

Water Crop Productivity of Faba Beans as Affected by Irrigation Deficit and Farmyard Manure additions

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Abstract : Conservation of adequate levels of soil organic matter in soils is prerequisite for prospective and high production of crop; therefore this work was carried out in Research and Production Station, NRC, El-Nubaria, El-Beheara Governorate to investigate the impact of organic manure application (10 and 15 ton/fed) and irrigation treatments (90 and 75 % from evapotranspiration, ETo) on faba bean (*Vicia faba* L. Giza 461) plant growth, productivity and water crop productivity.

The obtained results showed that plant growth characters i.e. total seeds/plant and seeds weight and seed index were clearly improved as a result of applied both factors under investigation. Decreasing irrigation water by 15 % from 90 to 75% of ETo improved total seeds per plant and seed weight by 14.0 and 28.0 % relative to the control (90 % of ETo). While FYM at 15 ton /fed increased the same characters by 45 and 47 % and 10 ton/fed by 9 and 21 % as compared with control. FYM under 90 % irrigation treatment comparing with control. Whereas, under irrigation treatment of 75 % increased same variable progressively. Irrigation treatment 75 % from ETo moderately enhanced seed index by 5.6 % relative to the 90 %. Application 10 and 15 ton FYM /fed increased seed index by 38 and 7.1 % relative to the control, respectively.

Application of FYM increased most of the studied parameters and increasing water deficit from 90 to 75 % from ETo associated with increasing studied plant characters. Irrigation at 75 % from ETo had a promotive effect with rate of increasing 46.58, 6.56, 0.7 and 1.25 % comparing with 90 % ETo for crude protein, N, P, K content in seeds of faba bean, respectively.

The highest values of yield and water crop productivity were obtained after FYM application rate 15 ton/fed (1455.8, 1589.7 kg/fed and 2.42, 3.52 kg/m³), under 90 and 75 % from ETo irrigation treatment and increasing FYM from 10 to 15 ton/fed have been improved by 18.7 and 18.6 % in same sequences comparing with control.

Keywords: Faba Beans, irrigation deficit, farmyard manure, water crop productivity.

Introduction

Egypt has a great challenge from now to next decades to produce enough food from the same amount of available water income from side and increased population randomly. Also, increase the cost of mineral fertilizers, so replace some of mineral fertilizers by farmyard manure (FYM) as a reasonable choice, which play an important role not only in absorb lots of soil water but also can release macro, micronutrients that plant needed and/or keep them from leaching¹.

One of the major problems that limit economically successful agricultural production especially in new reclaimed lands, its poor soil fertility where nutrient depletion of soil is a particular problem in developing countries, whither much grain-legume production occurs^{2,3}. Addition of fertilizers is necessary to overcome

poor soil fertility by supplying nutrients needed for maximize crop production. 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 function⁴). Government is facing sever situation induced by the intense uses of chemical fertilizers and is trying to solve by replacing alternative source which is known by low cost effective and safe environmental. Organic fertilizer, is alternate source of chemical fertilizer³.

Legumes are the major source of proteins for both human and livestock, especially in poor countries. Also, legumes can fix nitrogen in symbiotic association with rhizobia, and so they increase the soil nitrogen content⁵.

Drought is one of the most common environmental stresses that may limit agriculture production worldwide. Whenever, in many countries as a consequence of global climate change and environmental pollution, water use for agriculture is reduced⁶. Additionally large root system may improve a plants ability to continue growth during drought. Deficit irrigation is an irrigation requirements that can be applied by different application methods. The correct application of deficit irrigation requires thorough understanding of the yield response to water deficit⁷.

Conservation of adequate levels of soil organic matter in soils is prerequisite for prospective and high production of crop; therefore this work was carried out to investigate the impact of organic manure application and irrigation treatments on faba bean plant growth, productivity and water crop productivity.

