Effect of Supplementary Irrigation Schedules and Bio-Fertilization on Yield and Yield Attributes of Faba Bean (*Vicia faba* L.),and Lentil(*Lens culinaris* L.), under Rainfed Conditions

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ABSTRACT

Two field experiments were carried out during the two successive growing seasons (2006/2007 and 2007/2008) at El-Hammam farm, Marsa Matrouh, North Western Coast of Egypt, to study the effect of supplementary irrigation schedule and bio-fertilization on Faba bean (*Vicia faba* L.) and Lentil (lens culinaris, Medic) yields and its attributes.

The study included two regimes of bio-fertilizers (without bio-fertilization and bio-fertilization) with combined bio-fertilizer (Rhizobium leguminosarum bv. viciae and Bacillus megatherium var. phosphaticum strains) and three irrigation schedule (without supplementary irrigation (rain fed), one supplementary irrigation 45 mm and two supplementary irrigation 90 mm),. The obtained results showed that:

-adding two supplementary irrigations(90mm) caused the highest values for all measured characteristics of yield and its components in both studied crops.

-The measurements of yield and its components i.e., plant height at harvest (cm), number of branches/plant; number of branches/m2; number of grains/plant; number of grains/pod; 100 grains weight (g); and biological, straw and grains yields (kg/fed) were significantly increased by adding bio-fertilizer than the control.

-In respect to the interaction between the two studied factors, biofertilizer and two supplementary irrigation with 90 mm/fed gave the highest values for all measured characteristics in both crops,

Key words: Faba bean (*Vicia faba* L.), Lentil (*lens culinaris* L.), bio-fertilization, rainfall, supplementary irrigation.

INTRODUCTION

For over half a century, the world has relied on increasing crop yields to supply an ever increasing demand for food. One of the major problems that limit economically successful agricultural production worldwide is poor soil fertility. Nutrient depletion of soil is a particular problem for small land holders in developing countries, where much grain-legume production occurs (Baset and Shamsuddin, 2010). It was suggested that the average annual nutrient depletion rates across 37 African countries were 22 kg N /ha, 25kg P/ha and 15kg K/ha (Sanchez, 2002). Therefore, addition of fertilizers is necessary to correct poor soil fertility by supplying nutrients needed for optimum crop growth (ELsheikh et al., 2005).

In the last three decades, the use of nitrogen fertilizer has increased almost nine folds (Vance, 2001). The increasing use of nitrogen and phosphorus fertilizers in high productive systems have created environmental problems such as deterioration of soil quality, surface and groundwater as well as air pollution, reduced biodiversity and suppressed ecosystem function (Schultz et al, 1998, Socalow, 1999 and Vance, 2001).

Crop Scientists all over the world are facing the alarming situation induced by the intensive uses of chemical fertilizers and they are trying to overcome this condition by exploring alternative source which is cost effective and save the environment. Biofertilizers, are alternate source of chemical fertilizer (Baset and Shamsuddin, 2010).

Legumes are the major source of proteins for both man and livestock, especially in poor countries, where animal protein is expensive (Hubbell and Gerald, 2003). It is the main food for millions of people and the source of protein for the middle and low income groups (Salih, 1981).

Grain legumes play an essential role in human nutrition balancing the deficiencies of cereal-based diet (Dart and Krantz, 1977). The importance of legumes is that they can fix nitrogen in symbiotic association with rhizobia, and so they increase the soil nitrogen content (Poth et al., 1986). This association enables legumes to benefit from an augmented nitrogen supply and can grow well on relatively poor soils (Heywood et al., 1985).

Faba bean (*Vicia faba* L.) and Lentil (*Lens culinaris*, Medic) are grown world-wide in cropping systems as a grain (pulse) and green-manure legume. The grain legumes contribute to the sustainability of cropping systems via: 1) its ability to contribute nitrogen (N) to the system via biological N fixation, 2) diversification of systems leading to decreased disease, pest and weed build-up and potentially increased biodiversity, 3) reduced fossil energy consumption in plant production, and 4) providing food and feed rich in protein.

