THE EFFICACY OF DIFFERENT IRRIGATION LEVELS ON THE YIELDS OF SOME SUMMER CROPS UNDER INTERCROPPING SYSTEMS

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Abstract

Field studies were performed between 2014 and 2019 on clay soil in a farmer's field in Al - Yadudeh area south of Amman - Jordan, to investigate the efficacy of different irrigation levels (0.40, 0.60 and 0.80 of field capacity) on the yields of bean, squash and okra as they are grown under sole cropping and intercropping systems, using 1:2 and 2:1 row arrangements. Results showed that the highest significant yields of bean (10.20 ton ha^{-1}) and squash (37.05 ton ha^{-1}) were obtained when minimum soil moisture level was maintained throughout the growing season at 0.60 of field capacity (FC) under 1:2 intercropping row arrangement, while the highest significant yield of okra (13.64 ton ha^{-1}) was registered when it was intercropped with bean in 1:2 row arrangement at minimum soil moisture level of 0.80FC. Additionally, okra intercropped with squash affected each other negatively and obtained the lowest significant yields specially, when they were grown under minimum soil moisture of 0.40 FC in 1:2 and 2:1 row arrangement respectively. Moreover, the highest significant yields of bean, squash and okra, as they are grown under sole cropping were obtained at minimum soil moisture level of 0.80FC, as compared to minimum soil moisture level of 0.40 and 0.60FC. It seems that squash was more beneficial to bean than okra and bean was more beneficial to okra and squash than squash to okra and okra to squash. Regarding the efficiency of intercropping as it was evaluated by land equivalent ratio (LER), the results showed that all the three combinations of intercropping with their row arrangements and under the three soil moisture levels gave LER values more than one, demonstrating the superiority of intercropping than sole cropping.

Key words: intercropping, soil moisture level, summer crop yields, efficiency

Irrigated agriculture in Jordan, as in many other countries, uses less of the available fresh water, and its contribution to the national products is also low. However, there is an increasing competition for water demand among household, industry and tourism; therefore, the efficiency of water use in irrigated agriculture must be raised to make it clear there is room for these requirements (IWAUP 2009).

Therefore, crop productivity and saving irrigation water are two main issues that raising a lot of concern nowadays. However, the scientific challenge is to find out a cropping system that could address these two issues considering water scarcity, in many of countries including Jordan.

Jose G.F Jr. (2018), indicated that intercropping could be a method, used to increase overall crop production without increasing water inputs. Willey R.W. (1979) and Sharaiha R., and Gliessman S. (1992) pointed out that intercropping is one of the multiple cropping systems, involving growing two or more crops in a given piece of land to produce a greater yield resulted from the complementary use of growth resources over time and space.

Additionally, Yu. Hong *et al*, (2019), mentioned that intercropping can reduce pressure on water resources through exploitation of complementarities between species. Moreover, Gaballa *et al*, (2007), concluded that soybean intercropped with corn in 1:2 row arrangement, could save up to 7% of irrigation amounts. Philip T. *et al* (2007), found that squash intercropped with corn affects corn yield negatively under limited soil moisture. Furthermore, Sharaiha R. and Hadidi N. (2008), in their study on microclimate effects on bean and potato yields grown under intercropping system, showed that bean plant seems to have beneficial effect on potato regardless to the variety.

It can be concluded also, that the higher yield of been as it was intercropped with potato resulted from the significant higher water use efficiency and lower evapotranspiration, especially under 2:2 bean/potato intercropping row arrangement. Moreover, Sharaiha R. *et al* (2012)

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and Bucur D. (2017, 2019) concluded that the highest yields of corn and potato yields were obtained under intercropping at soil moisture level of 75% FC, while that of fava bean intercropping was at 65% FC.

Since the amount of water applied under intercropping system depends on the crops combination and on intercropping row arrangements, more work of this nature is needed to provide more information and better understanding of these principles in order to optimize crop water productivity. Therefore, the objectives of this experiment were to study the effect of different soil moisture levels on the yields of bean squash and okra as they were grown under intercropping and sole cropping, and to evaluate the efficiency of intercropping according to land equivalent ratio (LER) under different row arrangements and soil moisture levels.

MATERIALS AND METHODS

The experiment was initiated in the year 2014 and carried out in a farmer's field located in Yadudeh in Madaba region.

The farm is situated on a latitude 31°59°N, longitude 35°59°E, and at an altitude around 820m above sea level. Soil pH varied between 7.6 - 8.2, classified as a clay soil (66% clay, 21% silt and 13 % sand).

The climate of Madaba is a Mediterranean, characterized by dry hot summer (maximum average temperature of 32.7°and minimum average temperature of 20.4°C), mild wet winter (maximum average temperature of 12°C and minimum average temperature of 4.2°C), and extreme variability in rainfall within and among years. Composed poultry manure was applied (25 Mt. ha-1) two weeks before planting.

