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Comparative study between Bio-and phosphorus fertilization on growth, yield and fruit quality of Banana (*Musa* spp.) grown on sandy soil

By

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دراسة مقارنه بين التسميد الحيوي والفوسفوري وتأثيره علي نمو ومحصول وجودة ثمار الموز المنزرع في ارض رمليه

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1. INTRODUCTION

Banana (*Musa spp*) is considered to be one of the most important popular and favorite fruits in the world since it has an excellent flavour, with high nutritional value.In Egypt banana is one of the most popular fruit where it's acreage ranks fourth after citrus, grapes and mangoes. The area, grown with banana have enormously increased through the last decade reaching about 54274 feddans with total production of about 855092 metric tons according to the latest statistics of ministry of agriculture in 2006.

Increasing banana productivity under Egyptian condition is one of the main target of many specialists. In this respect, there is a general agreement that several factors affect the productivity of banana plants. One of the important factors which play a vital role in this respect, is fertilization .Thus a great attention is focused on fertilization in order to correct plant nutritional status and enhance vegetative growth of banana plants which in turn will be reflected on increasing yield and improving fruit quality **(Palmer,1979)**.

Banana plants grown in sandy soil need intensive fertilization program. The importance of chemical fertilization to the nutrition of banana could be indicated by the high concentration of nutrient elements found in all plant tissues, thus it is well known that banana needs large amount of fertilizers especially nitrogen and potassium. Moreover, it draws nutrients from a very limited soil depth because of its relatively shallow root system **(Saleh, 1996)**. The high fertilization requirements of banana orchards are accelerated by leaching of many elements particularly nitrogen. The leached nitrogen is compensated by the application of either nitrogen or organic sources. Bananas are known to demane high requirements of N and K. **Lopez-Morales (1994)** recommended 600-675 kg k_2o/ha (K fertilizer)for the best economic responses of banana plants. Beside, in arid and semiarid regions, particularly in sandy soils, the pH level is usually high to the extent that most of macro and micronutriens elements are in unavailable forms. Increasing pHCA (measured with $CaCl_2$) more than 5 caused a marked decrease in available P, Zn, and Mn concentrations to a level that excessive manufactured fertilizers needed for banana plants. These chemical fertilizers are considered as air, soil, and water polluting agents during their production and utilization. The pollution of the soil and water resulted from leached chemical fertilizers into the soil, which transferred through the plants to the human and causes serious diseases. Moreover, using phosphate fertilizers for along-term becomes of concern because the phosphate fertilizers may lead to the accumulation of (Cd) and other heavy metals in the soils as a result of the presence of these metals in the phosphate rocks (PRs) from which phosphate fertilizers are produced **.**

Consequently, it has drown the attention of researchers and banana growers to use the biofertilizers and organic fertilizers which are safe for human and environment. Thus, it's preferred to avoid pollution and reduce the cost of fertilizers. The effectivenss of organic matter to supply the required nutrients to the crops is determined by their chemical composition, and C:N ratios. Also Using microbial solution, including effective

Micro-organisms (EM) has illustrated greater nutrient use efficiencies of crops when such inoculates were added to either organic matter or soil **(Sangakkara and Weeraskera, 1999).**

Effective and Beneficial Microorganisms (EM) are a mixed culture of fermentative, soil-based, beneficial microorganisms which can be applied to many environments to break down organic matter. When applied in agriculture, EM increases the microbial diversity of soil, thus, enhancing growth, yield, quality, and disease-resistance of crops.**.** As toxins are oxidants, the application of EM was expected to reduce this oxidizing property due to Em's antioxidation propreties (**Higa and Wididana, 1991).** EM cultures do not contain any genetically modified microorganisms. EM is made of mixed cultures of microbial species that occur naturally in environments worldwide but which have decreased in many soils due to over-farming, and chemical fertilizer and pesticide use. The principal microorganisms in EM are:

A. Photosynthetic Bacteria: The photosynthetic or phototropic bacteria are a group of independent, self supporting microbes. These bacteria synthesize useful substances from secretions of roots, organic matter and/or harmful gases (eg. hydrogen sulphide), by using sunlight and the heat of soil as sources of energy.