Material and Methods

Field experiments were conducted under drip irrigation method during winter growing seasons of 2013/2014 at Research and Production Station, National Research Centre, El-Nubaria, El-Beheara Governorate, Egypt (latitude 30.8667N, and longitude 30.1667E, and mean altitude 21 m above sea level). This work was conducted to investigate the effect of organic manure application (10 and 15 ton/fed) and irrigation treatments (90 and 75 % from evapotranspiration, ETo) on faba bean (*Vicia faba* L. Giza 461) plant growth, productivity and water crop productivity. The average annual rainfall during growing season are 73 and 68 mm for the examined growing season, respectively.

Soil texture is loamy sand with pH 8.12 (1/2.5) and soil EC 2.34 dSm⁻¹ (1/1) by *Hanna Instruments HI 2550 pH/ORP/EC/TDS/NaCl Benchtop Meter*, CaCO₃ (14.21%) after⁸, OM (0.46%), total nitrogen (1.2 %) and extractable P (18 ppm) in soil were determined after⁹. Soil water retention at 0.1 (Field capacity) and 15.0 (Wilting point) bars were estimated after¹⁰. Soil available water was calculated by subtracting FC – WP.

Farm yard manure was characterized by EC- 2.37 dS/m (1:10), pH - 6.82 (1:10) and C:N - 1:13.24. Experimental design was in a split plot arrangement with four replicates. The main factor, irrigation deficit as a rate of ET (90; 75 %), were distributed in main plots, and FYM rates (10 and 15 tom/fed) allocated in the subplots. Plant distances were 0.25 m apart; 0.90 m among rows with total length of lateral 30 m. Sub-Plot area was 30 m length × 6 laterals, with total area of 180 m². One lateral was lifted between each two irrigation treatments as a protected area. Agriculture practices of faba bean cultivation were carried out regarding to recommendations of the Ministry of Agriculture.

Experimental soil was treated by the FYM rates and well ploughed till 25 cm with 150 kg/fed of superphosphate (15 % P₂O₅) and 50 kg /fed potassium sulphate (50 % K₂O). Seeds of the faba beans (*Vicia faba* L. Giza 461) inoculated by rhizobia and sown by hand (2-3 seeds per hole) on November 26th 2014, at rate 70 kg/fed. Irrigation was applied by drip irrigation system. Ammonium sulphate at 60 kg /fed was applied through irrigation system in 3 doses after 15 from sowing and each 20 days. Flowering stage stated at 60 days from planting date and lasted 35 days. Faba bean plants were harvested after 000 days and irrigation was stopped 15 days before.

Total calculated 601.4 and 458.6 m³/fed for 90 and 75% irrigation treatments, respectively. The total water consumptive during faba bean growing season was 601.4 and 451.1 m³/fed.

Ten plants from each treatments were taken to determine some growth characters, i.e. biological weight, pods weight, seeds/pod, total seeds/plant, seeds weight; seed index, plant height, no. branch, plant weight, no.pods/plant. At harvest seed biological and economical yield (seeds) expressed in ton/fed were determined for each treatments. Plant samples were taken at harvest for measurement of dry weight of shoot, total-N, proline, and some mineral contents of shoots. Seed yield and some chemical constituents of the yielded seeds were also determined at harvest. Plant samples were oven dried (70 °C) for 48 h and total nitrogen was estimated for faba bean by Kjeldahl method, according to ¹¹.

Water crop productivity from irrigation unite (WCP) for seeds was calculated according to ¹² as follows:

$$\text{WCP (kg/m}^3\text{)} = \frac{\text{Seed yield (kg)}}{\text{Total irrigation applied (m}^3\text{)}}$$

Data were subjected to the analysis of variance (ANOVA) allocate to the split plot in a randomized complete block design after to the procedure out- lined by ¹³. The significant differences (LSD) between treatments were compared with the critical difference at 5% probability level.

Results

Table (1) showed the influence of irrigation deficit and FYM application on the faba bean growth characters such as biological weight, no. of branch, plant height, plant weight, no. of pods/plant and no. seeds/plants. The obtained results indicated that the ability of these plant characters to respond for both investigated factors. It is normally to get the minimum values at control whom get half of the recommended N, P and K fertilizer only under both irrigation deficit. There is general trend under both irrigation treatments, where increasing FYM associated with increasing the studied plant growth characters.

