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# Role Of Biofertilizers In Maintaining Nutritional Status Of Soil In Sonbhadra And Mirzapur Districts Of Eastern Uttar Pradesh, India

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**ABSTRACT:** *In recent years, agricultural growth in India has accelerated remarkably, but most of this growth has been driven by increased yield per unit area rather than by expansion of the cultivated area. Looking towards 2030, to meet the demand for food grain and to feed a growing population on the available arable land, it is suggested that annual crop production should be increased to around 580 Mt and that yield should increase by at least 2% annually. Crop production will become more difficult with climate change, resource scarcity (e.g. land, water, energy, and nutrients) and environmental degradation (e.g. declining soil quality, increased greenhouse gas emissions, and surface water eutrophication). To pursue the fastest and most practical route to improved yield, the near-term strategy is application and extension of existing agricultural technologies. This would lead to substantial improvement in crop and soil management practices, which are currently suboptimal. First, the disciplines of soil management and agronomy need to be given increased emphasis in research and teaching, as part of a grand food security challenge. Second, continued genetic improvement in crop varieties will be vital. However, our view is that the biggest gains from improved technology will come most immediately from combinations of improved crops and improved agronomical practices. The paper provides a perspective on biofertilizers that how it can help the farmers to provide good and sufficient amount of grains to the people.*
***Key words:*** *climate change, crop production, soil management, greenhouse gas*

## I. INTRODUCTION

The physical and chemical parameters of our ecosystem are directly or indirectly controlled by the geological setup of the region, which in turn affects landscape development, to a greater extent. The chemical parameters, most importantly the soil and water are affected by the bed rock lithology because the geologic materials and processes control the availability of nutrients to the life systems. Geological setup of the region importantly controls the potential for the occurrence of mineral deposits thereby, increasing the prospects of socio-economic development of a particular region. The development and exploitation of mineral resources is not only helpful in creating high-paying jobs and tax revenues in the local area, but in providing secondary jobs and contributing to regional and national economic growth. The socio-economic status of Mirzapur and Sonbhadra districts of eastern Uttar Pradesh nave been taken into consideration in relation to their geological setting, natural and mineral resources of the region *(*Bajarangi, 1995).

### 1. Physiography and Climate:

*Mirzapur District* is located between 25.8°N to 25.15°N latitude and 82.34°E to 82.58°E longitude, with the geographical area of 4521 sq. Kms and the population of 205,264 (2001 census*).*

*Sonbhadra District* district of Uttar Pradesh, lying between 23.52 & 25.32°N latitude and 82.72 & 83.33°E longitude, towards the extreme southeast of the state is bound by Mirzapur District to the northwest, Chandoli District to the north, Bihar state to the northeast, Jharkhand state to the east, Chhattisgarh state to the south, and Madhya Pradesh state to the west. Sonbhadra has the geographical area of 6788 sq km² and the population of 1,463,468 *(*2001 census*).* Sonbhadra district can be called the power capital of India, as the region has many power (energy) stations at Shaktinagar, Anpara, Obra, Renusagar and Pipri *(*Dwivedi *et.al.*, 1995*).*

## II. TOPOGRAPHY

The southern hilly tracts of eastern Uttar Pradesh, covering Mirzapur and Sonbhadra districts forms a distinct geographical region called Vindhyachal plateau. These two districts comprise mainly of Archaean to Neoproterozoic rocks and Quaternary flood plain/ alluvial deposits. It includes the Kaimur and the Vindhyachal Hills (general elevation 300-650 m) of eastern Uttar Pradesh. *(*Banfield, and Eggleton, 1988*)*. The Vindhyan range comprises a conspicuous geomorphic unit in Central India. The southern part of the range is also a 400-500 m high escarpment nearly straight and facing south overlooking the valley of Son river. The landscape is dotted with hills, mountains, plateaus, waterfalls and rivers. The altitude ranges between 299 and 355 m above mean sea level *(*Kalsotra and Prasad 1980).

