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Effect of Bio-Fertilizer on physiology of growth and development of maize (*Zea mays* L.) in Sulaimani region

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ABSTRACT

Effect of inoculation with Phosphorus biofertilizer and different dozes of nitrogen and P_2O_5 on the physiology of growth and development of maize were studied through conducting two different field-experiments at two different locations, Bakrajo (35˚ 34″ 307´N, 765masl) and Kanipanka location (35˚ 22″ 37´N, 545masl), in sulaimani region. The treatments included, T_1(no biofertilizer, only recommended NP) , T_2(50% recommended NP+ Phosphorus biofertilizer), T_3(Recommended N+ phosphorus biofertilizer), In addition to vegetative traits (such as plant height, LAI, No. of days to 50% silking, No. of days from 50% silking to physiological maturity(PM)), and reproductive traits (such as 500kernel weight, Biological Yield (BY), Yield, and Harvest Index(HI)), the root-shoot ratio(R/S) was studied in three different stages of growth pre-silking, at- silking and post-silking, results showed increasing in dry weight of root-shoot ratio and significant differences among studied traits, showing positive response of maize hybrid to phosphorus biofertilizer..

INTRODUCTION

Biofertilizer is a material containing microorganism(s) added to a soil to directly or indirectly make certain essential elements available to plants for their nutrition. Various sources of biofertilizers include nitrogen fixers, phytostimulators, phosphate solubilizing bacteria, plant growth promoting rhizobacteria, etc… (Shekh, 2006). Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution (Shevananda, 2008). One of more important factors that impact the physiology of plants growth and development is the availability of nutrients which can uptake by plants from soil. Phosphate and nitrogen are important for plant growth, however plants have a limited ability to extract them from the environment, and thus need microbes involved in "nutrient recycling," to help a plant uptake and absorb these nutrients at optimal concentration, while plants donate waste byproducts to microbes for food. With this symbiotic relationship, plants develop stronger and bigger root systems. The larger the plants' roots, the more living space and food there is for the microbes to use. In a way, microorganisms serve as biofertilizers (El-kholy ., 2005). An example is the fungus Penicillium bilaii, which allows plants to absorb phosphates from the soil. It
does this by producing anorganic acid which dissolves soil phosphates into a form which plants may use. A biofertilizer made from this organism is applied either by

coating seeds with the fungus (called inoculation), or applying the fertilizer directly into the ground. At later stages of growth, leaf senescence was delayed in inoculated plants, thus favoring dry matter accumulation and grain filling (Sarig *et al* ., 1990). In field experiments in Argentina, corn inoculated with Azospirillum lipoferum showed double the seeds per ear, an increase in seed dry weight by 59 % , and a significant stimulation in root development at harvest time (Fulchieri and Frioni, 1994). Another example is the bacterium *Rhizobium*. (Shekh, 2006). Use of these microorganisms as environment friendly biofertilizer helps to reduce the much expensive phosphatic fertilizers. Phosphorus biofertilizers could help to increase the availability of accumulated phosphate (by solubilization), efficiency of biological nitrogen fixation and increase the availability of Fe, Zn etc., through production of plant growth promoting substances (Kucey ., 1989). Trials with PSB indicated yield increases in rice (Tiwari ., 1989), maize (Afzal ., 2005) and other cereals (Ozturk *et al* ., 2003). Increased root, shoot weight with dual inoculation in maize have been reported by (Chabot *et al* ., 1993), while grain yields of the different maize genotypes treated with Azospirillum spp. Varied between 1700 and 7300 kg ha^{-1}(Salmone and Dobereiner, 2004). Root elongation assay was used for selection of effective plant growth promoting rhizobacteria, and data revealed that rhizobacterial isolates significantly differed in their potential to promot the elongation (Shaharoona and Zahir, 2006). Use of biofertilizers offers agronomic and environmental benefits for intensive agricultural systems in Egypt, and data obtained revealed that using Azospirillum brasilense or commercial biofertilizer cerealin with half N rate (144kgN/ha) caused a significant increase in yield (Mohammed *et al* ., 2001). Seed inoculation with *Rhizobium* , phosphorus solubilizing bacteria, and organic amendment increased seed production of the crop(Panwar *et al* ., 2006). Increasing yield was attributed to the plant growth promoting substances by root colonizing bacteria more than the biological nitrogen fixation, (Lin *et al* ., 1983) stated that yield increased due to promoting root growth which in turn enhancing nutrients and water uptake from the soil. There were positive and synergistic interactions between factors like interactions between mycorrhizal inoculation and phosphate biofertilizer on N concentration and phosphate biofertilizer and vermicompost on P concentration (Darzi *et al* ., 2009).

