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The efficiency of bio-fertilization in the growth and yield of Sweet corn (*Zea mays* var. *regosa*)

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Abstract:

The experiment was carried out in order to evaluate the effect of Trichoderma harzianum fungus (T.26) and two isolation of Pseudomonas fluorescens bacteria (Pf.I) and (Pf.n) inoculums and their combinations on the growth and yield of sweet corn plant under field conditions.

Sweet corn sown plot were with drip irrigation, at harvest, plant biomass, yield and N, K, P, Mn and Fe and other agronomic parameters were measured.

The results showed significant superiority of all bio fertilization treatments comparison to control treatment to all character of growth parameters such as contain length stem, number of leaves, the concentration of total chlorophyll, and shoot fresh and dry weight of shoots. Also uptake of N, P, K, Fe and Mn and yield quantity contain and number of ears per plant, number and weight of seeds in ears.

The results also showed the significant superiority of the treatments combination between the Trichoderma harzianum (T.26) treatment and Pseudomonas fluorescence (Pf.I) in all the qualities of *growth, absorption elements and productivity studied comparable with single bio fertilizer treatments and comparison treatment.*

Key words: Sweet corn, Trichoderma, Pseudomonas, Nutrient uptake.

INTRODUCTION

Sweet corn (Zea mays (L.) saccharide Strut) is gradually becoming an important vegetable crop in world (Ortaş and Sari 2003). Since it forms a useful ingredient in the daily consumption, so it requested extensively by food industry. Borin, Lana et al. (2010) reported that sweet corn is a vegetable addressed to industrial processing in many tropical climate, Sweet corn is a heavy feeder requiring high amount of nutrients such as nitrogen, phosphorus and potassium(Ortaş and Sari 2003). Most of the required nutrients are usually applied in the form of inorganic fertilizers (Borin, Lana et al. 2010). Even though many studies have shown that organic manure has a potential to increase soil concentration of nutrients and organic matter Akintoye1 an Olaniyan (2012), Peng et al.(2013) (Borin, Lana et al. 2010, Johnson, Colquhoun et al. 2012). The residual effects of increased nutrients and organic matter in soil following manure or compost application on crop yield and soil properties (Eghball et al., 2004, and Lazcanoet al., 2010).

In general, the rhizosphere harbours an extremely complex microbialcommunity including saprophytes, epiphytes, entophytes, pathogens and beneficial microorganisms (Harman, 2006). In natural systems, these microbial communities tend to live in relative harmony where all populations generally balance each other out in their request for food and space (*Panayotov* et al., 2010).

Beneficial rhizosphere organisms are generally classified into two broad groups based on their primary effects, i.e., their most well-known beneficial effect on the plant: (i) microorganisms with direct effects on plant growth promotion [plant growth promoting microorganisms (PGPM)] and (ii) biological control agents (BCA) that indirectly assist with plant productivity through the control of plant pathogens, In addition to their primary effects on plant productivity and health, respectively, recent work has shown that these beneficial microorganisms possess secondary, i.e., more (Saharan and Nehra.,2011).

Recently discovered effects that may bestow them increased interest for plant growers (Whipps, 2004; Vassilev et al., 2006). More specifically, PGPM have shown activities relating to bio control of soil-borne pathogens. Conversely, BCA have demonstrated properties that directly promote plant growth. It has been focused on case studies of recent and some key earlier examples of the added interests of PGPM and BCA through their secondary beneficial effects.

Among bio-control *Pseudomonas* spp bacteria, have been broadly studied for their ability to reduce the development of various soil borne plant pathogens (Paulitz et al., 1992) In addition to their beneficial effect on the development of plants in the presence of pathogens, *Pseudomonas* spp. were also shown to improve plant growth in absence of pathogens. In this regard, multiple strains of *fluorescent pseudomonas* have the ability to stimulate seed germination as well as shoot and root development of different crops, including chickpea, eggplant, soybean and tomato (Dileep Kumar, 1998).

With regard to *Trichoderma*spp fungal. are probably the most studied for their effects on reducing plant diseases? Their mode of action has been multifaceted including parasitism, competition, antibiosis, and/or induced resistance (Harman et al., 2006), in addition to the effectiveness of *Trichoderma* spp. in controlling plant pathogens.

Many studies have shown the direct benefits of these fungi on plant growth and production. In absence of pathogens, *T.harzianum* applications increased (i)germination of pepper seeds, (ii) emergence of seedlings of bean, radish, tomato, pepper, and cucumber, (iii) seedling length and leaf area in pepper and (iv) dry weight of cucumber plants (Kleifeld and Chet, 1992).Yedidia et al. (2001) revealed that *T. harzianum* increased cucumber plant root area by 95%, root length by 75%, dry weight by 80%, shoot length by 45%, and leaf area by 80% when compared to the control. With regard to the added secondary benefits of *Trichoderma* spp. on plant growth, two main mechanisms of action have been revealed in the past decade: (i) increased plant nutrition through solubilisation and/or enhanced uptake of macro- and micronutrients and (ii) production of plant growth factors. These mechanisms are responsible for the so-called 'bio fertilizer effect' of *Trichoderma*spp. Mazhabe (2010) and Al-Rajhi. (2013) documented the abilities of *T. harzianum* to enhance nitrogen use efficiency in corn but provided no insight into the specific mechanisms involved, In cucumber plants, inoculation with *T. harzianum* caused a significant increase in P, Cu, Fe, Zn, Mn and Na concentration in the plant roots which was accompanied by a 25%, 30% and 70% increase in Zn, P, and Mn, respectively in the shoots (Yedidia et al., 2001). *T. atroviride* has been shown to produce and degrade indole acetic acid (IAA), the most common plant auxin and to possibly possess aminocyclopropane carboxylic acid (ACC) deaminase activity that would control ethylene production (Gravel et al., 2007).

