Improving plant growth and protect plants from pests and solubilization of rock phosphate is a biological process such as nitrogen fixation and phosphorus. This process converts nutritionally important elements (nitrogen, phosphorus) from unavailable to available form through the interior of the plant and promotes growth by the application of various processes and gives healthy harvest of crops (Abdul Halim, 2009). In Malaysia, industrial scale microbial inoculants are started in the late 1940’s and peaking up in 1970’s taking guide by Brady rhizobium inoculation on legumes. Government research institute, the Malaysian Rubber Board (MRB) had been conducting research on Rhizobium inoculums for leguminous cover crops in the inter rows of young rubber trees in the large plantations. Besides, University Putra Malaysia (UPM) also has conducted many researches since 1980’s on Mycorrhiza and initiated the research to improve plant growth and protect plants from pests and solubilization of rock phosphate (Rokhzadi et al., 2008).

Biofertilizers are the products containing cell of different types of beneficial microorganisms. Thus, biofertilizers can be important components of integrated nutrients management. Organisms that are commonly used as biofertilizers component are nitrogen fixers (N-fixer), solubilizer (K-solubilizer) and phosphorus solubilizer (P-solubilizer), or with the combination of molds or fungi. These potential biological fertilizers would play key role in productivity and sustainability of soil and also protect the environment as eco-friendly and cost effective inputs for the farmers. With using the biological and organic fertilizers, a low input system can be carried out and it can be help achieving sustainability of farms.

Biofertilizers are important components of integrated nutrients management. These potential biological fertilizers would play key role in productivity and sustainability of soil and also protect the environment as eco-friendly and cost effective inputs for the farmers. They are cost effective, ecofriendly and renewable source of plant nutrients to supplement chemical fertilizers in sustainable agricultural system.

Biofertilizers are products containing living cells of different types of microorganisms which when, applied to seed, plant surface or soil, colonize the rhizosphere or the interior of the plant and promotes growth by converting nutritionally important elements (nitrogen, phosphorus) from unavailable to available form through biological process such as nitrogen fixation and solubilization of rock phosphate (Rokhzadi et al., 2008). Beneficial microorganisms in biofertilizers accelerate and improve plant growth and protect plants from pests and diseases (El-yazeid et al., 2007). The role of soil microorganisms in sustainable development of agriculture has been reviewed (Lee and Pankhurst, 1992; Wani et al., 1995).

What is the biofertilizer?

The term biofertilizer or called 'microbial inoculants' can be generally defined as a preparation containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulytic microorganisms used for application of seed, soil or composting areas with the objective of increasing the numbers of such microorganisms and accelerate certain microbial process to augment the extent of the availability of nutrients in a form which can assimilated by plant (NIIR Board, 2004). In large sense, the term may be used to include all organic resources (manure) forplant growth which are rendered in an available form for plant absorption through microorganisms or plant associations or interactions (NIIR Board, 2004).

The knowledge of applied microbial inoculums is long history which passes from generation to generation of farmers. It started with culture of small scale compost production that has evidently proved the ability of biofertilizer. This is recognize when the cultures accelerate the decomposition of organics residues and agricultural by-products through various processes and gives healthy harvest of crops (Abdul Halim, 2009). In Malaysia, industrial scale microbial inoculants are started in the late 1940’s and peaking up in 1970’s taking guide by Brady rhizobium inoculation on legumes. Government research institute, the Malaysian Rubber Board (MRB) had been conducting research on Rhizobium inoculums for leguminous cover crops in the inter rows of young rubber trees in the large plantations. Besides, University Putra Malaysia (UPM) also has conducted many researches since 1980’s on Mycorrhiza and initiated the research to...
evaluate the contribution of nitrogen from *Azospirillum* to oil palm seedlings (Abdul Halim, 2009).

*Mycorrhiza* inoculums are the biofertilizer that is increasingly being utilized and accepted in agriculture industry of Malaysia. Large scale productions of biofertilizer are produced mainly for supplying nutrient, amelioration of toxic effect in soils, root pest and disease control, improved water usage and soil fertility (Abdul Halim, 2009). Since the substrate for inoculate are abundant such as the mine sands and agricultural wastes, the production cost is cheaper and environmentally safe.

