Journal of Advance Research in Pharmacy and Biological Science (ISSN: 2208-2360)

DOI: https://doi.org/10.53555/nnpbs.v2i5.702 **Publication URL: http://nnpub.org/index.php/PBS/article/view/702**

EFFECT OF BENEFICIAL MICROORGANISMS ON COWPEA PRODUCTIVITY AND SOIL HEALTH

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Abstract: -

Soil microorganisms are the most abundant biota in soil, responsible for a number of abilities such as nutrient cycling and organic matter decomposition, maintenance of soil fertility and restoration and plant health and sustainability in ecosystem functioning. Beneficial microbial inoculants such as actinomycetes, diazotrophic bacteria, mycorrhizal helper bacteria (MHB), mycorrhizal fungi, rhizobia etc. are known to promote plant growth. Microorganisms are also antagonistic to plant pests, parasites or diseases. Many of the beneficial microbials are naturally present in soil, although in certain cases, it may be advised to increase their populations and activity either through direct inoculation or by applying agricultural management techniques. In cognizance with the above, an experiment was conducted to evaluate the effect of microbial inoculants on overall productivity of cowpea and soil health. Results revealed that the application of Rhizobium sp. as seed treatment increased the productivity of cowpea (up to 15%) at various stages of plant growth parameters like plant dry weight, no. of fresh leaves and branches, pods, overall leaf moisture and root length as compared to control. Total microbial population numbers, available K and phosphorus (P) in soil were also increased significantly after the soil was treated with this microbial inoculant indicating the role of beneficial microbial in improving the plant nutrient status and soil health.

Keywords: - *Cowpea. Microbial inoculants. Mycorrhizal helper bacteria. Plant nutrient status. Rhizobium sp.*

INTRODUCTION

Soil is as an excellent medium for the normal growth and development of plants as well as microbes (Tilak et al. 2005; Bouizgarne 2013; Sharma et al. 2015). The plant-microbe interaction in soil is either beneficial or harmful. The beneficial plant-microbe interactions are caused by symbiotic or nonsymbiotic bacteria and a highly specialized group of fungi (mycorrhizal fungi). Enhancement in nutrient acquisition pathway, production of plant growth regulators, alterations in physiological and biochemical properties of the host plant and defending the plant roots against soil-borne pathogens are the possible mechanisms usually involved during this beneficial association (Bhattacharyya and Jha 2012). Beneficial microorganisms are known to stimulate the plant growth and enhance their resistance to plant pathogens as well against abiotic stresses. According to Sinha et al. (2014), beneficial microorganisms can keep the soil environment rich in all kinds of micro and macro nutrients *via* nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil. Bacterial genera such as *Azospirillum*, *Bacillus*, *Pseudomonas*, *Rhizobium*, *Serratia*, *Stenotrophomonas* and *Streptomyces* fall under this category. These are known as plant growth promoting rhizobacteria (PGPR). Growth promoting substances are produced in large quantities by these soil microorganisms that influence indirectly on the overall morphology of the plants. Mycorrhizal fungi, on the other hand are known for its symbiotic associations with the roots of many different plants ranging from garden vegetables up to the trees of old growth forests. Approximately 6000 species of Glomeromycotina, Ascomycotina and Basidiomycotina are reported as mycorrhizal (Bonfante 2009). There exits mycorrhizal helper bacteria (MHB) that usually get involved in this mycorrhizal establishment and functioning.

Plant nutrition is essential for optimum crop yield and quality maintenance. The availability of required nutrients, together with the degree of interaction between the nutrients and the soil, play a vital role in crop development. A deficiency in any one of the required nutrient can limit plant growth. Beneficial microbes when applied as seed or soil inoculants, they generally multiply and participate in nutrient cycling and thereby benefit crop productivity (Singh et al. 2011). In general, 60-90% of the total applied fertilizer is lost and the remaining 10- 40% is taken up by the plants. In this regard, microbial inoculants have paramount significance in integrated nutrient management (INM) to sustain agricultural productivity and thereby to adopt a cost-effective and eco-friendly environment (Adesemoye et al. 2009a). Plant growth promoting rhizobacteria (PGPR) or co-inoculants of PGPR and arbuscular mycorrhizal fungi (AMF) can advance the nutrient use efficiency of plants. A synergistic interaction of PGPR and AMF has better suited to 70% fertilizer plus AMF and PGPR for P uptake. Similar trend were also reflected in N uptake on a whole-tissue basis, where, 75%, 80%, or 90% fertilizer plus inoculants were significantly comparable to 100% fertilizer application (Adesemoye et al. 2009b). Application of plant growth promoting rhizobacteria (PGPRs), ecto and endo mycorrhizal fungi, cyanobacteria, plant disease suppressive beneficial bacteria, stress tolerance endophytes and bio-degrading microbes (Singh et al. 2011) and many other useful microorganisms led to advancement in soil physico-chemical properties, improved nutrient uptake, plant growth and tolerance to abiotic and biotic stress (Bharadwaj et al. 2014).

