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Effect of Integrated use of Bio-fertilizers, Chemical Fertilizers and Farmyard Manure on Soil Health Parameters of Pearl Millet *(Pennisetum glaucum L.)*

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Abstract

Soil fertility level influenced by bio fertilizers, which play an important role in fixing atmospheric nitrogen, solubilizing insoluble form of phosphorous and potash and mobilizes the immobile nutrients in soil. These processes enhance the nutrient status of soil. A pot culture experiment was conducted during the year 2016-17 at Agriculture Research Station, Amravati. In this study, microbial consortium consisting of bio fertilizers viz. nitrogen fixers, P solubilize, K releasing bacteria and nutrients mobilizers were used. There were two microbial consortia (MC1 and MC2) consisting of nitrogen fixers *Azospirillum* and *Azotobacter* were applied alone and with recommended dose of FYM to the soil treated with different doses of chemical fertilizers. The soil health parameters like soil available N, P, K were found to be maximum in the treatments with microbial consortia MC1 along with recommended dose of FYM and 75% recommended dose of chemical fertilizers compared to other treatments. Maximum yield parameters like seed yield and straw yield of Bajra were recorded in the treatments applied with microbial consortia MC1 along with recommended dose of FYM and 75% recommended dose of chemical fertilizers compared to other treatments. This study clearly showed that the increased nutrient status of soil when the bio-fertilizers are applied along with recommended dose of FYM. This experiment shows that possibility of reduced use of chemical fertilizers with application of bio fertilizers.

Keywords: Pearl millet; *Azospirillum*; *Azotobacter*; PSB; KRB; AM-fungi

Introduction

Pearl millet (*Pennisetum glaucum L.*) is widely grown millet and ranks sixth in the world grown [1], especially in drought-prone semi-arid regions of Africa and Southeast Asia [2]. It grows on low fertility soil with annual mean rainfall of 200 mm, compared to maize and sorghum which require more rainfall [3]. It requires fewer nutrients but, could produce appreciable yields with adequate nutrients supply [4,5]. India is the largest producer of pearl millet in terms of production (10.05 m t) with an average productivity of 1156kg/ha [6].

It is cultivated on about 30 m ha in more than 30 countries of five continents. India has the largest area (7 million ha) with 9.25 million tons of production, it ranked third after wheat and rice and is grown in Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Haryana, Tamil Nadu, Andhra Pradesh and Karnataka [7].

In crop production, nutrient management is an important practice to attain higher yields. Now-a-days, farmers are exuberantly using chemical fertilizers and this is considered as one of the main sources of environmental pollution and also destroys soil health. The continuous use of higher levels of chemical fertilizers by the farmers has led to the problem of soil degradation, which is proving detrimental to crop production in our country. In this context, it is necessary to provide conditions for effective use of natural processes, such as bio fertilization, the process of fixing/mobilizing/solubilizing nutrients through microorganisms [8].

Use of organic sources along with chemical fertilizers not only conserves moisture, reduces erosion and also increases the nutrients use efficiency, thereby improving the overall productivity of soil [9]. Integration of inorganic, organic and bio-fertilizers play a vital role in enhancing crop productivity and sustaining soil fertility, this proves great promise for increasing farmer's income. Nitrogen fixers and phosphate solubilizers contribute through biological fixation of nitrogen, solubilization of fixed nutrients and enhanced uptake of plant nutrients [10]. Considering all these benefits of bio fertilizers, this study was taken up in bajra to enhance the yield and to reduce the use of chemical fertilizers.

Material and Methods

The pot experiment was carried out to study the effect of inoculation of efficient biofertilizers consortia (*Azospirillum*+ P solubiliser + K solubiliser + VAM) and (*Azotobacter* + P solubilizer + K solubilizer + VAM) on growth and yield of Pearl millet at. Agricultural Research station, Amaravathi during the year 2016-2017. The biofertilizers used in the two microbial consortia were collected from Agricultural Research station, Amaravathi. These cultures were mixed with recommended dose of FYM and then applied to soil (6 kg pot^{-1}) filled in the pots prior to application of recommended dose of chemical fertilizers and then sowing was taken up. The experiment was laid out in completely randomized design with thirteen treatments and three replications.

Soil pH

pH of the soils was determined by taking (1:2) soil and water suspension. 10 g of soil was weighed in a beaker, 20 ml of distilled water was added and the contents were stirred with glass rod intermittently, the suspension was allowed to stand for half an hour. The pH was measured by using pH meter.

Electrical conductivity

EC of the soils were determined by taking (1:2) soil and water suspension. 20 g of soil was weighed in a beaker, 40 ml of distilled water was added and stir the contents and allow the soil to settle 15 min. Wash the electrodes carefully and immerse them into soil solution. The EC of the soil suspension was measured by using conductivity bridge and expressed in dSm^{-1}.