1. Climate: The climate is tropical monsoonal, with the year divisible into winter (November-February), summer (April-mid June) and rainy (late June-October) seasons. The mean monthly minimum temperature ranges between 13.4 and 30.7$^{o}$C and the mean monthly maximum between 23.4 and 40.2$^{o}$C. About 9 months of the year are dry and 3 months are moist, the later receiving about 87% of the total annual rainfall (mm) due to the south-west monsoon. The average rainfall varies between 850 and 1300 mm. About 85% of the annual rainfall occurs during the rainy season from the southwest monsoon.
2. Drainage System: The Son River flows through the Sonbhadra district from east to west direction, which forms the main drainage system of the area. It flows parallel to the strike direction of Vindhyan, in the softer rocks of the Lower Vindhyan Group. Its tributary, Rihand River and Bijul River, flows north to south to join the Son at a right angle. Geologically, the Son valley is an extension of Narmada valley. The Son has a steep gradient of 35-55cm/km with quick run off and ephemeral regimes. The river mostly receives all its tributaries only from one side i.e. from the south and Ghaghar River from the north. Ghaghara River, which mostly drains through limestone country and joins Son River at Chopan. The Kanhar river flowing south to north and meets the Son River near Kota at right angle. Similarly Panda River flows south to north and meets Son River at Kon near the state boundary with Bihar (Gorikhan *et.al.* 2000).

Mirzapur District is drained by two major rivers i.e., Ganga and Belan. After its confluence with Yamuna at Allahabad, Ganga drains the Lower Kaimur Sandstones, in east west direction, across the Mirzapur District towards Varanasi. Later it is joined by its north south flowing tributary, Belan River.

## III. SOIL RESOURCES OF SONBHADRA & MIRZAPUR DISTRICTS

Soil, is the building block of civilization and prerequisite for human survival and it governs the nutritional status, thus they decide the socio-economic condition of any region. The texture, structure and nutritional status of a soil depend primarily on the nature of the substrate or parent rock from which it is derived. Therefore the parent rock material plays a very important role in deciding the soil fertility. The formation and development of a soil is a dynamic process influenced by the nutrient content of parent rock, weathering ability of minerals present, their water-holding capacities, past and present climates, vegetation, position in the landscape and time. Sonbhadra and Mirzapur districts in eastern Uttar Pradesh, experience the similar climatic conditions i.e., temperature and rainfall, but the complexity of rock types in Sonbhadra District results in a wide variety of soils. Thus the geology and lithological diversity of Sonbhadra District provide parent/ bedrock are responsible for the development varieties of soils making the soil more fertile as compared to Mirzapur District *(*Prakash, 1975).

The soils developed in the Sonbhadra district are derived from the underlying bedrock consisting of Archaean to Proterozoic sandstones, limestone, phyllites, shale, slate and granite. They are products of erosion, deposition, weathering and leaching over a long period of time. The region represents broadly 3 major soil groups: alfisols, ultisols, and vertisols. The alfisols and ultisols are developed in the northern and central part of Sonbhadra district. Soils of the floodplains and low terraces are formed from recent river alluvium of varying parent material composition brought by the rivers Son (Fig. 3) along with their tributaries (Ghaghar, Rihand, Bijul, Kanhar, Panda). They make very fertile soil at the places along the banks of Son River and its tributaries at Agori, Mitapur, Hardi, Harra, Kota, Kon. Thick piles of sediments brought by River Ghaghar have been dumped at Patwadh and Chopan, where they make alfisols. In the central part of Sonbhadra district the weathering of glauconitic (hydrous potassium iron silicate) sandstone and olive shale provide a natural fertilizer in areas like Salkhan, Patwadh, Gurdah, Semia Tola and many more. Shales from Arangi, Chopan Porcellanite and Bijaigarh and phyllites and slates from Mahakoshal belt, on weathering form clay minerals (hydrous aluminum silicates of magnesium, iron and potassium) with increase the water holding capacity of the soil and thus making it more fertile. The fine texture of soil supports the water-holding capacity and facilitates chemical weathering, which results in release of mineral nutrients (Banfield and Eggleton, 1988*)*. The ultisols type of soils are developed in the southern part of Sonbhadra District, with Dudhi complex granite gneissic parent rock. The chemical weathering of granite gneiss releases important nutrients like potassium, sodium, calcium, aluminium, iron, magnesium and silica, all important for agriculture. These granitic parent rocks have undergone intense weathering under hot and humid climate to the extent that they have developed laterites. Soil production ranges from very high for certain to very low for those forming in shifting sand or an steep rocky slopes *(*Auden, 1933*)*.