There are lot of perception is lay on biofertilizer. It is often perceived to be more expensive than the chemical fertilizers due to the lack of skills and technology to produce biofertilizer products from abundant wastes. Besides, the effect on the crops is slow, compared to chemical fertilizers. Special care such as storage or mixing with powders is also needed to handle microbial inocula to make they remain effective for extended use. As biofertilizers contain living organisms, their performance therefore depends on environment surrounding. Hence, outcomes are bound to be inconsistent (Rahim, 2002). Short shelf life, lack of suitable carrier materials, susceptibility to high temperature, problems in transportation and storage are biofertilizer bottlenecks that still need to be solved in order to obtain effective inoculation.

**BIOFERTILIZER MAKING**

There are several things need to be considered in biofertilizer making such as microbes’ growth profile, types and optimum condition of organism, and formulation of inoculum. The formulation of inocula, method of application and storage of the product are all critical to the success of a biological product. In general, there are 6 major steps in making biofertilizer. These includes choosing active organisms, isolation and selection of target microbes, selection of method and carrier material, selection of propagation method, prototype testing and large scale testing. First of all, active organisms must be decided. For example, we must decide to use whether organic acid bacteria or nitrogen fixer or the combination of some organisms. Then, isolation is made to separate target microbes from their habitation. Usually organism are isolate from plants root or by luring it using decoy such as putting cool rice underground of bamboo plants.

Next, the isolated organisms will be grown on Petri plate, shake flask and then glasshouse to select the best candidates. It is also important to decide form of our biofertilizer product wisely so that the right carrier material can be determined. If it is desired to produce biofertilizer in powder form, then tapioca flour or peat are the right carrier materials. Selection of propagation method is mainly to find out the optimum condition of organism. This can be achieved by obtaining growth profile at different parameter and conditions. After that, prototype (usually in different forms) is made and tested. Lastly, biofertilizer is testing on large scale at different environment to analyze its effectiveness and limitability at different surrounding.

Biofertilizers are usually prepared as carrier-based inoculants containing effective microorganisms. Incorporation of microorganisms in carrier material enables easy-handling, long-term storage and high effectiveness of biofertilizers. Sterilization of carrier material is essential to keep high number of inoculant bacteria on carrier for long storage period. Gamma-irradiation or autoclaving can be used as method for sterilization.

Various types of material can be used as carrier for seed or soil inoculation. The properties of a good carrier material for seed inoculation are inexpensive and available in adequate amounts. It must non-toxic to inoculants bacterial strain and non-toxic to plant itself. Because it acts as carrier for seed inoculation, it should have good moisture absorption capacity and good adhesion to seeds. Last but not the least; carrier should have good pH buffering capacity, easy to process and sterilized by either autoclaving or gamma radiation.

**MOST IMPORTANT MICROORGANISMS USED IN BIOFERTILIZER**

Organisms that are commonly used as biofertilizers component are nitrogen fixers (N-fixer), potassium solubilizer (K-solubilizer) and phosphorus solubilizer (P- solubilizer), or with the combination of molds or fungi. Most of the bacteria included in biofertilizer have close relationship with plant roots. *Rhizobium* has symbiotic interaction with legume roots, and Rhizobacteria inhabit on root surface or in rhizosphere soil.

The phosho-microorganism mainly bacteria and fungi make insoluble phosphorus available to the plants (Gupta, 2004). Several soil bacteria and a few species of fungi possess the ability to bring insoluble phosphate in soil into soluble forms by secreting organic acids (Gupta, 2004). These acids lower the soil pH and bring about the dissolution of bound forms of phosphate.