The manure used contained 1.22 % N, 1.3 % K and 1.5% P. Three summer crops namely okra (*Ablmoschus esculentus*, Local variety, squash (*Cucurbita maxima*), Jazi variety and been (*Phaseolus vulgaris*), Bronco variety were planted late March, using the same two row arrangements (1:2, and 2:1) for the three combinations; bean/ squash, bean/ okra, and squash okra), in addition to their sole crops.

However, three levels of soil moisture (40% FC, 60% FC and 80% FC) were used. Split plot design was employed with three replications, intercropping being the main plot, and the levels of soil moisture as sub plot (Figure 1). Each plot consisted of six rows 0.65 m apart and 4 m long, and within row spacing of 0.15 m for bean: 0.25 m for okra, and 0.35 m for squash.

Weeds were kept under control by hand weeding. Drip irrigation system was used by installing surface lateral plastic pipes of 16 mm diameter on every planting row in order to deliver water to plants. In line drippers with a discharge rate of 4 liters/hour and 40 cm spacing were used.

To monitor the applied volume of water, flow meters were connected to three replicates that have the same level of soil moisture (fig 1). Soil moisture measurements were taken in order to calculate the soil moisture level (SML), and amount of water is calculated according to the required SML using the following formulas SML= PWP+ 2/3(FC- PWP) and the amount of water for each level A= S x Bd x Rd x (FC - SML) / 100, where A= amount of water (m^3), S=surface area (m^2), Bd = bulk density (m^3/m^3), Rd=root depth (m).

However, the amount of water was recorded by water meter (Sisesti V. I., 1974). Average soil moisture measurements were taken by auger at 15, 45 and 75 cm depths.

RESULTS AND DISCUSSION

Bean Yield

Results from this study (*table 1*), shows that bean sole crop gave different significant yield response when it was planted under three soil moisture levels (40%, 60%, and 80% of FC). However, bean sole crop grown under a soil moisture level of 80% FC, gave an increase in yield of 24% and 21% over the yield obtained by bean sole crop grown under 40% and 60% of FC, respectively. The higher yield of bean sole crop obtained under soil moisture of 80% FC could be attributed to the increasing in irrigation frequency that lead plant roots to absorb water from the soil much better and that might reflect positively on bean yield production. These present results are in general agreement with those obtained by Jianfang G. *et al*, (2019), in their study of the Effects of Irrigation Amount and Irrigation Frequency on Flue-Cured Tobacco Evapotranspiration and Water Use Efficiency.

When sole cropping and intercropping are considered, almost all intercropping combinations of bean with squash and with okra under the soil moisture levels of 40%, 60%, and 80% of FC, gave greater yields of bean than that produced under sole cropping at the same soil moisture levels. The higher intercropped bean yield might be due to the more efficient use of available resources per unit area. This fact has been reported previously by many researchers; S. Mahmud S. *et al*, 2018; Sharaiha R. *et al*, 2012; Yuan Y. *et al*, 2017.

Soil moisture level 0.40 FC							Soil moisture level 0.60 FC							Soil moisture level 0.80 FC						
T1	S	S	S	S	S	S	T5	B	B	O	B	B	O	T3	B	S	S	B	S	S
T2	S	S	O	S	S	O	T7	O	O	B	O	O	B	T8	O	O	O	O	O	O
T3	B	S	S	B	S	S	T4	O	O	S	O	O	S	T7	O	O	B	O	O	B
T4	O	O	S	O	O	S	T8	O	O	O	O	O	O	T1	S	S	S	S	S	S
T5	B	B	O	B	B	O	T3	B	S	S	B	S	S	T2	S	S	O	S	S	O
T6	B	S	S	B	S	S	T1	S	S	S	S	S	S	T4	O	O	S	O	O	S
T7	O	O	B	O	O	B	T9	B	B	B	B	B	B	T5	B	B	O	B	B	O
T8	O	O	O	O	O	O	T6	B	S	S	B	S	S	T9	B	B	B	B	B	B
T9	B	B	B	B	B	B	T2	S	S	O	S	S	O	T6	B	S	S	B	S	S

Note: O: Okra. S: Squash B: Bean

Figure 1 **Experiment layout for one replicate**

Table 1, showed that bean intercropped with squash, under the three soils moisture levels (40% FC, 60% FC and 80% FC), gave a significant more yield production than bean planted with okra. The resulting average yield of bean planted with squash in 1:2 row arrangement was higher by 24.6% than the average yield of been grown with okra under the same row arrangement, regardless of the soil moisture levels.

While the resulting average yield of bean planted with squash in 2:1 row arrangement was higher by18.4% than the average yield of been grown with okra under the same row arrangement, regardless of the soil moisture levels. Moreover, when soil moisture levels (40% FC, 60% FC and 80% FC) are considered, the resulting average yields of bean planted with squash gave greater yields by 26.3%, 15.1% and 25.6% respectively, than the average yields of bean planted with okra under the same soil moisture level, regardless to the patterns of row arrangements.