All these factors indicate that Trichoderma fungal and Pseudomonas bacteria inoculums can function to help produce plants of better quality under field conditions. The hypothesis of this work is *T. harzianum* fungal and *P. fluorescens* bacteria inoculation increase sweet corn growth and nutrient uptake. The aim of this study was to test whether single and dual *T.*

harzianum and *P. fluorescens* inoculations can help improve sweet corn nutrient uptake and increase yields under field conditions.

MATERIALS AND METHODS

This study was conducted in the summer of 2013 in the Research Farm of The Ministry of Science and Technology in Al-Madaan town south of Baghdad, Iraq 44″ N longitude ,33″ E latitude and 35 m above mean sea ,the soil is sandy clay loam having 7.1 to 7.4 pH. Some soil chemical and physical properties are given on TABLE 1, Corn seedlings were planted 10 days old on holes, the distance between in the lines was 1m and in between plant row was 30 cm, with drip irrigation. The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications involving 6 treatments which included control (without bio-fertilizer) (T1); *T. harzianiu*m g/seedling(1.7×10^{9})CFU inoculums (T.26) (T2), *P.fluoresces* g/seedling(1.3×10^{8}) Iraqi inoculums (Pf.I) (T3), *P.fluoresces* gm/seedling (1.3×10^{8}) India inoculum (Pf.n) (T4), *T. harzianiu*m inoculums (T.26) + p. *fluoresces* (Pf.I)(T5) *T. harzianiu* inoculums (T.26) + *P. fluroescens* (Pf.n) (T6), addition organic farm yard manure and inorganic fertilizer recommended dose of NPK were applied as per the treatments. Fifty percent of N and full dose of P and K were applied in the furrows as per treatments and thoroughly mixed in soil. The remaining half of the nitrogen was top dressed at 30 days after planting.

The compost and mineral fertilizer NPK added with soil at depth of 30 cm and irrigated and after three days of 10 days sweet corn seedlings were sowed: Process took place with drip irrigation and other agricultural operations necessary with continuous follow-up of the field and in the stage of pre-flowering was measured chlorophyll concentration By method of Agarwal et al. (1986). Plants were harvested at maturation stage, at milking stage, in each plote.10 leaves from each plots were taken as indicated by Jones (1998) for nutrient content measurement. Plant leaves taken to Lab and washed with di ionized water after that dried at 75 C^{o}. The dried plant leaves were ground using a *Tima mill*. Ground plant material was ashed at about 550 C^{0}, and the residue was extracted with 3.3% HCL. After the digestion of the plant material, the concentration of phosphorus was determined by the Murphy and Riley (1962) method using a flame photometer. potassium and trace elements Fe, Mn were estimated using an atomic absorption spectrometer Atomic Absorption Spectro Photometer. While Nitrogen concentration was measured using a kildal device based on the Jackson (1958).As well as the uprooting of three plants of each repeater for calculating the productivity, which included a number ears per plant, number and weight of seeds in ears.

Table (1) :Physical properties of the soil field

Character	Soil texture	Clay (g.kg^{-1})	Silts (g.kg^{-1})	Sandy (g.kg^{-1})	EC s/cm
Value	Sandy Silts Clay	50.42	33.62	15.95	872

DATA ANALYSIS

All data were statistically analysed using the analysis of variance (ANOVA) procedure in the SAS program (SAS 2009) to assess the effects of different treatments. Means were compared using the least significant difference (LSD) test when the ANOVA showed significant bio-fertilizer effects ($P \leq 0.05$).

RESULTS AND DISCUSSION

The results are sown the effect of inoculums such as *Trichoderma harzianum* (T.26) and bacteria *Pseudomonas* *fluroescens* (Pf.I) and (Pf.n) and combination son sweet corn growth and yield under field conditions. The significant superiority of all bio fertilizer treatments compared to control treatment was determined. All the standards of growth and yield of sweet corn plants, which included high plant, fresh and dry weight of shoots, number leaves, concentration chlorophyll in leaves, uptake of N, P, K, Fe and Mn and yield and components which included a number ears per plant , number and weightof seeds in ears were obtained.