Grain legumes are major crops cultivated in the Northern and the River Nile Governorates of Egypt. For example, Faba bean (*Vicia faba* L.) is produced in an average area of 69720 ha, with an average yield of 1896 kg/ha (AOAD, 2007). Grain legumes are important cash crops for farmers (Watson, 1981) under dry lands conditions. Supplementary irrigation could significantly prevent from undesirable effects of water deficit. Oweis et all.(2004) reported seed and biological yield in lentil increased by supplementary irrigation .Increasing seed and biological yield through supplementary irrigation reported by many researchers Zhang,H.et al.(2000)Therefore, the objectives of this study were to determine the effects of biological fertilization and supplemental watering on faba bean and lentil productivity under rainfed conditions at the North Western Coast of Egypt.

MATERIALS AND METHODS

Site description

Two field experiments were conducted at El-Hammam farm, Matrouh Governorate, North Western Coast of Egypt for two consecutive winter seasons 2006/2007 and 2007/2008 to study the effect of supplementary irrigation schedule), and bio-fertilizer application on faba bean and lentil crop productivity.

Meteorological data of temperature, dew point and relative humidity which were obtained from Egyptian Meteorological Authority, Agricultural Research Center during the two growing seasons 2006-2007 -2008 are shown in table (1).

Treatments

The experiments included 6 treatments, which were the combination of three irrigation schedules as supplementary irrigation treatments and two bio-fertilizers treatments as follows:

Irrigation schedule:

1-without supplementary irrigation (rainfall only), control (W0).

2-one supplementary irrigation by 45 mm (189m3/fed) after 45 days from sowing (W1).

3-two supplementary irrigations by 45 mm (378m3/fed) of each, the first after 45 days from sowing and the second at flowering stage (W2).

All the experimental plots received irrigation by 45 mm immediately after sowing to obtain good plant establishment.

Bio-fertilizer application:

1-without bio-fertilization (control) (F0).

2- inoculation with combined bio-fertilizer (Rhizobium leguminosarum bv. viciae and Bacillus megatherium var. phosphaticum strains) (F1).

Experimental design and execution

A separate experiment was devoted to each investigated legume crop, where the treatments were arranged in split plot design in four replications, the main plots were occupied with supplemental irrigation treatments and the subplots were devoted to bio-fertilizer treatments.

The land was prepared by deep pouching, harrowing, leveling and ridging. The land was then divided into plots 6 x 3.8 m each., 50 kg N/fed as urea was broadcasted immediately after sowing. Phosphorus was applied at a rate of 45 kg P2O5/fed as triple super phosphate broadcasted before sowing.

Certified seeds of faba bean (*Vicia faba* L.) cultivar (Giza 5) and Lentil (*Lens culinaris* Medic.) cultivar (Giza 9) were obtained from Legumes Research Division, Agriculture Research Center, Ministry of Agriculture and Reclamation Giza, Egypt.

Seeds prepared was carried by soaking in tab water for 24 hours and air dried for one hour then , the seeds were divided into two equal parts, the first one was without bio-fertilizer (control), and the second was inoculated with the combined bio-fertilizer. Two to three seeds were placed in a hole on the top of the ridge with 20 cm spacing (between holes) and 70 cm (between ridges).

The supplementary irrigation treatments were added by gated pipe distribution system and the irrigation water quantities measured through flow meter. irrigation system. The soil was fallow in the summer before sowing each of faba bean and lentil in both seasons. Seeds were sown in 15th November 2006 and 25th November 2007 at rate of 30 kg/fed, in the first and second seasons, respectively. While The harvesting dates were 1st April 2006 and 8th April 2008 In the first and second seasons, respectively.

Yield measurements

At maturity, each plot was harvested separately by cutting the plants. Plants were then threshed on a large mat, then collected to measure yield and its components of each plot.

The following parameters, of each of faba bean and lentil yield and its components, were recorded:

1. plant height at harvest (cm),
2. number of branches/plant;
3. number of branches/m2;
4. number of pods/plant;
5. number of grains/pod;
6. 100 grains weight (g); and
7. biological, straw and grains yields (kg/fed)