The terrain in Mirzapur District is hard rocky and the soils are residual, well-drained entisols and alfisols, derived from recent alluvium and Kaimur sandstones (Dhandraul orthoquartzites), sandy to sandy loam in texture and reddish to reddish brown in colour *(*Singh *et al.* 2002). The entisols are formed in recent alluvium, in the northern part of district along gangetic alluvium. Due to its terrain, low soil fertility and extremely low level of state and central government public investment, Mirzapur has not broken away from its feudal past. The geology has affected the socio-economic structure of the region.

Thus we conclude that the soils derived from the hard compact sandstone in Mirzapur District have low fertility and nutritional value when compared to those in Sonbhadra District. The diverse lithology of the latter is dominated by the parent rocks like shales, phyllites, slates, limestone and granite gneiss, which are highly susceptible to chemical weathering under hot humid climate, make the soil more fertile with higher amounts of nutrients like calcium, magnesium, potassium and sodium *(Ram et al*., 2001).

India is the second largest producer of vegetable crops next to China covering an area of 8.4 m ha with a production of 146.5mt and average productivity of 17.3 t/ha.

### 1. SONBHADRA DISTRICT AGRICULTURE AT A GLANCE

**Table 1: Agriculture and land utilization of Sonbhadra district**

| Sl.No | Particular | Year | Unit | Statistics |
|---|---|---|---|---|
| 1. | Agriculture Land utilization | | | |
| | Total Area | 2010-11 | Hectare | 678800 |
| | Non-Agricultural Land | 2010-11 | Hectare | 467206 |
| | Cultivated Barren Land | 2010-11 | Hectare | 152529 |

**Source: District Industrial Profile of Sonbhadra District, 2011**

Food crops which are produced in Sonbhadra are Paddy, Wheat, Barley, Jowar, Bajara, Maize, Sawa, Kondo, Urd, Moong, Lentil, Gram, Pea, Arhar, Mustard/Toria, Linseed, Sesamum and Potato etc.

### 2. MIRZAPUR DISTRICT AGRICULTURE AT A GLANCE

**Table 2: Agriculture and land utilization of Mirzapur district**

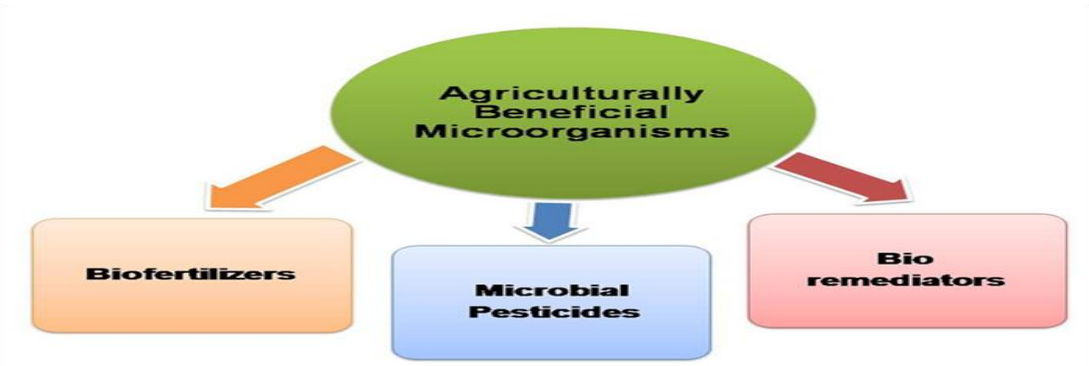
| Sl.No | Particular | Year | Unit | Statistics |
|---|---|---|---|---|
| 1. | Agriculture Land utilization | | | |
| | Total Area | 2010-11 | Hectare | 452212 |
| | Non-Agricultural Land | 2010-11 | Hectare | 8666 |
| | Cultivated Barren Land | 2010-11 | Hectare | 13493 |

**Source: District Industrial Profile of Mirzapur District, 2011**

Food crops which are produced in Mirzapur are Paddy, Wheat, Barley, Jowar, Bajra, Maize, Kodon, Urd, Mung, Lentil, Gram, Pea, Arhar, Mustard/Toria, Linseed, Til, Groundnut, Sunflower, Sugarcane, Potato, Onion, Other vegetables etc.