The results also showed a significant superiority of sweet corn plants treated with combination *T. harzianum* (T.26) inoculums fungi and *P. floresense* (Pf.I) inoculum bacteria recorded as 146cm, 341g ,35.6g, 8,3, 24.34 mg/gm, (75.26, 16.46, 63.84, 0.91 and 0.655) mg.plant^{-1}, 420.7 seeds.ears^{-1}, 2.2ears.plant^{-1} 493.6 gm,plant^{-1} while they recorded the treatment of comparison values amounted to less than 107cm, 223 gm, 21.8gm, 5.3 leaf , 18.59 mg.gm^{-1}, (44.67,8.71, 35.64, 0.52 and 0.366) mg.plant^{-1},182mg.plant^{-1}, 1.3ears.plant-1 and 203.9 g.plant^{-1} for the same standards, respectively (Tables 2, 3 and 4).

Table (2): Effect biofertilizer-fungal and bacterial and combination on plant growth parameters sweet corn

Treatment	High plant(cm)	fresh weight (g.Plant^{-1})	dry weight (g.Plant^{-1})	Number of Leaves	Chlorophyll Concentration
Control	107	223	21.8	5.3	18.59
T.26	140	331	34.8	8.0	24.05
P.I	138	305	31.1	8.0	22.71
P.n	135	288	29.2	8.0	21.37
T.26 +P.I	146	341	35.6	8.3	24.34
P +P.n	144	329	34.3	8.6	24.11
L.S.D	*4.93*	*12.25*	*1.41*	*0.94*	*1.45*

Mean values ± standard deviation with the same letters are not significantly different (LSD test, P<0.05).

Table (3): Effect Biofertilizer-fungal and bacterial and combination on sweet corn shoot system Concentration nutrition.

Treatment	Concentration of nutrition mg / plant				
	N	P	K	Fe	Mn
Control	44.67	8.71	35.64	*0.520*	*0.366*
T.26	72.80	14.75	61.33	*0.879*	*0.616*
P.I	64.99	13.67	54.70	*0.785*	*0.555*
P.n	60.88	13.05	51.13	*0.731*	*0.522*
T.26 +P.I	75.26	16.46	63.84	*0.910*	*0.655*
P +P.n	73.20	16.23	63.22	*0.903*	*0.648*
L.S.D	*0.991*	*0.8781*	*1.321*	*0.1113*	*0.1875*

Mean values ± standard deviation with the same letters are not significantly different (LSD test, P<0.05).

Table (4) :Effect of bio fertilization-fungal and bacterial and combination in yield quotient for sweet corn.

Treatments	number of seeds. $ears^{-1}$	number $ears.plant^{-1}$	Yield $g.plant^{-1}$
Control	182.0	1.3	203.9
T.26	400.0	2.0	441.2
P.I	393.0	2.0	412.0
P.n	379.0	1.7	324.0
T.26 +P.I	420.7	2.2	493.6
P +P.n	387.0	1.5	301.0
L.S.D	16.23	0.18	33.20

Mean values ± standard deviation with the same letters are not significantly different (LSD test, P<0.05).

These results confirm the superiority of all bio fertilization treatments in effect on growth and yield characters of sweet corn can be attributed to the important role played by these bio fertilizers to increase the Solubilisation of many nutrients to the roots and the production of some plant hormones stimulating plant growth and playing to increase growth and increase the root area to absorb nutrients from the soil, which reflected positively on the increased plant growth and number of leaves per plant and this means increased leaf area effective in the photosynthesis process and increase the susceptibility of plants to manufacture carbohydrates and thus increase holds the dry matter of the plant , thereby increasing quotient yield and its components that these findings are consistent with several previous research , which confirmed the effectiveness of both biologists working in stimulating the growth of various types of crop plant has confirmed the Zhang et al (2013) Who confirmed ability of isolates of the fungus *Trichoderma* spp. to produce hormones Auxin, gibberellins' and Cytocainin and colonize the roots of seedlings bitter orange , which is reflected in the stimulation of plant growth and increase the concentration of many elements of the Greater and Lesser Securities , as well as consistent with the results of saeed et al (2011) who Confirmed the effectiveness of three isolates of the fungus *T.harzianum* to increase various growth standards bitter orange seedlings when added with water irrigation , soil treatment or seed treatment.

With regard to the results of the increase for all Characteristics of growth and productivity caused by the treatment of cross pollination in this study, it confirms that vaccination more than the work of biologist, fungi or bacterial With positive impact in stimulating plant growth and improve the nutritional status as well as increase the quotient which is consistent with the results of some research has noted Anjanappa et al (2012) that the processing of cucumber plants with Psedomonas bacteria and Trichoderma fungus within integrated nutrition management Cucumber plant achieved a significant increase on the pollination both factors biologists in all growth parameters such as plant height, leaf area, the concentration of chlorophyll, fresh weight and dry plant and holds a single plant and total yield as these findings are consistent with the results of Shanmugaiah et al (2009) which Confirmed interoperability led to the increase significantly in the percentage of seed germination, root length, plant height and leaf area and dry weight of maize plants compared to non-bio- fertilizer with the addition of vaccination outweigh the mushroom inoculation with bacteria the individually in all traits.

The results of this study may be recommended the need to expand research that are interested bio fertilizer and private study overlap in the inoculation of more than biological factor to achieve the maximum benefit from the microorganisms soil for plant growth and reduce reliance on chemical fertilizers.

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