Table 1: Meteorological parameters of the 2006-2007 and 2007 -2008 seasons

Month	Temp. (°c)			Dew point (mm)			Humidity(%)	
	Min.	Max.	Avg.	Min.	Max.	Avg	Min.	Max.
				2006/07				
Nov.	16.7	20.0	18.40	8.3	11.2	9.75	50.3	63.7
Dec.	12.3	15.6	13.95	5.0	10.8	7.9	54.7	67.7
Jan.	10.5	18.2	14.35	4.1	10.4	7.25	59.7	69.7
Feb.	10.6	18.5	14.55	5.1	11.7	8.4	57.0	69.7
March.	12.0	20.9	16.45	5.9	12.4	9.15	58.7	67.0
April	13.7	20.8	17.25	9.0	12.9	10.95	49.0	68.7
May.	17.6	26.0	21.8	7.3	17.3	12.3	59.3	68.7
				2007/08				
Nov.	13.9	24.6	19.25	7.2	15.6	11.4	55.0	63.0
Dec.	10.7	20.2	15.45	6.3	11.1	8.7	53.3	64.0
Jan.	10.1	17.1	13.6	7.2	9.9	8.55	63.7	78.2
Feb.	9.6	17.2	13.4	6.1	8.9	7.5	61.9	76.2
March.	12.4	23.0	17.7	5.5	11.4	8.45	57.7	75.2
April	14.0	24.3	19.15	7.9	12.4	10.15	53.0	70.4
May.	16.2	25.5	20.85	11.9	15.7	13.8	56.4	71.7

Source: Egyptian Meteorological Authority, Cairo, Egypt.

The soil texture (0-20cm) is loamy sand . it's parent material varies between calcium carbonate and gypsum with 34.8-41.2 caco3 %

. Statistical analysis

Multifactor Analysis of Variance (ANOVA) was used to determine the effect of different treatments on measured parameters. Least significance difference was used to compare between means (Gomez and Gomez, 1984). Data combined analysis of the two experiments was done according to Lazic (2008). Significance was accepted at $p<0.05$.

RESULTS AND DISCUSSION

. Effect of supplementary irrigation:

Table (2) showed that all measured parameters i.e., plant height at harvest (cm), number of branches/plant; number of branches/m2; number of pods/plant; number of grains/pod; 100 grains weight (g); and biological, straw and grains yields (kg/fed) were significantly increased by supplementary irrigation schedule 45 and 90 mm viz, non irrigation (rain), in both seasons.

The highest values of mentioned characters were obtained by adding 90 mm as a supplementary irrigation.

The superiority of supplemental irrigation at rate of 90 mm on the yield and its components in both seasons may be due to the increment in number of pods/m2, number of grains/m2, and weigt of 100 grains as indicated in Table (2).

These findings agree with those obtained by Dart and Krantz, (1977) and Ahmed et. al.,(2007) Increasing growth characters as a result of adding water supplemental irrigation at a rate of 90 mm caused superiority in yield and its components. These results may be due to the effect of water on encouraging cell division, elongation and turgidity which in turn increase dry matter.

In this respect, it is worthy mention that the major problem facing grain legumes production in Egypt northern governorates is synchronizing of inadequate rainfall incidences during the most drought susceptible stage of growth and development (Abdel, 1993). Most studies on grain legumes for improving yield confirmed that pod development and seed filling stages were the most drought sensitive (Abdel, 1982 and El-Hamadany, 2005).

. Effect of bio-fertilization:

Data in Table (3) showed that the yield and its components was increased significantly in all characters with application of bio-fertilizer i.e., plant height at harvest (cm), number of branches/plant; number of branches/m2; number of grains/plant; number of grains/pod; 100 grains weight (g); and biological, straw and grains yields (kg/fed) than those of the control (without bio-fertilizer). There were significant differences in all yield characters and these differences were fairly true under the probability of 5% level of significance. Bio-fertilizers had markedly affected all mentioned characters compared to those plants without bio-fertilizer. The increment in yield and its components of faba bean and lentil may be in directly due the effects of bio-fertilization package on enhancing vegetative growth, root growth and dry matter accumulation.