B. Lactic acid bacteria Lactic acid bacteria produce lactic acid from sugars and other carbohydrates, developed by photosynthetic bacteria and yeast.

C. Yeast: Yeasts synthesize antimicrobial and other useful substances required for plant growth from amino acids and sugars secreted by photosynthetic bacteria, organic matter and plant roots. The bioactive substances such as hormones and enzymes produced by yeasts promote active cells and root division. These secretions are also useful substrates for effective microbes such as lactic acid bacteria and actinomycetes.

One of the probable solutions of the problems confronting banana growers is the use of biofertilization as a partial alternative for chemical fertilization. Biofertilizers can be defined as preparations containing life or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms which accelerate certain microbial processes to augyment the extent of the availability of nutrients in a form can be easily assimilated by plants**.**

Biofertilization mainly comprises nitrogen fixers *i.e.Rrhizobium, azotobacter, azospirillum,* azolla or blue green algae, phosphate dissolvers (*vesicular-arbuscular mycorrizae)* and available potassium (*bacillus* and *pseudomonas,* which are termed as silicate bacteria). These organisms may affect their host plants by one or more mechanisms. Nitrogen fixation occurs by grass-bacteria association in tropical soils and production of growth promoting substances or organic acids enhancing nutrient uptake as well as protection against pathogens. The utilization of biofertilizers is considered as a promising alternative, particularly in the developing countries. Biofertilizers encourage low-income farmers to plant the most profitable banana plants through cost reduction of the most expensive horticultural processes. It makes possible the expansion in new reclaimed soils through overcoming drought, salinity, and some pathogen stresses as well as decreasing of applied fertilizers by increasing the availability of most macro and micoelements.

This investigation aimed to evaluate the effect of biofertilizers for 'Grand Naine' banana plants to reduce the environmental pollution resulted from using chemical phosphorus fertiliyzers which leached into the soil and transferred through the plants to the human and causes serious diseases, in addition the hazard effect of chemical accumulation in human and animal health. This investigation encourages the production of clean cultivation which agree with the needs of present and future time, these fruits have a good quality properties to export and save foreign currency for Egypt, therefore the national income would be increased. It makes possible the expansion in new reclaimed soils and planted with banana plants. Moreover, it could be achieved this aim on producing the other fruit crops for the export markets.

Accordingly, the present investigation was planned and conducted to evaluate the different treatments of fertilization either with mineral fertilization or biofertilizer (Effective Micro-orgamisms EM) through studying their effect on some characteristics of vegetative growth measurements, leaf mineral composition, yield, as well as some physical and chemical properties of fruits.

2. REVIEW OF LITREATURE

2.1 Effects of Bio-and phosphorus fertilization on the vegetative growth:

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The vegetative growth of banana as a (Pseudostem height and circumference, number of green leaves /plant, number of total leaves/plant, leaves initiation rate and leaf area)were studied by several authors because it is a very important indicator to yield quality . In this point, **EI-Demerdash. (1988)** stated that the mycorrhizal treatment of both Maghrabi and Hendi banana plants increased number of green leaves, average leaf area, fresh and dry weights of leaves, corms and roots. At the same time, **Jeeva *et al.* (1988)** studied the effect of *Azospirillum* on growth and development of banana cv. Poovan and found that inoculation with *Azospirillum* plus the highest rate of nitrogen (100%) enhanced the height, leaf production and leaf area. Likewise, **Umesh *et al.* (1988)** verified that the length, fresh, and dry weights of roots were increased when banana plants cv. Dwarf Cavendish were inoculated with *Glomus.fasciculatum mycorrhizae.*

At the same time, **Jaizme-Vega *et al.* (1991)** found that inoculation of young plants of *Musa acuminata* with both *Glomus mosseae* and *G. fasciculatum* increased fresh root weight and percentage of radicular infection. Moreover, **Lin (1991)** demonstrated that EM enhanced plant height and improving the growth of paddy rice. Also The application of poultry manure and EM treatments were studied by **Yousaf *et al.* (1993)** who found that the poultry manure and EM treatments produced the highest fresh biomass which were statistically superior to all other treatments.