## IV. ROLE OF BIOFERTILIZERS IN MAINTAINING THE NUTRITIONAL STATUS OF THE SOIL

The sustainability of any soil depends on the biofertilizers or microorganisms, which in term increases agricultural production by means of supply of major nutrients like nitrogen and phosphorous. Bio-fertilizers are selected strains of beneficial soil micro-organisms cultured in the laboratory and packed in a suitable carrier. They can be used either for seed treatment or soil application. They are low cost, renewable sources of plant nutrients which supplement chemical fertilizer *(*Mishra, 2007).




**Source: (Internet) https://www.google.co.in/search**

**Fig. 1: Agriculturally beneficial microorganisms**

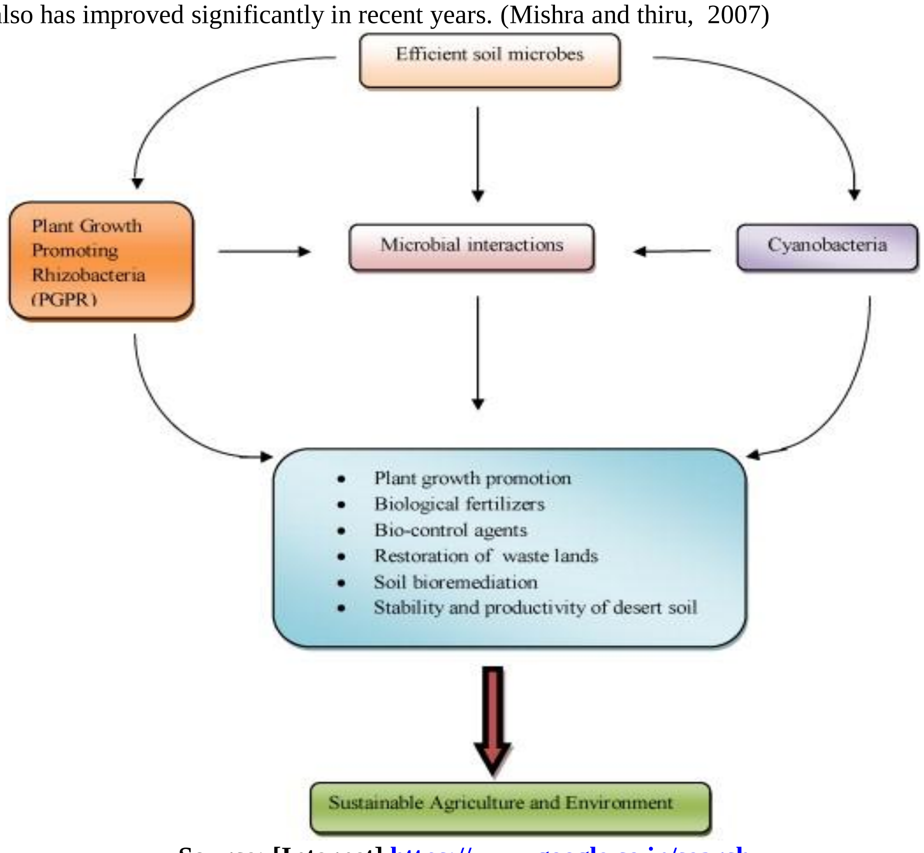
**1. Rhizobium inoculants**

Inoculation is the process of applying commercially available rhizobial bacteria to legume seed or into the soil where legume crops – soybeans, peanuts, alfalfa, peas and lentils – will be planted. Rhizobia are the active ingredient in all legume inoculant products. The presence of rhizobia is necessary for a legume to be able to convert atmospheric nitrogen into a usable form in the absence of readily available nitrogen from fertilizers or manure. This process is referred to as nitrogen fixation and thus can fix 50-100 kg N/ha. Depending on agro-climatic conditions, the variety planted and pest control measures the increase in yields of crops due to inoculation with Rhizobium inoculants varies from 10-70 per cent over uninoculated control (Mazumdar, 1988). Farmers can realize multiple benefits in using nitrogen-fixing rhizobia, including improved crop performance, reduced production costs and reduced greenhouse emissions associated with the production of synthetic nitrogen fertilizers.