Pulses are important because of their nutritional security, crop diversification and sustainable crop production system; pulses are also the cheapest source of proteins for vegetarians. Cowpea (*Vigna unguiculata* L.) is one of the important annual food crop grown mainly to be used as pulse, vegetable and fodder (Ushamalini et al. 1998). It is usually consumed as food in the form of dried seed. Cowpea is drought-tolerant warm-weather crop well adapted to the drier regions of the tropics, where other food legumes do not perform well. It has ability to fix atmospheric nitrogen through root nodules. Poor soil with more than 85% sand, less than 0.2% organic matter and low level of phosphorus is favourable for the growth of cowpea (Singh 2003). *Rhizobium* has been used as an efficient nitrogen fixer for many years. It plays an important role in increasing crop yield by converting atmospheric nitrogen into usable forms (Sharma *et al*. 2011). Being resistant to different temperature ranges, *Rhizobium* enters the root hairs, multiplies and form nodules (Nehra et al. 2007). *Rhizobium* inoculants are reported to increase the grain yields of bengal gram (Patil et al. 1974), lentil (Rashid *et al*. 2012), pea, alfalfa and sugar beet (Ramachandran et al. 2011), berseem (Hussain et al. 2002), ground nut (Sharma *et al*. 2011) and soybean (Grossman et al. 2011). Khaitov et al. (2016) reported an inoculation effect of chickpea with *Rhizobium* strains that significantly increased shoot, root dry matter, nodule number, shoot length, root length, shoot dry weight, root dry weight, pod number and yield by 17, 12, 52, 43, 36, 64, 28, 55% respectively over control (uninoculated). Significant improvement in soil nutrient status such as total nitrogen, available phosphorus and organic carbon content after microbial inoculation was also observed. In cognizance with the above, a field experiment was conducted in the present investigation to evaluate the effect of beneficial microbial inoculants like *Rhizobium* sp. on overall productivity of cowpea and soil health.

Materials and methods

Field experiments were conducted under terrace land situation of Meghalaya, India. The soil of the experimental field was acidic (pH: 4.7) containing 2.1% organic carbon, 259, 13.8 and 112 kg ha^{-1} of N, P_2O_5 and K_2O respectively. The initial fungal and bacterial population in the soil was $16x10^5$ g^{-1} and $149x10^6$ g^{-1} soil respectively. Treatments comprised of recommended doses of fertilizer (RDF) i.e. 20-6040 kg ha^{-1} of N, P_2O_5 and K_2O and RDF + *Rhizobium* sp. Fertilizers as per the treatment were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP). Cowpea was sown in rows 30 cm apart. Thinning operation was done after germination to maintain inter row spacing of 8 cm between the plants. *Rhizobium* sp. was applied as seed treatment @10 ml/kg of seed. The crop was sown in the month of April and harvested on June in both the years. The yield and yield attributes were recorded after the harvest.

Soil samples were collected after harvest of the crop from the experimental plot (0-30 cm depth) and air dried in the laboratory. Further the samples were sieved through 2 mm sieve, and analyzed for various parameters such as pH, available N, P, and K. Soil pH (1:2.5 soil/water) was measured using a glass electrode. Available N was estimated using the alkaline

$KMnO_4$ distillation method (Subbiah and Asija 1956), available P by the Bray-I method (Bray and Kurtz, 1945), and available K by ammonium acetate extraction followed by emission spectrometry (Jackson 1962).