Regarding to the importance role of the irrigation treatments on the plant growth characters with increasing percentage 21.9, 13.5, 6.5, 16.3, 4.6, 26.4 and 3.4 %, respectively. Also, it is clear to mention that application FYM increased all the investigated plant growth characters of faba bean by 9, 18, 4.4, 7.1, 6.2, 10.8; 15.7 and 49.5, 45.0, 11.9, 11.8, 85.6; 27.1 %for 10 and 15 ton of FYM per fed as comparing with untreated cones.

However, plant growth characters i.e. total seeds/plant and seeds weight and seed index were clearly improved as a result of applied both factors under investigation. Data on hand revealed that the first two characters were highly responded as a result of water deficit and FYM in combined or individually. Where decreasing irrigation water by 15 % from 90 to 75% of ETo improved total seeds per plant and seed weight by 14.0 and 28.0 % relative to the control (90 % of ETo). While FYM at 15 ton /fed increased the same characters by 45 and 47 % and 10 ton/fed by 9 and 21 % as compared with control treatments.

Lastly, FYM under 90 % irrigation treatment comparing with control. Whereas, under irrigation treatment of 75 % increased same variable progressively. Fortunately, 75 % irrigation treatment from ETo moderately enhanced seed index by 5.6 % relative to the 90 %. While it is clear that FYM had a pronounced effect on seed index where 10 and 15 ton FYM /fed increased it by 38 and 7.1 % relative to the control, respectively.

Table (2) illustrated the effect of the water deficit and FYM application rates on the seeds content of N, P, K , crude protein of faba bean. Data noticed that increasing FYM increased most of the studied parameters and increasing water deficit from 90 to 75 %from ETo associated with increasing studied plant characters. The lowest values were recorded in control treatments in both studied water deficit, while the highest values were obtained after increasing FYM at 15 ton/fed. Meanwhile the effect of water deficit at 75 % from ETo had a promotive effect with rate of increasing 46.58, 6.56, 0.7 and 1.25 % comparing with 90 %from ETo for crude protein, N, P, K content in seeds of faba bean.

With respect to the yield and water crop productivity (WCP), data in table (2) revealed that the lowest values were recorded in control (1215.5, 1350.0 kg/fed and 2.02, 2.99 kg/m³), while values at 75 % of ETo irrigation treatment was higher by about (1350.4/1215.5 kg/fed) and 2.99/2.02 kg/m³), for yield and WCP

relative to the 90 % irrigation treatment, respectively. Where the rate of increase was combined with increasing FYM application from 10 to 15 ton/fed.

The highest values of yield and WCP were obtained after FYM application rate 15 ton/fed (1455.8, 1589.7 kg/fed and 2.42, 3.52 kg/m³), under 90 and 75 % from ETo irrigation treatment.

According to the effect of the main studied factor (water deficit) irrigation at 75 % from ETo had a superior effect on yield and WCP of water deficit faba bean with increasing percentage 9.95 and 46.58 % , respectively. While application FYM at 10 ton /fed improved the yield and WCP by 5.1 and 5.0 % , respectively as compared with control.

Table (1) Effect of water deficit and FYM application rate on plant growth characters of faba bean (mean of two seasons).