While *Rhizobium*, Blue Green Algae (BGA) and *Azolla* are crop specific, bio-inoculants like *Azotobacter*, *Azospirillum*, Phosphorus Solubilizing Bacteria (PSB), Vesicular Arbuscular Mycorrhiza (VAM) could be regarded as broad spectrum biofertilizers (Gupta, 2004). VAM is fungi that are found associated with majority of agriculture crops and enhanced accumulation of plant nutrients (Gupta, 2004). It has also been suggested that VAM stimulate plant growth by physiological effects or by reducing the severity of diseases caused by the soil pathogens (Gupta, 2004). Examples of free living nitrogen fixing bacteria are obligate anaerobes (*Clostridium pasteurianum*), obligate aerobes (*Azotobacter*), facultative anaerobes, photosynthetic bacteria (*Rhodobacter*), cyanobacteria and some methanogens. The example of K-solubilizer is *Bacillus mucilaginosus* while for P-solubilizer are *Bacillus megaterium*, *Bacillus circulans*, *Bacillus subtilis* and *Pseudomonas straita*.
Nitrogen

Nitrogen is one of the major important nutrients very essential for crop growth. Atmosphere contains about 80 percent of nitrogen volume in Free State. The major part of the elemental nitrogen that finds its way into the soil is entirely due to its fixation by certain specialized group of microorganisms. Biological Nitrogen Fixation (BNF) is considered to be an important process which determines nitrogen balance in soil ecosystem. Nitrogen inputs through BNF support sustainable environmentally sound agricultural production. The value of nitrogen fixing legumes in improving and higher yield of legumes and other crops can be achieved by the application of biofertilizers (Kannaiyan, 2002).

Biological nitrogen fixation is one way of converting elemental nitrogen into plant usable form (Gothwal et al., 2007). Nitrogen-fixing bacteria (NFB) that function transform inert atmospheric N2 to organic compounds (Bakulin et al., 2007). Nitrogen fixer or N-fixers organism are used in biofertilizer as a living fertilizer composed of microbial inoculants or groups of microorganisms which are able to fix atmospheric nitrogen. They are grouped into free-living bacteria (Azotobacter and Azospirillum) and the blue green algae and symbionts such as Rhizobium, Frankia and Azolla (Gupta, 2004).

The list of N2-fixing bacteria associated with non-legumes includes species of Achromobacter, Alcaligenes, Arthrobacter, Acetobacter, Azomonas, Beijerinckia, Bacillus, Clostridium, Enterobacter, Erwinia, Derxia, Desulfovibrio, Corynebacterium, campylobacter, Herbaspirillum, Klebsiella, Lignobacter, Mycobacterium, Rhodospirillum, Rhodo-pseudomonas, Xanthobacter, Mycobacterium and Methylosinus (Wani, 1990). Although many genera and species of N2-fixing bacteria are isolated from the rhizosphere of various cereals, mainly members of Azotobacter and Azospirillum genera have been widely tested to increase yield of cereals and legumes under field conditions.

Rhizobium inoculation is well known agronomic practice to ensure adequate nitrogen of legumes instead of N-fertilizer (Gupta, 2004). In root nodules the O2 level is regulated by special hemoglobin called leg-hemoglobin. This globin protein is encoded by plant genes but the heme cofactor is made by the symbiotic bacteria. This is only produced when the plant is infected with Rhizobium. The plant root cells convert sugar to organic acids which they supply to the bacteroids. In exchange, the plant will receive amino-acids rather than free ammonia.

Azolla biofertilizer is used for rice cultivation in different countries such as Vietnam, China, Thailand and Philippines. Field trial indicated that rice yields are increased by 0.5-2 t/ha due to Azolla application (Gupta, 2004). Azobacter and Azospirillum can fix atmospheric nitrogen in cereal crops without any symbiosis while blue-green algae have been found to be very effective on the rice and banana plantation (Gupta, 2004). El-Komy (2005) demonstrated the beneficial influence of co-inoculation of Azospirillum lipoferum and Bacillus megaterium for providing balanced nitrogen and phosphorus nutrition of wheat plants. The inoculation with bacterial mixtures provided a more balanced nutrition for the plants and the improvement in root uptake of nitrogen and phosphorus was the major mechanism of interaction between plants and bacteria.