MATERIALS AND METHODS

Two different field- experiments were conducted in two different locations in sulaimani region namely Bakrajo and Kanipanka during the summer season of 2009 on a silty clay soil, by using Complete Randomized block Design with three replications. Seeding dates were in July 14 and 16 at both locations, respectively. Experimental unit area was $7.5m^2$(3m x 2.5m), consisted 4 rows, the planting

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patterns of the (MSI4317 Hybrid, which handed from Agricultural Research Center of Sulaimani) consisted of 70cm between rows and 20cm between plants, The traits includes bio and chemical fertilizer application, T_1(no biofertilizer, only recommended chemical fertilizer of Nitrogen and Phosphorus, 200 kg N ha-¹ and 200 Kg ha-¹ T.S.P 48%P_2O_5), T_2 (Bio-Fertilizer 100g ha^{-1}+ 50% of recommended fertilizer NP), and T_3(Recommended Nitrogen fertilizer + Bio-Fertilizer 100g ha^{-1}).

Commercial phosphorus biofertilizer(tested at the libraries of Agricultural research Center of Sulaimni) are commonly used with vegetable crops, for increasing production and improvement of quality, was used throughout this investigation, as recommended by the producer(100g of biofertilizer inoculated with seeds will sown to one hectar area). In order to obtaining the root-shoot ratio, the weight of roots and shoots was measured at three different stages of growth which were pre-silking (one month after emergence), at silking stage, and post-silking (one month after silking) . Immediately after sampling, the fresh weight of samples was recorded before being dried at 80^oC in an aerated oven to constant dry weight. Vegetative and reproductive growth characters were measured such as, leaf area which was measured by using al-Sahoky method [Al-sahoky, 1990], Plant height, No. of days required to 50% silking, No.of days required from 50% silking to physiological maturity(PM), and weight of 500 kernel(g), biological yield(Mg ha-1), yield(Mg ha-1) , and Harvest Index(HI). Meterological data of the two locations used especially during the period post silking for determining the longivity of leaves and their abilities to photosynthesis.

RESULTS AND DISCUSSION

Table 1. indicates that there were significant differences in the response of maize hybrid to the effect of treatments on its vegetative growth traits that studied in the two locations, in Bakrajo the superiority was toT_3 which represents the effect of phosphate biofertilizer and full dose of recommended Nitrogen, exceeding T_1(recommended NP) in plant height, LAI, and No.of days from 50% silking to physiological maturity(PM), and followed by T_2(Biofertilizer and 50% of recommended NP) which exceeded T_1 in No. of days from seeding to 50%silking,

Table (1): Studied vegetative traits in Location 1 and Location 2.

Treatments	Location 1. bakrajo				Location 2. Kanipanka			
	Plant Height cm	LAI	No. of days to 50% silking	No.of days from 50% silking to PM	Plant Height cm	LAI	No. of days to 50% silking	No.of days from 50% silking to

								PM
T1	108.333	5.548	63.666	58.833	131.833	5.95	53	54
T2	111.666	5.166	65.666	60.166	135.5	6.166	54	51
T3	114	6.574	64.666	62	137.833	6.823	52.666	56.5
L.S.D	2.926	0.608	1.308	2.069	3.943	0.627	0.755	1.683

While in Kanipanka T_3 exceeded T_1 in plant height and LAI, and No.of days from 50% silking to physiological maturity, but T_2 exceeded T_1 and T_3 in the No. of days to 50% silking.

According to the data of table 1, the effect of biofertilizer was evaluated positively, there were an increase in plant height, LAI, and increase in the seed filling period which determined by the number of days required from 50% silking to PM. at both locations, and the maize response was more greater in kanipanka location than Bakrajo due to favorability of environmental factors of that location in comparison to the first location, the positive results of using phosphate biofertilizer may related to increasing the availability of nutrients as a biological activity of it; Results were similar to previous research(Shekh, 2006, El-kholy *et al* ., 2005 and Sarig *et al* ., 1990).

Table 2 show significant differences among reproductive traits in both locations, The maximum weight of 500 kernel Wt. , Biological Yield and Yield were to $T_{3,}$while the minimum records were to T_1 in both locations, but there was non significant differences in HI at the two locations, may relate to instability of HI due to different environments, positive effect of biofertilizer may resulted from its ability to increase the availability of Phosphorus and other nutrients especially under the specialty of the calcareous nature of the soil of the region which cause decreasing on the nutrients availability, results agree with (Kucey *et al* ., 1989,Tiwari *et al* ., 1989,Afzal *et al* ., 2005, and Ozuturk *et al* ., 2003).