Generally, under bio-fertilizer treatment, grain, straw and biological yields, were increased in both seasons as shown in Table (3), and the bio-fertilized Faba bean Giza 5, scored the highest values of all characters yield and its components. These results are in harmony with those reported by many

Table 2: Supplementary irrigation effect on faba bean and lentil yield and its components (means of two seasons)

Treatment \ Characters	Plant height (cm)	Number of pods/plant	Number of branches/plant	Number of branches/ m2	100 grains weight (g)	Number of grains/pod	Grains yield (kg/fed)	Straw yield (kg/fed)	Biological yield (kg/fed)
				Faba bean					
W0	36.50	6.31	1.53	35.60	63.60	2.16	519.20	1056.90	1576.20
W1	46.10	7.51	2.16	36.60	73.70	2.69	682.90	1543.30	2226.30
W2	56.20	9.57	3.12	44.90	83.10	3.53	977.50	2376.80	3315.60
LSD (5%)	2.95	0.38	0.16	10.01	3.09	0.26	68.80	159.70	174.30
				Lentil					
W0	26.50	16.63	2.76	41.40	3.18	4.75	173.07	398.05	573.12
W1	36.10	17.83	3.39	50.85	3.69	5.92	227.63	523.56	753.19
W2	46.20	19.89	4.35	65.25	4.16	7.77	325.83	749.42	1077.25
LSD (5%)	4.58	0.92	0.26	8.32	0.12	0.57	22.93	52.75	77.68

W0 = rainfall only W! = rainfall + one supplementary irrigation
W2 = rainfall + two supplementary irrigations

Table 3: Bio-fertilizer effect on faba bean and lentil yield and its components (means of two seasons)

Treatment \ Characters	Plant height (cm)	Number of pods/plant	Number of branches/plant	Number of branches/m2	100 grains weight (g)	Number of grains/pod	Grains yield (kg/fed)	Straw yield (kg/fed)	Biological yield (kg/fed)
				Faba bean					
F0	38.6	6.42	1.78	71.3	65.6	2.33	560.7	1251.7	1828.1
F1	43.2	7.39	2.22	38.3	70.3	2.68	684.8	1536.0	2182.6
LSD (5%)	2.2	0.27	0.16	7.11	1.46	0.12	42.9	80.8	140.7
				Lentil					
F0	28.60	16.74	3.01	45.15	3.28	5.13	186.90	429.87	618.77
F1	33.20	17.71	3.45	51.75	3.52	5.90	228.27	525.01	755.28
LSD (5%)	1.62	0.53	0.39	4.68	ns	0.26	14.30	32.89	49.19

F0 = without bio-fertilization F1 = inoculation with combined bio-fertilizer

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Table 4: Effect of the interaction between supplementary irrigation and bio-fertilizer on faba bean and lentil yield and its components (means of two seasons)

Characters / Treatment	Plant height (cm)	Number of pods/plant	Number of branches/plant	Number of branches/m2	100 grains weight (g)	Number of grains/pod	Grains yield (kg/fed)	Straw yield (kg/fed)	Biological yield (kg/fed)
				Faba bean					
W0 + F0	34.9	5.90	1.36	27.0	61.2	1.95	469.4	938.6	1407.9
W0 + F1	37.9	6.72	1.69	44.3	65.9	2.38	569.1	1175.4	1744.5
W1 + F0	43.3	7.20	1.97	35.0	71.3	2.56	631.1	1410.7	2069.7
W1 + F1	48.8	7.82	2.36	38.3	76.1	2.83	734.9	1675.9	2382.8
W2 + F0	64.2	9.02	2.70	42.8	81.1	3.38	870.4	2149.9	3067.9
W2 + F1	58.3	10.12	3.55	47.0	85.0	3.68	1084.7	2603.6	3563.2
LSD (5%)	4.44	0.55	0.32	14.2	2.92	0.24	85.8	161.6	281.4
				Lentil					
W0 + F0	24.90	16.12	2.54	36.83	2.91	3.90	161.86	258.98	424.04
W0 + F1	27.90	16.94	2.87	41.62	3.14	4.76	196.24	313.99	513.43
W1 + F0	33.30	17.42	3.15	45.68	3.40	5.12	217.62	348.19	569.01
W1 + F1	38.80	18.04	3.54	51.33	3.62	5.66	253.41	405.46	662.08
W2 + F0	54.20	19.24	3.88	56.26	3.86	6.76	300.14	480.22	783.56
W2 + F1	48.30	20.34	4.73	68.59	4.05	7.36	374.03	598.46	975.69
LSD (5%)	3.58	0.61	0.47	8.43	0.18	0.47	28.63	52.38	85.29

W0 = rainfall only W! = rainfall + one supplementary irrigation
W2 = rainfall + two supplementary irrigations
F0 = without bio-fertilization F1 = inoculation with combined bio-fertilizer

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researchers (Beck and Duc, 1991, Anderson and Ingram, 1993 and ELsheikh et al., 2005).

