{e}	0.61±0.01^{e}	72.60±0.30^{f}	70.35±2.0^{cde}
T7-PSB1+KSF2+100%RDF	0.67±0.01^{d}	0.67±0.01^{d}	72.73±0.15^{f}	69.31±2.0^{cde}
T8 KSB2+KSF2+100%RDF	0.80±0.01^{b}	0.80±0.01^{b}	75.50±0.20^{d}	74.59±2.45^{bc}
T9-KSB2+PSF1+100%RDF	0.67±0.01^{d}	0.67±0.01^{d}	79.60±0.20^{b}	80.52±2.0^{b}
T10-PSF1+KSF2+100%RDF***	0.90±0.02^{a}	0.90±0.02^{a}	82.70±0.20^{a}	87.69±2.0^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	147.14	149.36	2369.24	56.80
S.Ed(±)	0.051	0.056	0.85	7.84
CD at 5%	0.11	0.12	1.75	16.22

Different letters in each column denote significant difference (p>0.005,n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "f, i" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bcd, cd, de, cde, def, gh,fg etc.

Table.11 Chlorophyll and carbohydrate in leaf of cauliflower

TREATMENTS	CHLOROPHYLL LEAF (CAULIFLOWER)	CHLOROPHYLL LEAF (CAULIFLOWER)	CARBOHYDRATE LEAF CAULIFLOWER	CARBOHYDRATE LEAF CAULIFLOWER
	First year	second year	First year	second year
T0-CONTROL+100%RDF	36.70±0.20^{h}	37.76±0.15^{i}	0.09±0.01^{d}	0.14±0.02^{f}
T1-PSB1****+100%RDF	42.50±0.20^{f}	42.20±0.20^{fg}	0.26±0.02^{ab}	0.23±0.02^{bc}
T2-PSF1*****+100%RDF	43.50±0.20^{e}	42.63±0.20^{f}	0.25±0.02^{ab}	0.23±0.02^{bc}
T3-KSB2$^{\#}$+100%RDF	41.33±0.15^{g}	41.70±0.20^{g}	0.22±0.02^{bc}	0.21±0.02^{bcd}
T4-KSF2$^{\#\#}$+100%RDF	40.80±0.10^{g}	40.60±0.20^{h}	0.11±0.02^{d}	0.16±0.02^{def}
T5-PSB1+PSF1+100%RDF	44.26±0.11^{d}	43.70±0.20^{e}	0.16±0.02^{cd}	0.22±0.015^{bc}
T6-PSB1+KSB2+100%RDF	44.50±0.20^{d}	45.60±0.20^{d}	0.15±0.02^{cd}	0.15±0.02^{ef}
T7-PSB1+KSF2+100%RDF	45.16±0.15^{c}	46.70±0.20^{c}	0.15±0.02^{cd}	0.18±0.01^{cdef}
T8-KSB2+KSF2+100%RDF	44.76±0.15^{cd}	45.40±0.20^{d}	0.26±0.02^{ab}	0.26±0.01^{ab}
T9-KSB2+PSF1+100%RDF	46.50±0.20^{b}	47.70±0.20^{b}	0.14±0.02^{d}	0.20±0.02^{cde}
T10-PSF1+KSF2+100%RDF***	49.40±0.30^{a}	50.70±0.20^{a}	0.32±0.06^{a}	0.30±0.02^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	937.7	969.67	22.46	21.49
S.Ed(±)	0.51	0.77	0.082	0.068
CD at 5%	1.06	1.59	0.17	0.14

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas " h, I, d, f " is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bc, bcd, def, ef, cdef, fg etc.

Table.12 Leaf area and dry weight of cauliflower

TREATMENTS	LEAF AREA (CAULIFLOWER)	LEAF AREA (CAULIFLOWER)	DRY WEIGHT CAULIFLOWER	DRY WEIGHT CAULIFLOWER
	First year	second year	First year	second year
T0-CONTROL+100%RDF	43.76±0.15^{h}	42.60±0.20^{k}	19.70±0.20^{j}	20.50±0.20^{h}
T1-PSB1****+100%RDF	52.40±0.20^{e}	51.40±0.20^{h}	22.70±0.20^{g}	23.13±0.15^{g}
T2-PSF1*****+100%RDF	53.70±0.20^{d}	54.50±0.20^{g}	28.60±0.20^{e}	28.40±0.20^{e}
T3-KSB2$^{\#}$+100%RDF	49.30±0.20^{f}	48.06±0.15^{i}	32.40±0.20^{d}	34.20±0.20^{d}
T4-KSF2$^{\#\#}$+100%RDF	48.50±0.20^{g}	46.70±0.20^{j}	20.56±0.11^{i}	20.70±0.20^{h}
T5-PSB1+PSF1+100%RDF	69.50±0.20^{a}	67.40±0.20^{b}	21.70±0.20^{h}	22.60±0.20^{g}
T6-PSB1+KSB2+100%RDF	68.53±0.25^{b}	62.70±0.20^{d}	24.57±0.25^{f}	25.26±0.25^{f}
T7-PSB1+KSF2+100%RDF	69.30±0.20^{a}	64.70±0.20^{c}	24.50±0.40^{f}	25.70±0.20^{f}
T8 KSB2+KSF2+100%RDF	58.60±0.20^{c}	58.70±0.20^{e}	35.36±0.30^{c}	36.40±0.20^{c}
T9-KSB2+PSF1+100%RDF	58.20±0.20^{c}	57.70±0.20^{f}	36.63±0.23^{b}	38.70±0.20^{b}
T10-PSF1+KSF2+100%RDF***	69.70±0.20^{a}	71.76±0.15^{a}	42.66±0.05^{a}	44.10±0.20^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	6837.24	6915.28	3259.22	4769.44
S.Ed(±)	0.77	0.73	0.88	0.77
CD at 5%	1.59	1.52	1.83	1.59

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "h, j k" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* a,b,c,d,e,f, g etc.