Table (2): Studied Reproductive traits in Location 1 and Location 2.

Treatment	Location 1. bakrajo				Location 2. Kanipanka			
	Wt. of 500 kernel g	Biological Yield Mg ha-1	Yield Mg ha-1	HI	Wt. of 500 kernel g	Biological Yield Mg ha-1	Yield Mg ha-1	HI
T1	91.096	14.916	5.586	0.374	94.02	16.694	6.113	0.366
T2	92.151	15.556	6.029	0.366	94.633	16.595	6.177	0.37
T3	93.165	16.046	6.516	0.385	95.722	17.833	6.958	0.39
L.S.D	1.308	0.699	0.504	NS	1.021	0.714	0.506	NS

The biofertilizer effect on the root-shoot ratio at the different stages of the growth was shown in tables 3 and 4 and the figures 1 and 2, indicating an increase in the root growth much more due to using phosphorus biofertilizer (T_2) than the situation of using chemical fertilizer only(T_1), Shoot dry matter production was reduced to a higher degree than root length, resulting in a higher root-shoot ratio (RS) due to biofertilizer effect. There was larger root-shoot ratio at the period pre-silking due T_3 treatment in compare to T_1 and T_2 especially at Bakrajo with higher growth rate, and maximum weight of root growth recorded at the silking stage which was considered as the end of vegetative growth , showing larger root-shoot ratio at the silking stage. There were similar performance with few differences in Kanipanka, the results agree with similar research (Ozturk ***et al*** ., 2003, Salomone and Dobereiner, 2003).

Table (3): Root-Shoot ratio measured at pre-silking, At silking and post-silking(Loc.1)

Treatments	presilking			At Silking			Post Silking		
	Root DW	Shoot DW	R/S	Root DW	Shoot DW	R/S	Root DW	Shoot DW	R/S
T1	1.68	10.176	0.165	32.583	213.888	0.152	36.333	178.583	0.204
T2	1.84	7.43	0.248	50.083	182.083	0.275	49.833	201.666	0.247
T3	2.75	10.19	0.27	36.555	188.861	0.194	39.583	190.861	0.207
LSD	NS	NS		3.699	13.957		2.491	10.331	

Table(4): Root -Shoot ratio measured at pre-silking, At silking and post-silking(Loc.2)

Treatments	presilking			At Silking			Post Silking		
	Root DW	Shoot DW	R/S	Root DW	Shoot DW	R/S	Root DW	Shoot DW	R/S
T1	2.354	12.666	0.186	38.455	286.2	0.134	42.555	198.666	0.214
T2	3.75	12.289	0.305	65.324	225.025	0.29	66.75	246.583	0.271
T3	3.983	13.8	0.289	48.975	228.987	0.214	57	225.916	0.252
L.S.D	NS	NS		9.585	35.656		3.826	15.163	

Root Dry Weight increase may came from the elongation of the roots under the effect of the phosphorus biofertilizer which induced the uptake ability of the roots to nutrients and positive increase in the yield parameters because of improving the root system as a source-sink relationship to the reproductive part (shoot), that agree with (Mohammed et al ., 2001), (Ozturk et al ., 2003) and (Panwar et al ., 2006). There were an indications to shoot increase too under the effect of biofertilizer because there were general modification in growth performance.

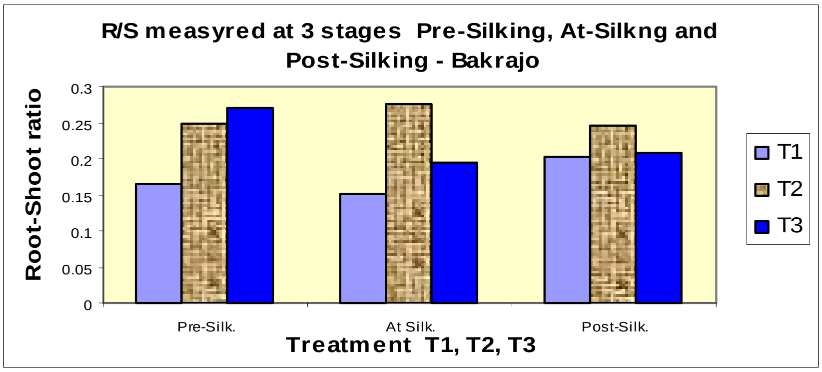

Fig.1: Root-Shoot ratio of three stages pre-silking, atsilking and post silking in Bakrajo.