Planting inoculated legumes also delivers a significant environmental benefit. The production of synthetic nitrogen fertilizers generates large volumes of carbon emissions. Reducing the need for synthetic nitrogen fertilizers decreases greenhouse gas emissions. And by applying less nitrogen to their fields, growers lower the risk of nitrogen leaching into the groundwater.

A final consideration for keeping legumes in a regular rotation is that these plants tend to decompose rapidly, leaving organic matter in the soil, thus improving its physical, chemical and biological condition (Prakash, 1975).

Through research and selection, today's inoculant technology represents significant advancement, even when compared to only 5 or 10 years ago. As the technology has advanced, inoculants suppliers have consistently increased their ability to deliver significantly higher levels of live, beneficial bacteria to each seed. Ease of use also has improved significantly in recent years. (Mishra and thiru, 2007)




**Source: [Internet] https://www.google.co.in/search**

**Fig. 2: Efficient of microbes**

**2. Response of crops to *Azotobacter* Inoculation**

Seed inoculation of *A. chroococcum* increases the yield of field crops by about 10% and of cereals by about 15-20%. Beneficial effects of *Azotobacter chroomcoccum* inoculation has been obtained for various cereal, vegetables, oil seed, legume and cash crops. Inoculation experiments with *Azotobacter* gave better yield performance only at lower levels of nitrogen (0-30 kg N $ha^{-1}$. Addition of farmyard manure (FYM), compost and other organic amendments to agricultural soils improves the efficiency of *Azotobacter* and hence the plant grown and yield (Prakash, and Dalela, 1982).

**3. *Azospirillum* Inoculants**

Positive effects of *Azospirillum* inoculation on growth and yield of several crop plants, mainly cereals is due to the plant growth promoting substances besides the nitrogen fixing capacity. These inoculants are recommended in non-leguminous crops like jower, bajra, ragi and other millets like Italian millet, kodo, barn yard millet, small millet and oats. Increases in grain and fodder yields of millets due to inoculation are almost equivalent to that attainable with 15-20 kg N/ha (Radhakrishnan, 1987).

**4. Phosphate Solubilizing Bacterial Inoculants**

Inoculation with an efficient P-solubilizing microorganism not only improves the availability of phosphorous from insoluble sources of phosphorus in soil but also enhances use efficiency of phosphatic fertilizers such super phosphate. In general, 25% of super phosphate could be saved by application of rockphosphate and phosphomicroorganisms. These inoculants are recommended for all crops (Ram *et.al.*, 2001).

**5. Arbuscular-Mycorrhizal (Nutrilink) Inoculant**

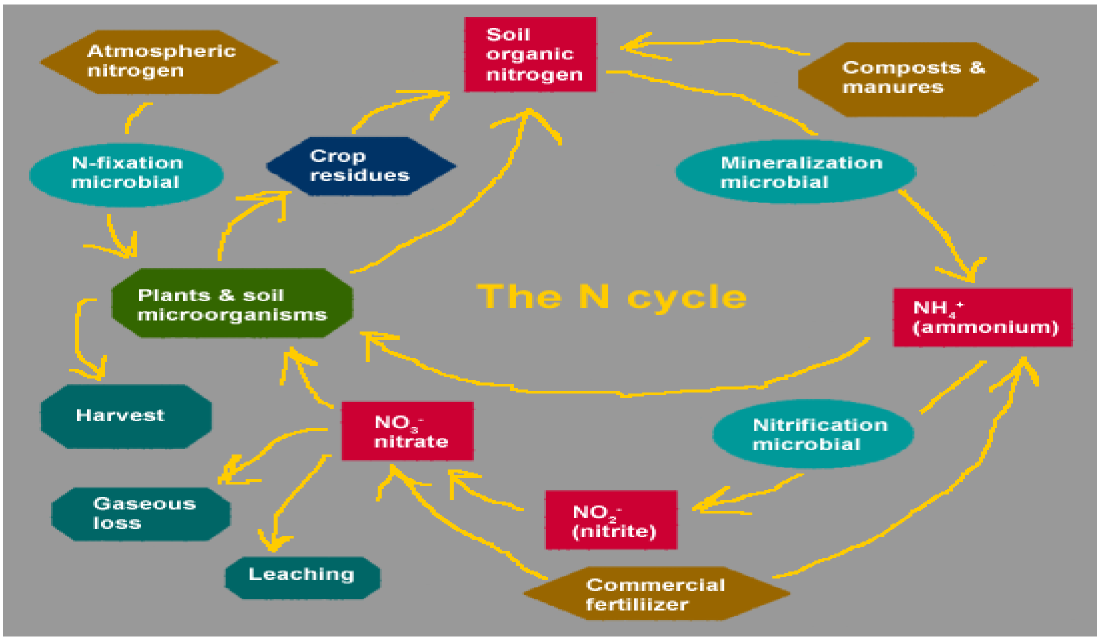
Arbuscular-Mycorrhizae (AM) are symbiotic associations between plant and specific group of fungi. The hyphae of AM form a bridge between plant and soil and serve to meet the requirements of plant nutrients especially phosphorus and trace elements like zinc, iron, copper, cobalt, magnesium, molybdenum etc. it also checks soil erosion, degradation and reduces losses caused by nematodes and plant pathogens (Srivastava and Mehrotra, 1973).