Bacterial and fungal population in soils (0-30 cm depth) were determined by serial dilution technique on nutrient agar media and rose bengal agar media respectively. In this technique, a soil suspension was prepared by adding 1.0 g soil to 10 ml sterile distilled water (SDW) and vortexed. Each suspension was serially diluted starting from 10^{-1} to 10^{-6}. Briefly, 0.1 ml of 10^{-6} (for bacteria) and 10^{-5} (for fungi) dilution was pipette onto the petriplate containing nutrient agar media and rose bengal agar media respectively and spread with a glass spreader and incubated at 28 °C for fungal and 35 °C for bacterial observation. Each colony that appeared on the plate after incubation was considered as one colony forming unit (cfu) (Waksman 1927; Nazir 2007). The number of cfu formed in the petriplate was multiplied by reciprocal of dilution factor to determine the number of population/gram soil.

Result and discussion

Application of *Rhizobium* sp. in combination with recommended dose of fertilizer significantly influenced the yield attributing components and yield of cowpea. Pod length, pod weight and pod yield were found significantly higher in the treatment RDF + *Rhizobium* sp. compared to recommended dose of fertilizer alone (Fig. 1, Fig. 2 and Fig. 3). Combined application of recommended doses of fertilizer along with *Rhizobium* sp. resulted in higher build-up of N, P_2O_5, and K_2O in the post-harvest soil as compared to recommended dose of fertilizer alone (Fig 4, Fig. 5, Fig. 6).

Soil microbial population (both bacteria and fungi) in post-harvest soil was also found significantly higher in the treatment having RDF + *Rhizobium* sp. as compared to RDF (Fig. 7, Fig. 8). The increase in crop yield and other yield attributes might be due to *Rhizobium* sp. Positive effect of *Rhizobium* sp. on yield of *Phaseolus vulgaris* was reported by Rad et al. (2014). During the experiment, longest pod and the maximum seed/plant and the maximum seed yield were obtained from treatment of seed inoculation with *Rhizobium leguminosarum*.

Similarly, the positive effect of *Rhizobium* sp. on crop growth and yield was also reported by Mfilinge et al. (2014) and Tagore et al. (2013). Application of *Rhizobium* sp. along with recommended doses of fertilizer exerted significant influence on build up available N, P_2O_5 and K_2O. This result was in accordance of result of Fatima et al. (2007). They reported that, soybean seed inoculated with *Rhizobium* sp. increased the yield and improved soil fertility for sustainable agriculture system. Improvement in soil bacterial and fungal population in the treatment having *Rhizobium* along with RDF might be due to adequate supply of nutrient and energy from applied *Rhizobium* sp. Increase in the microbial population numbers in soil after treating the soil with *Rhizobium* sp. was also reported by Trabelsi and Mhamdi (2013).

Conclusion

Hence, it can be concluded that application of beneficial microorganism like *Rhizobium* sp. as seed treatment along with recommended doses of fertilizer is beneficial for realizing the higher productivity of cowpea and improvement in soil health.

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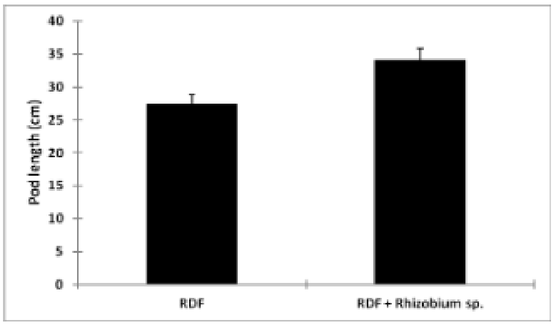