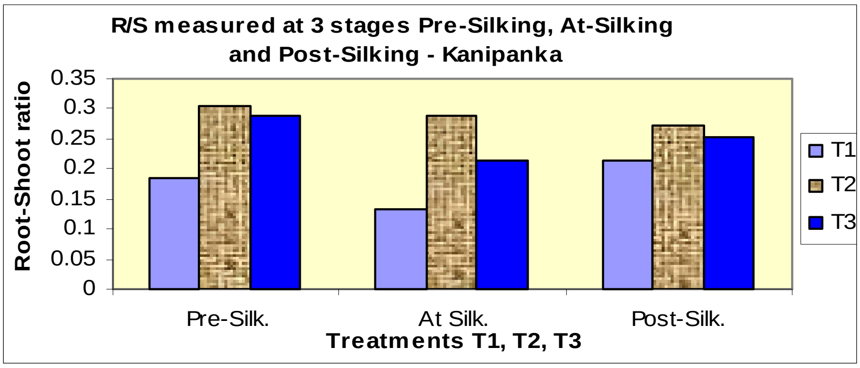

Fig.2: Root-Shoot ratio of three stages pre-silking, at-silking and post silking in Kanipanka

Table 5 and 6 show significant differences between the two locations due to physiology of growth which represented by dry matter accumulation and its patitioning to the root and shoot parts. It was noticed that growth rate at location 2 was more larger than location 1 due to most of the studied traits(although there were non significant differences between the two locations due to kernel yield and harvest index), there were significant increasing in the dry weight of shoot and root in the kanipanka location than in Bakrajo except the prestilking stage which was non significant, that may related to the favorite of some environmental factors in kanipanka which directly affected the bio fertilizer and its impact on the nutrient availability and growth (table 1,2), which positively influenced the maize photosynthesis and dry matter accumulation more actively that agree with (Lin et al ., 1983, Salmone and Dobereiner, 2004, Shevananda, 2008, and Darzi et al ., 2009).

Table (5):Root-Shoot weight at different stages of growth in L_1 and L_2

Location	Root Wt. Presilking	Shoot Wt. Presilking	Root Wt. At Silking	Shoot Wt. At Silking	Root Wt. Post Silking	Shoot Wt. Post Silking
Bakrajo	2.09	9.265	3.699	13.957	41.916	190.37
Kanipanka	3.356	12.918	9.585	35.656	55.435	223.722
L.S.D	NS	NS	5.859	21.318	2.636	10.593

Growth improvement and yield and biomass increasing was reported with the biofertilizer application which account important benifet to the maize producers and maize production in the region, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in yield and biological yield in the production of the unit area, as well as its undamaged effect on the soil and environment, and on other hand its positive effect on physiology of growth performance.

Table(6) : Studied traits of growth and yield in L_1 and L_2

Location	Days to 50% tasseling	Plant Height cm	LAI	Filling Period	Wt. of 500 kernel g	Biological Yield Mg	Yield Mg	HI
Bakrajo	64.666	111.333	5.763	60.333	92.137	15.506	6.043	0.38
Kanipanka	53.222	135.055	6.313	53.955	94.791	17.041	6.416	0.37
L.S.D	0.872	2.835	0.503	1.539	0.958	0.575	NS	NS

تاثير التسميد الحيوي في فسلجة النمو و التطور للذرة الصفراء في منطقة السليمانية

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الخلاصـــة

تم دراسة تاثير المعاملة بالتسميد الحيوي الفسفورى مع استعمال كميات مختلفة من النايتروجين مع الفوسفور المعدني في فسلجة النمو و التطورللذرة الصفراء، من خلال تطبيق تجربتين حقليتين في موقعين مختلفين،بكرةجو(٣٥°٣٤″٣٠٧´و٧٦٥ م ارتفاع عن مستوى سطح البحر) و كانيبانكة (٣٤° ″ ٢٢٣٧´ و ٤٥٤ م ارتفاع عن مستوى سطح البحر)في منطقة السليمانية. تم تصميم التجربتين وفق القطاعات العشوائية الكاملة و بثلاث مكررات. تضمن معاملات التسميد ت١ (صفر التسميد الحيوي+ فقط التسميد الكيمياوبالنايتروجيني و الفسفوري المقرر)، ت٢ (التسميد الحيوي+ ٥٠% التسميد الكيمياوى النايتروجيني و الفسفوري المقرر)، ت٣ (التسميد الحيوي +فقط التسميد النايتروجيني المقرر).فبالاضافة الى الصفات الخضرية مثل ارتفاع النبات، دليل المساحة الورقية، عدد الايام الى ٥٠% تزهير، عدد الايام من ٥٠%تزهير الى النضج الفسلجى، و كذلك الصفات الثمرية مثل وزن ٥٠٠ حبة، و الحاصل البايولوجي، حاصل الحبوب، و دليل الحصاد، فقد تم دراسة نسبة وزن الجذر الى الساق في ثلاث مراحل مختلفة وهي قبل ظهور الحريرة و اثناء ظهور الحريرة، و بعد ظهور الحريرة. اظهرت النتائج الازدياد في نسبة وزن