Water deficit treatments %ETo	FYM ton/fed	Plant Height (cm)	No. Branch	Plant weight (g)	No. Pod s/plant	Biological weight (g)	Pods Weight (g)	Seeds/pod	Total seeds/plant	Seeds weight (g)	Seed index
90	0	8.7	241.2	23.2	477.9	236.7	3.5	76.7	134.7	70.2	8.7
	10	11.0	246.3	24.0	524.3	278.0	4.0	81.2	164.3	71.3	11.0
	15	14.3	253.7	25.4	654.0	400.3	4.3	108.0	219.3	72.3	14.3
	Mean	11.3	247.1	24.2	552.1	305.0	3.9	88.6	172.8	71.3	11.3
75	0	11.3	261.3	23.5	547.3	286.0	3.5	84.0	165.3	71.2	11.3
	10	12.6	292.0	25.6	593.2	301.2	4.1	93.6	198.2	75.4	12.6
	15	14.7	308.7	26.8	878.4	569.7	4.6	125.4	302.0	79.2	14.7
	Mean	12.9	287.3	25.3	673.0	385.6	4.1	101.0	221.8	75.3	12.9
LSD 5%	Irrigation	1.4	13.2	1.1	15.7	26.7	0.1	8.3	11.2	1.6	0.8
	FYM	1.2	11.2	0.8	14.2	21.3	0.1	7.4	9.8	1.3	0.7
	Interaction	1.5	13.8	1.2	16.3	28.4	0.2	9.2	12.7	1.7	0.8

Table (2) Effect of water deficit and FYM application rate on plant growth characters of faba bean (mean of two seasons).

	FYM ton/fed	Biological weight (kg)	No. of branches	Plant height (cm)	pl W	No of Pods/plant	Pods weight (g)	No. of seeds/pod	Total seedsP	Seeds weight (g)	SI/100 seeds
90	0	485.2	8.5	94.2	251.3	22.1	231.5	3.5	75.2	133.2	69.4
	10	531.3	10.8	97.5	255.7	23.7	274.6	4.1	82.3	157.4	71.8
	15	652.1	14.1	100.2	254.1	25.7	295.3	4.4	105.4	215.3	73.2
	Mean	556.2	11.1	97.3	253.7	23.8	267.1	4.0	87.6	168.6	71.5
75	0	554.2	10.4	96.5	256.4	22.4	278.4	3.4	83.2	166.2	72.1
	10	589.1	12.5	105.4	287.8	25.8	298.3	4.2	94.1	201.2	76.5
	15	823.1	14.3	115.2	302.4	27.1	315.2	4.6	124.8	308.7	79.4
	Mean	655.5	12.4	105.7	282.2	25.1	297.3	4.1	100.7	225.4	76.0
	Irrigation	6.7	0.8	3.3	9.1	1.7	10.2	ns	5.4	13.2	1.7
	FYM	7.2	1.2	4.1	10.8	2.1	13.6	ns	6.5	16.5	2.3
	Interaction	8.4	1.3	4.5	12.3	2.3	15.4	ns	7.3	18.4	2.4

Table (2) Effect of water deficit and FYM application rate on seed macronutrients, crude protein, yield and water crop productivity (mean of two seasons).

Irrigation treatments % ETo	FYM	Yield	Water crop productivity	crude protein content	N	P	K
	Ton/fed	kg/fed	kg/m ³	%			
90	Control	1215.5	2.02	27.40	0.55	0.09	0.84
	10	1285.6	2.14	26.30	0.57	0.10	0.85
	15	1455.8	2.42	26.60	0.63	0.10	0.87
	Mean	1319.0	2.19	26.77	0.58	0.09	0.86
75	Control	1350.4	2.99	27.80	0.57	0.09	0.81
	10	1410.5	3.13	29.70	0.61	0.10	0.86
	15	1589.7	3.52	31.20	0.69	0.10	0.93
	Mean	1450.2	3.21	29.57	0.62	0.10	0.87
LSD %	Irrigation	55.3	0.6	1.6	0.08	ns	ns
	FYM	65.2	0.9	2.1	0.11	ns	ns
	Interaction	87.2	1.1	2.3	0.12	0.1	0.1

FYM; Farm yard manure

Meanwhile, increasing FYM from 10 to 15 ton/fed improved the same plant characters by 18.7 and 18.6 % in same sequences comparing with control. Also, it is worthy to mention that increasing FYM by 5 ton/fed enhanced both characters by about 13%.

Discussion

Chemical fertilizer supply plants by nutrients which are readily soluble in soil solution and thereby instantly available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil¹⁴. The increase in faba bean plant growth characters in response to application of FYM and chemical fertilizers is probably due to enhanced availability of nutrients. The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients.