Fig 1: Pod length (cm) cowpea in different treatments

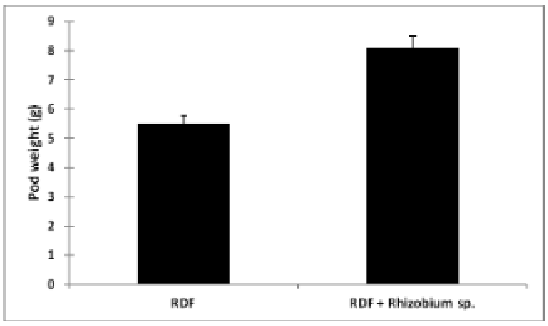

Fig 2: Pod weight (g) cowpea in different treatments

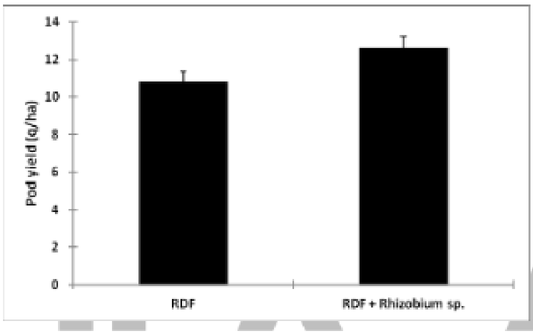

Fig 3: Pod yield (q ha^{-1}) cowpea in different treatments

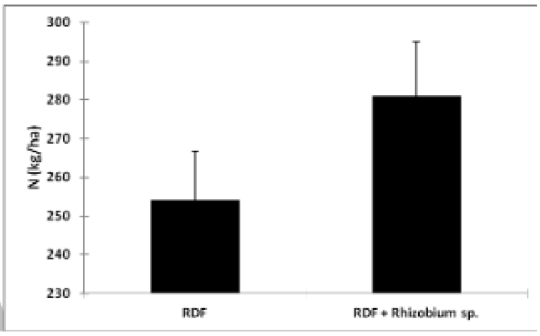

Fig 4: Nitrogen (kg ha^{-1}) content in the post harvest soil

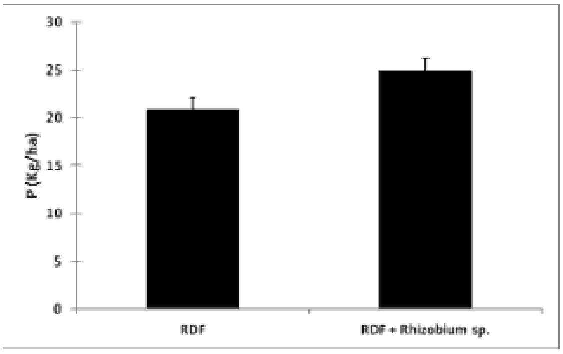

Fig 5: Phosphorus (kg ha^{-1}) content in the post harvest soil

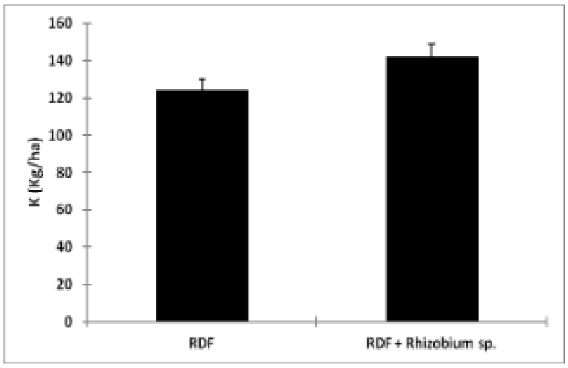

Fig 6: Potassium (kg ha^{-1}) content in the post harvest soil

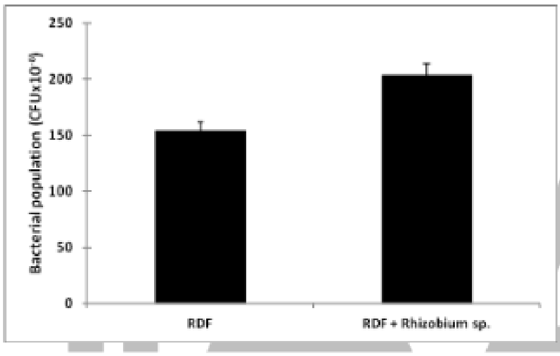

Fig 7: Bacterial population (CFUx10^{-6}) in the post harvest soil

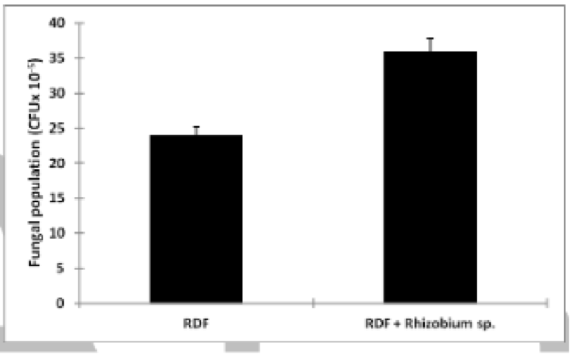

Fig 8: Fungal population (CFUx10^{-5}) in the post harvest soil