Alonso-Reyes *et al.* (1995) reported that the plant height of banana inoculated with *Glomus fasciculatum* and phosphate mobilizing bacterium (MOSP *Pseudomonas fluorcscens)* was greatly higher increased than the control. Also, they reported that inocnlation of *in vitro* derived banana plants with vesicular arbuscular mycorrhizae (VAM) at planting time and/or with a phosphate mobilizing bacterinm *(Pseudomonas fluorescens)* at planting or 45 days after planting, which applied as a root dip or a soil spray. Increased plant height of the inoculated plants significantly than that of control. Also, they found that dry weight of mycorrhizal inoculated plants was greater than those treated with phosphate mobilizing bacterium.

Inoculation of seven banana cultivars with VAM fungi *(Glomus mosseae* and *Glomus macrocarpum)* was carried out by **Declerck *et al.* (1995)** who mentioned that five arbuscular mycorrhiza (AM) fungi isolated from the rhizosphere of banana and were successfully cultured *in vitro* is association with genetically transformed roots of carrots. Moreover, they reported that the interaradical forms of the fungi as mycorrhizal root pie and single isolated vesicles constituted were excellent sources of inoculum for establishment of *in vitro* cultures and for the continuous culture of the species. It was concluded that this co-culture system was suitable for the establishment of *in vitro* of AM fungal strains. Likewise, **EI-Demerdash *et al.*(1995)** studied the effect of inoculation of Williams banana plants with *endomycorrhizae* (VAM) fertilized with different sources of phosphorus [superphosphate (SP) and rock phosphate (RP)] with different levels (0, 125,250 and 500 g/plant/year).The results showed that inoculation with *endomycorrhizae* (VAM) and P fertilization induced a significant increment in

vegetative growth (e.g. pseudostem length and number of green leaves/plant), as well as, the dry matter.

Jaizme- Vega and Azcon (1995) stated that, *Glomus fasciculatum* surpassed the other three species of vasicular arbuscular mycorrhizae effectively in improving banana plantlets growth by maximizing plantlets nutrition and enhancing mycorrhization during the first phase of plant development. Moreover, **Dibut-Alvarez *et al.* (1996)** investigated in field trials the potential of *Azotobacter chroococcum* as a nitrogen fixer and biostimulant for banana cvs. 'Giant Cavendish' and Burro CEMSA. Nitrogen was applied at rates equivalent to 50%, 80% and 100% of that required by the crop, with or without *Azotoryza*. They found that the biopreparation elaborated from *A. chroococcum* Bacterial inoculation (20 litres/ha.) stimulated the plant height, number of leaves and shoots and pseudostem diameter after 6 months for 'Giant cavendish' and after 90 days for burro CEMSA .

Application of EM4 was studied by **Wibisono *et al.* (1996)** they showed that applied EM4 to *Citrus medico* var. lemon gave significantly higher of number and length of root, fresh weight and dry weight of root of transplanted plant. The treatment of EM4 and rice straw gave significantly higher plant' number of shoots and number of leaves.

Effect of three arbuscular mycorrhizal (AM) fungi on growth of banana plants cv. Grand Naine was studied by **Jaizme-Vega and Pinochet (1997)**. They found that, inoculation of banana plants with either *Glomus mosseae* or *Glomus aggregatum* encouraged the highest increase of the most growth parameters under study and enhanced plant development compared with non-mycorrhizal plants and plant inoculated with the third AM fungi.

In an experiment carried by **Jaizme-Vega and Pionochet, (1997)** inoculation of micropropagated 'Grand Naine' banana plants with two isolates of *Glomus mosseae* (A and B). They found that, banana plants inoculated with the G. *mosseae-B* isolate showed a temporal growth, advantage over G. *mosseae-A* isolate in the very early stages of development. Also **Noval *et al.* (1997)** recommended that inoculating of *in vitro* produced plantlets of banana cv. 'Parecido al Rey' during acclimatization phase with 2 g/plant of VAM *Glomus mosseae* succeeded for maximizing the leaf number, leaf area, and total dry weight.