Co-inoculation of some Pseudomonas and Bacillus strains along with effective Rhizobium spp. is shown to stimulate chickpea growth, nodulation and nitrogen fixation. Findings of Mohammedi et al. (2010) showed that the highest sugar, protein, starch contents, nodule weight and seed nitrogen, potassium, phosphorus of chickpea were obtained from combined application of phosphate solubilizing bacteria, Rhizobium and Trichoderma fungus. Shanmugam and Veeraputhran (2000) stated that application of green manure and biofertilizer stimulated the growth of plants with more number of tillers and broader leaves in rice that could be the possible reason for the increased leaf area. Application of biofertilizer increased the number of leaves in betelvine and this could be due to properly colonized roots, increased mineral and water uptake from the soil and biological nitrogen fixation (Okon, 1984). It could be also attributed to the production of the IAA, gibberellins and cytokinins like substances produced by the bacterium as evident from the findings in banana by Jeeva (1987).

Phosphorus

The fixed phosphorus in the soil can be solubilized by phosphate solubilizing bacteria (PSB), which have the capacity to convert inorganic unavailable phosphorus form to soluble forms HPO4^-2 and H2PO4^- through the process of organic acid production, chelation and ion exchange reactions and make them available to plants. Therefore, the use of PSB in agricultural practice would not only offset the high cost of manufacturing phosphate fertilizers but would also mobilize insoluble in the fertilizers and soils to which they are applied (Chang and Yang, 2009; Banerjee et al., 2010). Evidence of naturally occurring rhizospheric phosphorus solubilizing microorganism (PSM) dates back to 1903 (Khan et al., 2007). Bacteria are more effective in phosphorus solubilization than fungi (Alam et al., 2002). Among the whole microbial population in soil, phosphate solubilizing bacteria (PSB) constitute 1 to 50%, while phosphorus solubilizing fungi (PSF) are only 0.1 to 0.5% in P solubilization potential (Chen et al., 2006). Number of PSB among total PSM in north Iranian soil was around 88% (Fallah, 2006). Microorganisms involved in phosphorus acquisition include mycorrhizal fungi and PSMs (Fankem et al., 2006). Among the soil bacterial communities, ecto-rhizospheric strains from Pseudomonas and Bacilli, and endosymbiotic rhizobia have been described as effective phosphate solubilizers (Igual et al., 2001). Strains from bacterial genera Pseudomonas, Bacillus, Rhizobium and Enterobacter along with Penicillium and Aspergillus fungi are the most powerful P solubilizers (Whitelaw, 2000). Bacillus megaterium, B. circulans, B. subtilis, B. polymyxa, B. sircalmous, Pseudomonas striata, and Enterobacter...
could be referred as the most important strains (Subbarao, 1988; Kucey et al., 1989). A nematofungus Arthrobotrys oligospora also has the ability to solubilize the phosphate rocks (Duponnois et al., 2006).

High proportion of PSM is concentrated in the rhizosphere, and they are metabolically more active than from other sources (Vazquez et al., 2000). Usually, one gram of fertile soil contains 101 to 1010 bacteria, and their live weight may exceed 2,000 kg ha-1. Soil bacteria are in cocci (sphere, 0.5 µm), bacilli (rod, 0.5-0.3 µm) or spiral (1-100 µm) shapes. Bacilli are common in soil, whereas spirilli are very rare in natural environments (Baudoin et al., 2002). The PSB are ubiquitous with variation in forms and population in different soils. Population of PSB depends on different soil properties (physical and chemical properties, organic matter, and P content) and cultural activities (Kim et al., 1998). Larger populations of PSB are found in agricultural and rangeland soils (Yahya and Azawi, 1998). In north of Iran, the PSB count ranged from 0 to 107 cells g-1 soil, with 3.98% population of PSB among total bacteria (Fallah, 2006).