**6. Blue-Green Algal (BGA) Inoculant for Rice**

A mixture of selected cyanobacterial cultures has been identified to develop a clay based formulation. The algae that are generally used for field application are species of *Aulosira, Tolypothrix, Scytonema, Nostoc, Anabaena* and *Plectonema* as a mixture. This has shown to be most effective as compared to soil and wheat straw based inoculants and provides maximum benefit in paddy cultivation in terms of crop yields and soil fertility. Their exceptionally good water holding capacity, their ability to concentrate nutrients such as nitrogen, phosphorus, fixed carbon and trace elements, their soil binding capacity and their ability to scavenge sodium from salt affected soils are additional ecological advantages (Mishra, 2011).

**7. Compost Inoculants for Nutrient enriched compost**

When crop residues are applied directly to the soil for crop production, it creates drastic nutrient imbalance due to higher carbon to nitrogen ratio. This also reduces the availability of other important nutrients required for plant growth. There is also production of substances toxic to the plant during their decomposition. Therefore, a combination of microorganisms is needed which can degrade lingocellulose efficiently. Such microorganisms can be used to develop inexpensive and eco-friendly technology for converting these crop residues to compost for obtaining nutrients for sustainable agriculture (Singh, 2002).




**Source: [Internet] https://www.google.co.in/search**

**Fig.3: Nutrient cycling & composting**

## V. BENEFITS OF COMPOST APPLICATION ON SOIL PHYSICAL AND CHEMICAL PROPERTIES

Effects on physical properties: Improvement in soil structure and aggregation. Low Bulk density. Increase in total water holding capacity. Biofertilizers are compounds of organic matter that are applied to crops for growth and health. Their constituent micro-organisms biologically interact with the soil, root and seed of plants, promoting the growth of micro-flora that enhances soil fertility. As chemical fertilizers cause a deterioration of the soil vitality over time, biofertilizers are attractive alternatives, benefiting harvests and soil alike.

Effects on chemical properties: Improves cation exchange capacity. Buffers Ph change. Slow release supply of organically bound nutrients such as N,P,K & S. enhances chelation, bioavailability of trace elements to plants (Ca, Mg, Fe, Mn, Cu, Zn "& B). Available C, energy source for active microbial population. Humic substances stimulate microbial population, Ammonification, Nitrification, N-fixation (Srivastava and Mehrotra, 1973).