At the same time, Early inoculation of micropropagated 'Grand Naine' banana plants with *Glomus intrardices* was highly beneficial for plant growth and more effective than either non-mycorrhizal plants (control) or those fertilized with a nutrient solution high in P. This treatment was more effective in promoting plant development through enhancing plant growth by improving plant nutrition. Also, they stated that inoculation of micropropagated banana plants cv. Grand Naine with VAMF *(Glomus Jntraradices)* and root-knot nematode *(Meloidogyne javanica)* resulted in increasing banana tolerance and compensating the damage caused by nematode, mainly by enhancing plant nutrition **(Pinochet *et al.*, 1997)**.

Ruiz (1997) reported that plantlets of banana clone 'Gran Enano' raised *in vitro* were planted in substrate (50% soil + 25% sand + 25' organic matter) following immersion in the biofertilizer phosphorine or a 5 g solution of *Azotobacter* or inoculation with 1 of 6 mycorrhizal strains alone or in combination with either phosphorine or

azotobacter, the 3 most effective mycorrhizal strains *(Glomus fasciculatum, Acaulospora escrobiculatas and G. mexico)* increased dry weight of the plants by 38- 50% and reduced the hardening period by 15-20 days. Also, he found that inoculation with mycorrhizae treatment with phosphorine or a combination of 6^{th} gave the highest increase in dry weight of the plants. Also, **Chunchun- Kumar *et al.* (1998)** revealed that among the symbiotic nitrogen fixing bacteria, *Azospirillum.* could be used to replace some of the nitrogen fertilizer requirement. Also, they reported that the efficiency of *Azospirillwn* as a bioferti1izer deponed on the soil and climatic factors and crop management.

At the same time; treated banana plants cv. 'Dwarf Cavendish' with RET - FLOPX 357 (a commercial mixture of microorganisms including N- fixing bacteria, humus producing bacteria, moulds and algae) in a liquid suspension resulted in increasing pseudostem circumference **(Fernandez-Falcon *et al.*, 1998) .**

The effect of interaction of Arbuscular Mycorrhizal fungi and the soil pathogen Fusarium Oxysporum F. sp . Cubnse on the first stages of micropropagated 'Grand Naine' banana studied by **Jaizme-Vega *et al.* (1998)** showed that, fresh weights of aerial portions, and entire plants for the control and *FOC*- inoculated treatment were significantly lower than the mycorrhizal and AMF + *FOC* treatments, both of which in turn showed slightly lower fresh weights than either of the AMF treatments. Also, dry weights of aerial parts followed a similar pattern, although some significant differences occurred between the control and FOC-inoculated treatments. Control and FOC-inoculated treatments had the significantly lowest root weights; no differences were found among the other treatments. Also, total plant height and pseudo stem height were significantly larger for all the mycorrhizal treatments than control treatment which was the smallest of all. The pseudo stem diameter of the control and FOC-inoculated treatments were lower than those of the rest of the treatments. The leaf count showed that practically no differences existed between treatments, but foliar surface area measurements showed that the mycorrhizal treated plants (both with and without *FOC)* had significantly higher values than the non-mycorrhizal but *FOC* inoculated plants. Also, they found that both mycorrhizal species of Glomus reduced internal *(rhizome necrosis)* and external disease symptoms.

Smith (1998) mentioned that inoculation of banana plants cv. 'Grand Naine' grown in sterilized or unsterilized soil with NPK + mycorrhizal inoculation + T.E (trace element) resulted in an increase in plant height, leaf area and stem circumference. Also, **Tiwary *et al.* (1998)** studied the effect of inoculation with *Azotobacter* and *Azospirillum* on growth of banana cv. 'Giant' grown with different N rates .They concluded that inoculation of sucker and soil with *Azospirillum* resulted in maximum plant height and leaf size in plants receiving 50 % of the recommended N dose.