Some bacterial species have mineralization and solubilization potential for organic and inorganic phosphorus, respectively (Hilda and Fraga, 2000; Khiari and Parent, 2005). Phosphorus solubilizing activity is determined by the ability of microbes to release metabolites such as organic acids, which through their hydroxyl and carboxyl groups chelate the cation bound to phosphate, the latter being converted to soluble forms (Sagoe et al., 1998). Phosphate solubilization takes place through various microbial processes / mechanisms including organic acid production and proton extrusion (Surange, 1995; Dutton and Evans, 1996; Nahas, 1996). General sketch of P solubilization in soil is shown in Figure-1. A wide range of microbial P solubilization mechanisms exist in nature and much of the global cycling of insoluble organic and inorganic soil phosphates is attributed to bacteria and fungi (Banik and Dey, 1982). Phosphorus solubilization is carried out by a large number of saprophytic bacteria and fungi acting on sparingly soluble soil phosphates, mainly by chelation-mediated mechanisms (Whitelaw, 2000). Phosphate solubilizing microorganism’s secret organic acids and enzymes that act on insoluble phosphates and convert it into soluble form, thus, proving P to plants (Ponmurugan and Gopi, 2006). Inorganic P is solubilized by the action of organic and inorganic acids secreted by PSB in which hydroxyl and carboxyl groups of acids chelate cations (Al, Fe, Ca) and decrease the pH in basic soils (Kpomblekou and Tabatabai, 1994; Stevenson, 2005). The PSB dissolve the soil P through production of low molecular weight organic acids mainly gluconic and ketogluconic acids (Goldstein, 1995; Deubel et al., 2000), in addition to lowering the pH of rhizosphere. The pH of rhizosphere is lowered through biotical production of proton / bicarbonate release (anion / cation balance) and gaseous (O2/CO2) exchanges. Phosphorus solubilization ability of PSB has direct correlation with pH of the medium.

**Figure-1.** Schematic diagram of soil phosphorus mobilization and immobilization by bacteria.

Release of root exudates such as organic ligands can also alter the concentration of P in the soil solution (Hinsinger, 2001). Organic acids produced by PSB solubilize insoluble phosphates by lowering the pH, chelation of cations and competing with phosphate for adsorption sites in the soil (Nahas, 1996). Inorganic acids e.g. hydrochloric acid can also solubilize phosphate but they are less effective compared to organic acids at the same pH (Kim et al., 1997). In addition, the microorganisms involved in P solubilization as well as can enhance plant growth by enhancing the availability of other trace element such as iron (Fe), zinc (Zn), etc. (Ngoc et al., 2006), synthesize enzymes that can modulated plant hormone level, may limit the available iron via siderophore production and can also kill the pathogen with antibiotic (Akhtar and Siddiqui, 2009).

The PSB solubilize the fixed soil P and applied phosphates resulting in higher crop yields (Gull et al., 2004). Direct application of phosphate rock is often ineffective in the short time period of most annual crops (Goenadi et al., 2000). Acid producing microorganisms are able to enhance the solubilization of phosphatic rock (Gyaneshwar et al., 2002). The PSB strains exhibit inorganic P-solubilizing abilities ranging between 25-42
respectively; with highest value of 0.74 mg P/50 mL from Pseudomonas putida, P. fluorescens Tabriz released 51 and 29 and 62% P, respectively; with highest value of 0.74 mg P/50 mL from FeO₄ (Ghaderi et al., 2008). Pseudomonas striata and Bacillus polymyxa solubilized 156 and 116 mg P L-1, respectively (Rodriguez and Fraga, 1999). Pseudomonas fluorescens solubilized 100 mg P L-1 containing Ca₃(PO₄)₂ or 92 and 51 mg P L-1 containing AlPO₄ and FePO₄, respectively (Henri et al., 2008).

PLANT GROWTH PROMOTING RHIZOBACTERIA

A group of rhizosphere bacteria (rhizobacteria) that exerts a beneficial effect on plant growth is referred to as plant growth promoting rhizobacteria or PGPR (Schroth and Hacock, 1981). PGPR belong to several genera, e.g. Agrobacterium, Alcaligenes, Arthrobacter, Actinoplanes, Azotobacter, Bacillus, Pseudomonas sp., Rhizobium, Bradyrhizobium, Erwinia, Enterobacter, Amorphosporangium, Cellulomonas, Flavobacterium, Streptomyces and Xanthomonas (Weller, 1988).