It is reported that sink capacity of the plant is dependent mainly on vegetative growth of plant, vigorous vegetative growth which increased due to the application of bio-fertilizer and supply of photosynthesis for formation of more branches and pods of legumes (Baset and Shamsuddin, 2010).

. Effect of the interaction between supplementary irrigation schedule and bio-fertilizer under rainfed conditions.

Data in Table (4) showed that the effect of the interaction between bio-fertilizer and supplementary irrigation schedule it had significant effect on all studied characters of faba bean and lentil except for number of branches/m2 which tended to behave in different way. The highest values of yield and its components were obtained by bio-fertilizing each of faba bean and lentil plants and adding supplemental irrigation water by 90mm. However, the lowest values for the mentioned characters were obtained without bio-fertilizer (control) and without supplementary irrigation (rainfed). These results are in agreement with those reported by(Osman et al., 2010).

CONCLUSION

The areas of the North Western Coast of Egypt are characterized by low rainfall rate (average of the last 50 years is 133 mm/year), but evapotranspiration is low due to mild temperatures, cloudy skies, formation of dew on the plants during he growing seasons, and soil texture which varies between sandy and sandy loamy that has reasonable water holding capacity, hence the decision makers planed to install some great canals to convey the Nile water to the different parts of Egyptian desert, such as El-Hammam canal, which was designed to support the rainfed agricultural with supplementary irrigation to get improved yields. The most important crops in this areas are grain legumes.

Under rainfed conditions in El-Hammam farm at North Western Coast of Egypt, it can be concluded that cultivating the bio-fertilized legumes and supplementary irrigation with 90 mm is recommended to obtain the highest yield for each of faba bean and lentil plants under rain fed conditions.

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الملخص العربى

تأثيرالرى التكميلى والتسميد الحيوى على إنتاجية ومكونات محصول الفول والعدس تحت ظروف الزراعة المطرية

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اقيمت تجربتان حقليتان بمنطقة الحمام بمحافظة مطروح بالساحل الشمالى الغربى لجمهورية مصر العربية خلال موسمين زراعيين ٢٠٠٦/٢٠٠٧ و٢٠٠٧/٢٠٠٨ لدراسة تاثير التسميد الحيوى وكمية ماء الرى كرى تكميلى على كل من محصولى الفول والعدس ومكوناتها واشتملت عوامل الدراسة على كلاً من:

١-التسميد الحيوى ويشمل:

أ-بدون تسميد ب-التسميد بالريزوبيوم + البكتريا المحللة للفوسفات

٢-الرى التكميلى ويشمل:

أ-بدون رى تكميلى (مطر فقط) ب-رى تكميلى بمقدار ٤٥ مم رية واحدة ت-رى تكميلى بمقدار ٩٠مم على ريتين

وقد نفذت تجربة لكل من محصولى الفول و العدس على حدة فى نظام القطع المنشقة مرة واحدة حيث وضع الرى فى القطع الرئيسية بينما وضع التسميد الحيوى فى القطع الفرعية فى اربعة مكررات.

تم اخذ القياسات التالية على المحصول ومكوناته عند الحصاد:

١-ارتفاع النبات (سم) ٢-عدد الافرع/نبات٣-وزن ١٠٠ بذرة٤-عدد القرون / م٢ ٥-وزن الحبوب/ م٢

٦-المحصول البيولوجى والحبوب والقش (كجم/فدان)

ويمكن تلخيص اهم النتائج المتحصل عليها كالآتى:

١-ادى التسميد الحيوى الى زيادة كلا من المحصول وصفات المحصول فى كلا الموسمين مقارنة بعدم التسميد.

٢-ادى اضافة ٩٠مم كرى تكميلى الى اعلى زيادة معنوية للصفات تحت الدراسة وتلاها اضافة ٤٥مم كرى تكميلى على التوالى لنفس الصفات السابقة فى كلا الموسمين مقارنة بالرى بماء المطر فقط.

٣-اعطى التفاعل بين التسميد الحيوى والرى التكميلى بمقدار ٩٠مم اعلى زيادة معنوية للصفات المدروسة فى حين لم تتأثر صفة عدد الأفرع/ م٢ معنويا.