The effect of soil application of active dry yeast *(Sacchromyces cervisiae)* on growth of pomegranate trees was studied by **Abo-Taleb *et al*. (1999).** They showd that all applications in general resulted in increasing vegetative growth over the untreated trees (control) for both cultivars in the two studied seasons. In addition, It could be noticed that the higher level of yeast application was more effective than the lower in enlarging the average shoot length, number of leaves per shoot and leaf area. The data also indicated that applying of yeast for three times per year 20

gm/L (2%) per tree are pronounced than the other applications in both seasons. The present results concerning the effect of using yeast application on vegetative growth parameters are in line with those obtained by **Ahmed *et al.* (1997)** on Red Roumy grapevines, **El-Mogy *et al.* (1998)** on Thompson seedless grapevines and **Mansour (1998)**on 'Anna' Apples trees. In this line, **Muller and Leopold. (1966)** demonstrated that, the enhancing effect of yeast preparation might be due to that yeast as a natural source of cytokinins enhanced cell division and cell enlargement so far increasing the extended of leaf surface area as well as enhanced the accumulation of soluble metabolites as maintained about the role of cytokinins. In relation to this subject, **Skoog and Miller (1957)** and **Savenkova (1984)** mentioned that yeast via. its cytokinins content might play a role in initiation and translocation of metabolites from leaves into the reproductive organs (Source-Sink relationship). Also, it might play a role in the synthesis of protein and nucleic acids and minimized their degradations (**Natio *et aI*., 1981** and **Legocka, 1987.).**

The effect of spraying with different yeast concentrations in banana plants was studied by **El-Shammaa (2001)**. He stated that spraying plants with different yeast concentrations induced significant increase in length of pseudostem and leaf area over the control. The increase in their values was positively correlated with the increase in yeast conc. up 2.5 gm/L, where 3 gm./L, failed to dominate in its effect. Moreover, no significant differences were detected between 2.0 and 2.5 gm/L concentrations for both seasons. While, the circumference of pseudostem and number of green leaves at shooting stage was not significantly affected by different treatments. These results are nearly similar to those of **Ahmed *et al.* (1997)** on grapes and **Abo-Taleb *et al.* (1999)** on pomegranate. Concerning bunch shooting percentages, the obtained data for the third and fourth rations (two season) indicated that application of active dry yeast was necessary for the regulation of bunch shooting. The shooting period was generally shorter as yeast concentrations increased up 2.5 gm/l to accelerate shooting percentages in July from 16.8 to 41.3% and 15.7 to 44.0 % for the third and fourth rations, respectively The same trend was generally obtained during August. It was also noticed that, total shooting percentages (July - September) varied between 81.5 - 94.6 % and 80.6 - 94.1 % by increasing yeast application up 2.5 gm/l. Worth while, low concentration (1 gm/l) failed to accelerate shooting, while the highest rate (3.0 gm/L.) delayed shooting with significant values as compared with either 2.0 or 2.5 gm./L. treatments.

The response of banana plants and guava seedlings, individually, to inoculation with free nitrogen fixing bacteria, mycorrhizal V AM and yeast as well as their different combinations on plant height, total number of leaves per plant, the dimensions of the third leaf from the top of banana plants as well as those of the mature guava leaves, plant diameter, roots and leaves fresh and dry weights and internode length. were studied by **(Soliman, 2001)**. The results obtained showed that inoculation with free nitrogen fixing bacteria (H) and its combinations with yeast (S) and mycorrhizal (M) improved the vegetative growth parameters. Whereas, H, H+S and H+M treatments significantly increased the prementioned growth parameters of banana plants and guava seedlings.

Moreover, **Abd El-Moniem *et al.* (2003)** studied the effects of chemical fertilizer and biofertilizer treatments on the pseudostem length, pseudostem circumference, number. of green leaves per plant and leaf area of 'Williams' banana plants during 2000/2001 and 2001/2002 seasons. Data revealed that, increasing the rate of