Table.13 Root length and fresh weight of cauliflower

TREATMENTS	ROOT LENGTH (CAULIFLOWER)	ROOT LENGTH (CAULIFLOWER)	FRESH WEIGHT CAULIFLOWER	FRESH WEIGHT CAULIFLOWER
	First year	second year	First year	second year
T0-CONTROL+100%RDF	9.70±0.10^{i}	12.23±0.15^{i}	146.93±1.11^{i}	254.37±1.86^{h}
T1-PSB1****+100%RDF	16.40±0.10^{d}	19.40±0.20^{d}	225.20±1.15^{c}	334.50±1.87^{b}
T2-PSF1*****+100%RDF	14.30±0.10^{f}	17.20±0.20^{f}	247.70±1.51^{b}	286.63±2.11^{e}
T3-KSB2$^{\#}$+100%RDF	14.13±0.15^{fg}	16.60±0.20^{g}	188.53±0.32^{f}	307.20±1.81^{d}
T4-KSF2$^{\#\#}$+100%RDF	11.63±0.15^{h}	14.60±0.20^{h}	153.20±0.20^{h}	267.60±1.81^{g}
T5-PSB1+PSF1+100%RDF	13.80±0.10^{g}	16.30±0.20^{g}	167.46±0.50^{g}	274.50±1.65^{f}
T6-PSB1+KSB2+100%RDF	15.86±0.15^{e}	19.50±0.20^{d}	151.60±1.08^{h}	287.50±2.20^{e}
T7-PSB1+KSF2+100%RDF	19.66±0.20^{c}	20.20±0.20^{c}	169.33±0.73^{g}	287.43±2.27^{e}
T8 KSB2+KSF2+100%RDF	14.23±0.15^{f}	18.70±0.20^{e}	192.20±0.90^{e}	325.10±1.95^{c}
T9-KSB2+PSF1+100%RDF	22.33±0.20^{b}	23.60±0.20^{b}	211.50±0.10^{d}	283.50±2.07^{e}
T10-PSF1+KSF2+100%RDF***	27.40±0.10^{a}	33.70±0.20^{a}	250.53±0.15^{a}	363.27±0.99^{a}
F-test	S	S	S	S
F-Tab	2.07	2.07	2.07	2.07
F-cal	3668.66	2492.86	6045.65	859.30
S.Ed(±)	0.55	0.75	3.22	7.28
CD at 5%	1.15	1.56	6.67	15.06

Different letters in each column denote significant difference (p>0.005, n=3) according to a tukey's HSD test. Each letter shows relative degree of significance (a=most significant whereas "i" is least significant and more than one alphabet signifies negligible difference among treatment compared *i.e.* ab, bcd, def, gh, fg etc.

Biofertilizer saved soil microorganisms; increased nutrient mobilization from non available form to available form, improved physic-chemical properties of soil inhibited the growth of pathogenic organisms and made plant healthy, resulting in increasing yield attribute. It has been reported that the bacterial strain of *Bacillus* were capable of producing IAA, cytokinine, N_2-fixiting and phosphate solubilising capacity. It is known that PGPR can promote plant growth by producing ACC deaminase, which reduces ethylene levels in the roots of developing plants, and by producing plant growth regulators such as indole acetic acid (IAA), gibberellic acid, and cytokinines which can stimulate plant cell elongation, cell division etc. (Cakmakci *et al*., 2001; Patten and Glick, 2002; Bashan and Bashan, 2005; Karlidağ *et al*., 2007; Bi *et al*., 2008; Pırlak and Kose, 2009). These strains might be used in sustainable and organic agriculture to increase transplant growth and content. The results obtained from the investigation indicated that curd yield, curd quality and growth parameters of cauliflower recorded at 120 kg N ha^{-1} were almost similar to those recorded at 60 kg N ha^{-1} and 2 kg biofertilizer ha^{-1}.

In conclusion, biofertilizer did not completely replace chemical fertilizers, but reduced the requirements of fertilizers to almost half. Resource poor subsistence farmers who are not in a position to afford full dose of chemical fertilizers may apply half dose of chemical fertilizers by inorganic sources and rest half by biofertilizers without harming on plant and environment. The present study shows that the tested PGPR strains will improve the crop yield. In the future study, bio fertilization could be used as an alternative fertilizer source for transplant performance in different plants. Biofertilizers increase the efficiency of nitrogen fertilizer (at every dose addition of biofertilizer has increased yield), increase the yield and quality of cauliflower and bring more profit to farmers. Therefore, farmers in resource poor condition can effectively utilize the biofertilizers to get more yield and income with limited use of nitrogenous fertilizer and further research is needed to investigate the long term effect of biofertilizer sustainable soil fertility management and crop production.

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How to cite this article:

Supriya Kumari, Vijay Rajwade, Pramod Ramteke, Rubina Lawrence and Harison Masih. 2017. Isolation and Characterization of Potassium and Phosphorus Solubilising Bacteria and Fungus (KSB, PSB, KSF, PSF) and its Effect on Cauliflower. *Int.J.Curr.Microbiol.App.Sci.* 6(4): 987-1006. doi: https://doi.org/10.20546/ijcmas.2017.604.124