PGPR increased recently as a result of the numerous studies covering a wider range of plant species and because of the advances made in bacterial taxonomy and the progress in our understanding of the different mechanisms of action of PGPR. In all successful plant-microbe interactions, the competence to colonize plant habitats is important. Single bacterial cells can attach to surfaces and, after cell division and proliferation, form dense aggregates commonly referred to as macro colonies or biofilms. Steps of colonization include attraction, recognition, adherence, invasion (only endophytes and pathogens), colonization and growth, and several strategies to establish interactions (Niharimbere et al., 2011). Plant roots initiate crosstalk with soil microbes by producing signals that are recognized by the microbes, which in turn produce signals that initiate colonization (Berg, 2009). PGPR reach root surfaces by active motility facilitated by flagella and are guided by chemotactic responses. This implies that PGPR competence highly depends either on their abilities to take advantage of a specific environment or on their abilities to adapt to changing conditions or plant species (Niharimbere et al., 2011).

CROP RESPONSES TO INOCULATION

Symbiotic nitrogen fixer and phosphate solubilizing microorganisms play an important role in supplementing nitrogen and phosphorus to the plant, allowing a sustainable use of nitrogen and phosphate fertilizers (Tambekar et al., 2009). Zaddy et al. (1993) studied the promoting of plant growth by inoculation with aggregated and single cell suspensions of A. brasilense. They reported that inoculation of single cell suspensions of Azospirillum (prepared with fructose) significantly increased the root surface area, root and foliage dry weight of the maize seedling as compared to plants inoculated with malate grown Azospirillum or the controls. Fulchieri and Frioni (1994) observed that maize inoculated with Azospirillum had enhanced dry weight of seed by 59 percent and also the yield which was similar to 60 kg urea N ha⁻¹. A significant positive effect on grain yield was obtained due to combined inoculation of Azospirillum and Pseudomonas striata in Zea mays (Prabakaran and Ravi, 1991) and cotton (Radhakrishnan, 1996). Crops inoculated with Azotobacter and Azospirilla reviewed by Wani (1990) indicated that Pearl millet and Sorghum, which are grown as dryland crops showed 11-12% increased yields due to inoculations. Maize, Wheat and Rice which receive better management and inputs than Pearl millet and Sorghum showed 15-20% increased yields due to inoculation.

Several soil bacteria and fungi notably species of Pseudomonas, Bacillus, Penicillium and Aspergillus etc., secret organic acids and lower the pH in their vicinity to bring about solubilization of bound phosphates in soil (Sundara Rao and Sinha, 1963). Saving of 50 percent of recommended level of P₂O₅ is possible in sugarcane by inoculation with phosphor-bacteria as the cane yield and sugar yield of 50 percent P₂O₅ and phosphor-bacteria treatments are on par with 100 percent P₂O₅ application (Kathiresan et al., 1995). Habibi et al. (2011) strongly suggested that using biofertilizers (combined strains) plus half a dose of organic and chemical fertilizers have resulted in the greatest grain yield and oil yield in medicinal pumpkin. They revealed that 50% of required nitrogen and phosphorus fertilizers could be replaced by bio and organic fertilizers, because bio and organic fertilizers improved the use efficiency of recommended nitrogen and phosphorus fertilizers and reduced the cost of chemical fertilizers, also prevented the environment pollution from extensive application of chemical fertilizers (Figure-2). Beans with R. leguminosarum and P. putida R 105 increased the number of nodules and acetylene reduction activity (ARA) significantly (de Freitas et al., 1993). A significant positive effect on grain yield and ARA in roots of barley was obtained due to combined inoculation of nitrogen fixer’s A. lipoferum, Arthrobacter mysores and the phosphate solubilizing strain Agrobacterium radiobacter by Belimov et al. (1995). Radhakrishnan (1996) reported that inoculation of Azospirillum and phosphor-bacteria resulted in higher root biomass and more bolls in cotton. Findings of Mohammadi (2010) showed that inoculation of biofertilizers (PSB+ Trichoderma fungi) + application of FYM had a great influence on canola growth, height and grain yield in compared to control treatment.