Organic carbon

Soil organic-carbon was estimated following the method described by Walkley et al. [11]. 1 g of soil was placed in a 500 ml conical flask. 10 ml of 1 N Potassium dichromate ($K_2Cr_2O_7$) solution was pipette into the conical flask. 20 ml of concentrated sulphuric acid was added and the mixture was allowed to stand for 30 min. A blank was also run in the same manner. The contents were then diluted to 200 ml with distilled water. Further 10 ml of 85% Ortho Phosphoric acid and 1ml of Diphenylamine indicator was added to each flask. The solution was titrated with 0.5 N Ferrous sulphate till a turbid blue colour changed to brilliant green. Soil organic carbon was calculated as given below and expressed in per cent.

Available nitrogen (N)

The alkaline potassium permangante method of Subbaiah et al. [12] was followed for the estimation of available N content in soil. 20 g of soil was taken in 800 ml dry Kjeldahl flask and 20 ml of distilled water was added. Then 100 ml of each of 0.32% $KMnO_4$ and 2.5% NaOH solutions were added. The froth formation during boiling was prevented by adding liquid paraffin (1 ml) and bumping by adding a few glass beads. The contents were distilled in Kjeldahl assembly at a steady rate and liberated ammonia was collected in a conical flask (250 ml) containing 20 ml of boric acid solution (with mixed indicator). The pink color of the Boric acid solution turns to green with the absorption of ammonia. 150 ml of distillate collected in about 30 min was titrated with 0.02 N H_2SO_4 till the original shade (Pinkish) was obtained. Blank was performed without soil.

Available phosphorous (P)

Available P in soil was determined by Olsen's method described by Olsen et al. [13]. 2.5 g air dried soil was placed into a 250 ml conical flask and add a pinch of Darco charcoal and 50 ml of Sodium bicarbonate extractant (0.5 M) was added. Then the contents were shaken for 30 minutes and filtered through Whatman No1 filter paper, 5 ml of clear and colorless filtrate was transferred into a 25 ml volumetric flask, 2-3 drops of p-nitrophenol was added, it turns to yellow colour. Then the filtrate was titrated with 5 N H_2SO_4 drop by drop till yellow colour disappears, To this 5 ml of Olsen's extract solution was added then diluted up to 20 ml with distilled water. Then 4 ml of Ascarbic acid was added and volume was made up to 25 ml and shaken well. After 5 min and the intensity of the blue colour developed was measured using 660 nm, blank was run without soil, and standard curve of P was plotted. Available P was expressed in Kg ha^{-1}.

Available potassium (K)

Available potassium content from soil was extracted by using 1 N NH_4OAC. The concentration of potassium in the extract ant was determined by flame photometer.

Results and Discussion

In the present study, different combinations of bio fertilizer, FYM and chemical fertilizers resulted in a highest nutrient status in the soil (Table 1). The available nitrogen, phosphorus and potassium content of the soil were maximum during flowering stage compared to initial and harvesting stage in all the treatments. At flowering, the highest available nitrogen, phosphorus and potassium (163.07 kg h^{-1}, 43.04 kg $h^{-1}$and 299.26 kg h^{-1}) were recorded in the treatment T11 (MC1 + 75% RDF + FYM) and lowest available nitrogen (132.85 kg h^{-1}) in the treatment T6 (MC2 + 50% RDF), lowest available P (25.45 kg h^{-1}) in the treatment T13 (100% RDF) and K (257.72 kg h^{-1}) recorded in the treatment T2 (MC2). At the time of crop harvest, the highest available N, P and K (147.98 kg h^{-1}, 38.09 kg h^{-1} and 288.87 kg h^{-1}) were recorded in the treatment T11 (MC1 + 75% RDF + FYM) and lowest available N (100.35kg ha-1) in the treatment T2 (MC2) and lowest P and K (21.67 kg h^{-1} and 245.53 kg h^{-1}) recorded in the treatment T13 (100% RDF).

Treatments	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})
T1 -MC1	133.80	27.28	275.03
T2-MC2	100.35	26.37	250.80
T3 -MC1+ FYM	138.44	29.12	285.41
T4-MC2+FYM	129.44	28.38	271.57
T5 -MC1+50% RDF	122.89	32.23	278.40
T6 -MC2+50% RDF	113.62	29.67	250.80
T7 -MC1+50% RDF +FYM	144.53	32.41	285.41
T8 -MC2+50% RDF +FYM	133.92	37.17	254.26
T9-MC1+75% RDF	135.35	37.91	281.95
T10-MC2+75% RDF	132.86	36.08	264.64
T11-MC1+75% RDF +FYM	147.98	38.09	288.87
T12-MC2+75% RDF +FYM	135.57	36.63	281.95
T13-100% RDF	131.25	21.67	245.53
CD	5.19	2.45	10.23
SE(± m)	1.77	0.84	3.50

Table 1: Influence of bio fertilizers consortium on Available N, P and K in pearl millet rhizospheric soil.