## VI. ROLE OF BIOFERTILIZERS IN SOIL FERTILITY AND AGRICULTURE

1. They supplement chemical fertilizers for meeting the integrated nutrient demand of the crops.
2. They can at best minimize the use of chemical fertilizers not exceeding 40-50 kg N/ha under ideal agronomic and pest-free conditions.
3. Application of Biofertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation
4. Some Biofertilizers *(eg, Rhizobium BGA, Azotobacter* sp) stimulate production of growth promoting substance like vitamin-B complex, Indole acetic acid (IAA) and Gibberellic acids etc.
5. They liberate growth promoting substances and vitamins and help to maintain soil fertility.
6. They act as antagonists and suppress the incidence of soil borne plant pathogens and thus, help in the bio-control of diseases.
7. Nitrogen fixing, phosphate mobilizing and cellulolytic microorganisms in bio-fertilizer enhance the availability of plant nutrients in the soil and thus, sustain the agricultural production and farming system.
8. They improve physical properties of soil, soil tilth and soil health in general.
9. They improve soil fertility and soil productivity.
10. Blue green algae like *Nostoc, Anabaena, and Scytonema* are often employed in the reclamation of alkaline soils (Wang *et.al.* 2009b).

## VII. CONCLUSION

Since a bio-fertilizer is technically living, it can symbiotically associate with plant roots. Involved microorganisms could readily and safely convert complex organic material in simple compounds, so that plants are easily taken up. Microorganism function is in long duration, causing improvement of the soil fertility. It maintains the natural habitat of the soil. It increases crop yield by 20-30%, replaces chemical nitrogen and phosphorus by 25%, and stimulates plant growth. It can also provide protection against drought and some soil-borne diseases. Bio-fertilizers are cost-effective relative to chemical fertilizers. They have lower manufacturing costs, especially regarding nitrogen and phosphorus use. *Azolla* is a small, eukaryotic, aquatic fern having global distribution.Prokaryotic blue green algae *Anabena azolla* resides in its leaves as a symbiont. Azolla is an alternative nitrogen source. This association has gained wide interest because of its potential use as an alternative to chemical fertilizers. Symbiotic nitrogen fixations by Rhizobium with legumes contribute substantially to total nitrogen fixation. *Rhizobium* inoculation is a well-known agronomic practice to ensure adequate nitrogen. The greater use of fertilizers and the introduction of new varieties of crops, especially cereals led to an estimated increase in food production of at least 50% during production period. Although chemical fertilizers may have a temporary, salutary effect on a crop in terms of yield, they also have a long-term destructive effect on the environment supporting the crop. In addition to soil erosion, chemicals can pollute the watershed. This, in turn, will harm livestock, wildlife and public health. Biofertilizers leave no such legacy. In fact, the opposite is true: they strengthen the soil profile, leave water sources untainted and edify plant growth without detrimental side-effects. Biofertilizers are known to play a number of vital roles in increasing the soil fertility, crop productivity and production in agriculture as they are eco friendly although they cannot replace chemical fertilizers that are indispensable for getting maximum crop yields. Intervention of bio-fertilizers would certainly enrich the nutritional status of the soil and lead to sustainable growth in the production of food crops in the districts of Mirzapur and Sonbhadra.

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**Fig. 4: District map of Uttar Pradesh showing Mirzapur and Sonbhadra district.**

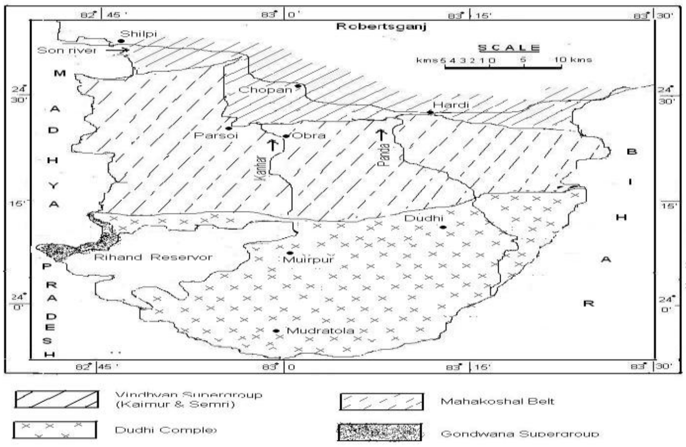


**Fig.5:** Simplified geological map showing distribution of rocks belonging to Dudhi Cmplex, Mahakoshal Belt, Vindhyan Supergroup and Gondwana Supergroup exposed in Sonbhadra district (modified after Mazumdar, 1988).

**Fig.6: Flood plain sediments along Son River at Mitapur near Chopan, Sonbhadra District.**