Findings of Mohammadi et al. (2011) showed that application of biofertilizers had a significant effects on nutrient uptake of chickpea (Table-1) combined application of Phosphate solubilizing bacteria and Trichoderma harzianum produced the highest leaf P content (0.33%) and grain P content (279 mg 100 g⁻¹). Ability of Bacillus sp. to produce organic acid such as
gluconic, citric and fumaric acids under P-limiting conditions may increase the solubility of poorly soluble phosphorus. These findings also showed that chickpea inoculated with biofertilizers have significantly higher grain protein content. Maximum protein content (%15.06) was observed in the treatment that received a combined inoculation of PSB and *T. harzianum* (Table-2).

**Table-1.** Effect of soil fertility systems on chlorophyll and nutrient accumulation in chickpea seed.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Chlorophyll (spad reading)</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Manganese</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mg/100g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Biofertilizers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSB (B₁)</td>
<td>43.41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2269&lt;sup&gt;c&lt;/sup&gt;</td>
<td>273.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1201.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>184.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.42&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>Trichoderma</em> (B₂)</td>
<td>43.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2295&lt;sup&gt;c&lt;/sup&gt;</td>
<td>266.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1176.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>183.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.56&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.35&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>PSB + fungi (B₃)</td>
<td>44.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2315&lt;sup&gt;c&lt;/sup&gt;</td>
<td>279.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1232.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>183.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.47&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Control (B₄)</td>
<td>43.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2167&lt;sup&gt;c&lt;/sup&gt;</td>
<td>264.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1199.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>184.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.36&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean values in each column with the same superscript(s) do not differ significantly by DMRT (*P* = 0.05).
### Table-2. Effect of soil fertility systems on grain yield and yield components of chickpea.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (kg ha(^{-1}))</th>
<th>Pod number per plant</th>
<th>Fertile pods per plant</th>
<th>Grain number per pod</th>
<th>100 grain weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofertilizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSB (B(_1))</td>
<td>1756.1(^{c})</td>
<td>39.72(^{b})</td>
<td>25.84(^{c})</td>
<td>1.083(^{b})</td>
<td>20.79(^{a})</td>
</tr>
<tr>
<td><em>Trichoderma</em> fungi (B(_2))</td>
<td>1866.2(^{b})</td>
<td>40.79(^{b})</td>
<td>27.41(^{b})</td>
<td>1.072(^{b})</td>
<td>21.15(^{a})</td>
</tr>
<tr>
<td>PSB + fungi (B(_3))</td>
<td>2560.3(^{b})</td>
<td>57.66(^{a})</td>
<td>35.07(^{a})</td>
<td>1.144(^{a})</td>
<td>21.19(^{a})</td>
</tr>
<tr>
<td>Control (B(_4))</td>
<td>1310.7(^{d})</td>
<td>30.83(^{c})</td>
<td>20.73(^{d})</td>
<td>1.028(^{c})</td>
<td>19.52(^{b})</td>
</tr>
</tbody>
</table>

Mean values in each column with the same superscript(s) do not differ significantly by DMRT (P = 0.05).

### CONCLUSIONS

Biofertilizer help in increasing crop productivity by way of increased BNF, increased availability or uptake of nutrients through solubilization or increased absorption stimulation of plant growth through hormonal action or antibiosis, or by decomposition of organic residues. Furthermore, biofertilizer as to replace part of the use of chemical fertilizers reduces amount and cost of chemical fertilizers and thus prevents the environment pollution from extensive application of chemical fertilizers. With using the biological and organic fertilizers, a low input system can be carried out, and it can be helped achieving sustainability of farms.

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