Similar results were observed by Yuvaraj [14] who reported that combined application of inorganic fertilizers and consortia bio fertilizers increased the available nitrogen in soil. The important characteristic of *Azospirillum* and *Azotobacter* is that they excrete ammonia into the rhizosphere in the presence of root exudates. The similar findings were also reported by Narula et al. [15] and Wua et al. [16]. The enhanced availability of nitrogen and phosphorus in the soil was recorded with the inoculation of *Azospirillum* and phosphobacteria [17,18].

Application of biofertilizer with FYM and chemical fertilizer can play an important role in improving P bioavailability. The increase in soil P content might be due to the P-solubilizing potential of the isolates used in biofertilizer. This might attribute to the production of organic acids, chelating Oxo-acids and solubilization of inorganic insoluble phosphates by microorganisms. Similar findings were reported earlier by Molla et al. [19] and Gupta et al. [20].

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The application of consortia of bio fertilizers, FYM and inorganic fertilizers increased the available potassium content in soil. This may be due to the presence of potash releasing bacteria in the biofertilizer consortia applied to the soil which in turn released soluble potassium from potassium-bearing minerals. The mechanism of potassium release from potash bearing minerals is by the production of organic acids, which quickly dissolves rock and chelate silicon ions, this leads to releasing K ions into the soil [21].

The soil organic carbon content of the soil was maximum during flowering stage compared to initial and harvesting stage in all the treatments. The soil organic carbon at flowering was observed to be maximum (0.51%) in the treatment T3 (MC1 + FYM) and least (0.40%) in the treatments T2 (MC2) and T13 (100% RDF). At the time of crop harvest, highest soil organic carbon (0.436%) was recorded in the treatment T3 (MC1 + FYM) and lowest (0.37%) in the treatment T13 (100% RDF). Das et al. [22] reported that manure application with PGPR showed higher organic carbon in soil as compared to the sole application of manures. FYM + PGPR treated soils showed highest organic carbon in the soil.

The pH and EC of the soil was maximum during harvesting stage compared to initial and flowering stage in all the treatments. The highest soil pH (7.96) was recorded in the treatments T13 (100% RDF), T6 (MC2+50% RDF), T10 (MC2+75% RDF) and lowest (7.80) in the treatment T1 (MC1) at flowering. The soil pH at the time of harvest was recorded to be maximum (8.05) in the treatment T13 (100% RDF) and lowest (7.83) in the treatment T3 (MC1 + FYM). At flowering the highest electrical conductivity (0.29 dSm^{-1}) was recorded in the treatment T4 (MC2 + FYM) and lowest (0.20 dSm-1) in the treatment T13 (100% RDF). Highest soil EC (0.34 dSm^{-1}) at the time of harvest was recorded in the treatment T4 (MC2 + FYM) and lowest (0.25 dSm^{-1}) in the treatment T5 (MC1 + 50% RDF) (Table 2).

These results are in accordance to the results of Patel et al. [23] and Lin et al. [24]. They showed that microbe's lower the soil pH by releasing of organic acids might get nullified with the presence or application of chemical fertilizers. Selvakumar et al. [25] reported that application of bio fertilizers with FYM increased the soil EC. This may be due to increased solubility of many nutrients.

Treatments	Organic carbon	pH	EC
T_1 -MC_1	0.38	7.89	0.27
T_2-MC2	0.40	7.96	0.26
T_3 -MC1+ FYM	0.43	7.83	0.30
T_4-MC2+FYM	0.41	7.83	0.34
T_5 -MC1+50% RDF	0.39	8.00	0.25
T_6 -MC2+50% RDF	0.39	7.98	0.31
T_7 -MC1+50% RDF+FYM	0.42	7.89	0.28
T_8 -MC2+50% RDF+FYM	0.41	7.97	0.31
T_9-MC1+75% RDF	0.39	7.94	0.30
T_{10}-MC2+75% RDF	0.38	7.95	0.29
T_{11}-MC1+75% RDF+FYM	0.41	7.91	0.33
T_{12}-MC2+75% RDF+FYM	0.40	7.94	0.29
T_{13}-100% RDF	0.37	8.05	0.32
CD	0.03	0.12	0.03
SE(± m)	0.01	0.04	0.01

Table 2: Influence of bio fertilizers consortium on soil organic carbon, pH and EC.

Conclusion

From the present study it is concluded that integrated application of bio fertilizer consortium along with organic and inorganic fertilizers significantly improved the soil nutrient status of pearl millet rhizosphere. The superior treatment was MC1+75% RDF + FYM.

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