Saved water could be used to increased cultivated area¹⁵. They added that the main purpose of applied deficit irrigation techniques for a specific crop is one or more of the following: i) maximizes the productivity of water, generally with adequate harvest quality, ii) allows economic planning and stable income due to a stabilization of the harvest.

These results are supported by the findings of¹⁶ whom concluded that the protein percentage of faba bean and some of other legumes differed according to irrigation regimes, where irrigation at 80% depletion of available soil moisture decreased crude protein % of faba bean. In addition,¹⁷ reported that at highest water stress (75% depletion) faba bean gave the highest protein percentage and¹⁸ added that undersevere, moderate and normal irrigations faba bean seed protein content improved through water stress treatment. **Musallam et al.**¹⁹ found that highly water deficit increased seed protein compared with low ones. They also reported that the increase in number of faba bean pods /plant due to influence of different fertilizer combinations. So, biological weight per plant, N, P, K and crude protein content in seeds might be due to the more availability of nitrogen, which plays an important role in cell division.

Additionally, FYM and its application rates offer more balanced nutrition to the plants, especially micro nutrients which positively affect plants growth characters²⁰. To achieve high yield maximization of seeds is an important factor. In the present investigation, organic manure alone and in combination with chemical fertilizers significantly increased plant growth characters over untreated control. Similar findings are reported by²¹ who found that irrigation at 25% of available soil moisture depletion significantly increased faba bean plant growth characters (height, number of branches/plant, number of pods/plant, seed index) and seed and straw yields/fed^{22,23}.

The productivity of faba bean plant is greatly dependent on the number of branches and pods per plant rather than the total number of pods/plant. In these investigation maximum number of pods per plant and hence no of seeds were observed in the all the treated plants. From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective seed yield if we can supplement it from organic

manures, which also help in providing essential micronutrients to the plants^{1;24}. In present investigation data observed reduction in yield and yield components with increasing irrigation water applied 90 % from ETo. The obtained data supported by²⁵ who tested the impact of three irrigation levels (80%, 100% and 120% of class A-pan) on the growth and yield of green bean. He found that vegetative growth parameters as well as yield components responded positively with increasing the irrigation level such as plant height, number of leaves and fresh and dry weights were increased with increasing irrigation rate.

A significant difference in seed index (100-grain weight of faba bean) as affected by variation in fertilizer packages was also observed by²⁶. Also,^{27;28} mentioned that suitable amount of irrigation water enhanced microorganisms production that encourage aggregates formation and hence increase soil ability to retain more nutrients and water.

From the above discussion, it is clear that FYM had a promotive effect on growth and productivity in faba bean. Organic manure can also be a better supplement of inorganic fertilizer to produce better growth and yield. All the treatments showed significant influence on growth and productivity of faba bean. It was observed that 15 ton/fed organic fertilizer along with 50 % recommended chemical fertilizer could give not only similar yield, but also increased by about 15 to 27 %. However, among organic manure treatments the 15 ton/fed itself produced the better grain yield compared to the 10 ton/fed. From the economic point of view farmers can use the combination of organic manure and reduced rate of mineral fertilizers to boost the yield of faba bean as well as to maintain and improve soil quality.

Conclusion

Growth characters and yield components were enhanced positively by application irrigation requirement at 75 % from ETo and application of 15 ton of FYM, which seems adequate for optimum seed production. Similarly, application of half amount of NPK recommended in addition to 15 ton/fed of FYM under irrigation treatment 75 % from ETo to faba bean on the field showed that under prevailing climatic and field conditions with good management practices, the growth and yield of faba bean could be greatly improved. Conclusively, under the prevailing poor soil organic matter content that act as soil conditions, fertilization at 50 % from recommended NPK is adequate for optimum growth, and seed yield of faba bean. However, further studies may be needed to conclude whether this level of application is capable of minimizing irrigation requirement while keeping the yields as high as possible.

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