الجذور الى الساق واختلافات معنويةبين الصفات المدروسة، مظهرا استجابة موجبة لهجين الذرة الصفراء للتسميد الفوسفوري الحيوي.

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Appendix 1.Mean square of studied vegetative and reproductive traits for two locations

S.O.V	d.f	M.S							
		Days to 50% tasseling	Plant Height cm	LAI	Filling Period	Wt. of 500 kernel g	Biological Yield Mg	Yield Mg	HI
Location	1	589.388	2532.347	1.362	183.042	31.702	10.599	1.592	1.3938
Blocks/Loc.	4	0.444	4.694	0.148	1.384	0.536	0.194	0.299	0.0008
Biofertilizer/Loc.	4	2.222	25.888	1.105	13.934	2.719	1.192	0.483	0.0003
Biofertilizer	2	3.722	51.722	1.973	20.934	5.355	2.106	0.929	0.0006
Biofertilizer*Location	2	0.722	0.055	0.236	6.933	0.084	0.276	0.037	7.07
Error	4	0.222	2.347	0.074	0.692	0.268	0.097	0.149	0.0004

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Appendix 2 Mean square of Root and Shoot dry weight for two location

S.O.V	df	Root Wt. pre-Silking	Shoot Wt. Pre-Silking	Root Wt. At-Silking	Shoot Wt.At-Silking	Root Wt.Post - Silking	Shoot Wt.Post-Silking
Location	1	7.216	60.046	562.208	12071.32	822.368	5005.568
Blocks/Loc.	4	0.989	8.749	20.049	265.396	4.058	65.532
Biofertilizer/Loc.	4	1.647	4.717	401.233	2178.826	296.741	1066.506
Biofertilizer	2	2.718	7.327	767.812	3881.053	533.497	1898.486
Biofertilizer x Location	2	0.573	2.108	134.653	476.600	59.986	234.526

Appendix 3: Meterological data of Bakrajo and Kanipanka of the duration from Jully to November 2009.

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Locations	Mon.	Air Temp ˚C	RH%	Precipitation mm	Sun shine duration (hr)	Wind speed (m/s)	Soil temp. ˚C	Pan evap(mm)	Cloud cover (oktas)
Bakrajo	Jul	32.4	24.2	0.0	9.5	1.3	30.3	9.6	0.1
	Aug	31.6	25.1	0.0	10.3	10.3	31.0	8.6	0.0
	Sep	26.2	34.3	0.3	9.0	9.0	27.1	5.4	1.1
	Oct	22.5	38.6	2.4	7.6	7.6	20.4	4.2	2.1
	Nov	13.2	68.3	4.5	5.2	5.2	12.6	2.4	3.5
Kanipanka	Jul	33.2	23.3	0.0	8.7	2.40	35.8	12.6	2.3
	Aug	34.2	22.2	0.0	10.7	2.30	35.7	12.3	0.4
	Sep	28.5	28.4	2.9	9.2	2.10	31.5	8.9	1.7
	Oct	23.7	30.3	26.7	7.8	1.80	25.4	5.7	2.3
	Nov	13.1	58.8	14.6	5.5	1.50	15.2	1.8	3.4

Appendex 4: Physical and Chemical analysis of the soil for the two locations

Location	PSD	Texture name	Total N ppm	CaCO3%	P-available μg^{-1}

	Clay	Silt	Sand				
Bakrajo	501.7	449.8	48.5	Silty Clay	19.93	33.76	4.26
Kanipanka	456.9	506.7	37.2	Silty Clay	27.66	34.26	5.7
Location	Soluble cations and Anions $Meq.l^{-1}$					K^{+} ppm	Na^{2+}ppm
	Ca^{2+}	Mg^{2+}	$CO3^{-}$	$HCO3^{-}$	Cl^{-}		
Bakrajo	2.66	1.09	0	8.09	2.76	2.67	27.66
Kanipanka	2.98	1.87	0	2.33	1.39	2.14	19.93