Furthermore, when bean was intercropped with squash in 1:2 and 2:1 row arrangement under the three soil moisture levels (*table 1*), significant differences were not obtained. This could be due to the associated crop (squash plant) that might act as natural mulch reducing soil temperature, helping to hold moisture in soil, and might hide the effect of the different soil moisture levels on bean yields. However, the same trend was obtained with bean when it was planted with okra. Moreover, contrary to these results was the effect of soil moisture levels on bean yields as it was planted with okra under the same row arrangement.

Table 1

Effect of soil moisture levels, crop combination and intercropping row arrangements on yield of bean (ton ha^{-1})

Treatments	Soil moisture level		
	0.40 FC	0.60 FC	0.80 FC
1 row Bean 2 rows Squash	9.80 ab	10.20 a	9.65 ab
2 rows Bean 1 row Squash	9.58 ab	9.51 ab	9.20 bc
1 row Bean 2 rows Okra	8.08 def	8.42 de	7.30 gh
2 rows Bean 1 row Okra	7.35 fg	8.70 cd	7.63 efg
Sole crop	8.43 de	6.93gh	6.79 h

The greatest bean yields were obtained when it was planted with okra under 60 % of FC in 2:1 (sig.) and 1:2 (insig.) as compared with the soil moisture level of 40% and 80 % of FC. It seems that bean grown with okra under 40% of FC is more sensitive to stress conditions due to long intervals between irrigations and also might be sensitive to soil moisture level of 80% of FC due to short intervals between irrigations.

Furthermore, almost all the intercropping results of bean gave higher significant yield production as compared to yield of bean sole crop under the same soil moisture levels. It is obviously clear that the best soil moisture level for bean as it was grown with okra in 2:1 row arrangement, under 60 % of FC, where it gave a significant increase of 14% and 18% over bean yield grown under 40% and 80% of FC within the same row arrangement, respectively, the same trend was observed when bean was intercropped with okra in 1:2 row arrangement. These cases might be due to the efficient use of resources. This fact has been mentioned by many researchers Yaan, R. *et al*, 2017; Sharaiha R. *et al*, 2004; Francis, 1985.

Additionally, when combinations (bean / squash and bean okra), cropping patterns (1:2 and 2:1 row arrangements), and the three soil moisture levels are considered (*table 1*). It seems that squash plants were more beneficial to bean than okra, under the same soil moisture levels and under the same row arrangements. It seems that the beneficial effect of squash on bean can be attributed to the efficient use of light due to the wider spaces between rows of bean created by the creeping stems of squash in 1:2 and 2:1 row arrangement. This fact was reflected significantly on the yields of bean that were intercropped with squash as compared to the bean intercropped with okra under the different soil moisture levels and the different cropping pattern. These results also could be attributed to the contrasting nature of the two associated crops, whereas squash with its creeping stem sprawling around the bush bean plants.

Thus, squash plant might act as a natural mulch and helping to hold moisture in soil that was utilized by bean plants instead of being lost through soil evaporation as in the case with okra. Similar results were obtained by Gliessman S (1988), working on Corn, bean and squash intercropping, and Haddidi *et al* (2011), working on the effect of intercropping on the performance of some summer crops grown under different row arrangements.

Squash Yield

There were no significant differences in yield of squash grown as a sole crop under the different soil moisture levels used (40%, 60 % and 80 % of FC) (*table 2*). This might indicate that there was no intra-specific competition among squash plants, since the stem of squash plants were creepy and prone to lighting. In addition, the creepy stem of squash might act as natural mulch, thus reducing soil temperature and helping to hold moisture in soil. As such, the effect of different soil moisture levels on bean yields might be hidden. Moreover, the competition for nutrition was also excluded since organic fertilizer was provided in adequate quantities. When a comparison is made between the yields of squash grown with bean or with okra, it is obvious that the yield of squash intercropped with bean gave greater yields than squash intercropped with okra, under all soil moisture levels used. Whereas, it gave an average significant increase of 15.1%, 33% and 26.7% over the average yields of bean grown with okra under the three soil moisture levels of 40%, 60 % and 80 % of FC, respectively, regardless to the cropping pattern of row arrangement used. It was noticed that squash grown with bean in 1:2 intercropping row arrangement gave a significant increase of 34% in average yield over the average yield of bean grown with okra under the same row arrangement, regardless of soil moisture level. However, when squash was grown with bean under 2:1 intercropping row arrangement, an increase in average yield of 16.5 % was obtained over the yield produced by squash grown with okra under the same row arrangement (2:1), regardless of soil moisture levels. The beneficial effect of bean on squash was expected since been used to fix atmospheric nitrogen in the soil that might be beneficial to squash crop. This fact was revealed by other researchers [Sharaiha, R. and R. Kluson (1994), Ananthi, T. et al., (2017), and Michael K. et al., (2017).

Table 2

Effect of soil moisture levels, crop combination and intercropping row arrangements on yield of squash (ton ha^{-1})

Treatments	Soil moisture level		
	0.40 FC	0.60 FC	0.80 FC
1 row Squash 2 rows Bean	30.82 b	37.05 a	28.57 cd
2 rows Squash 1 row Bean	35.77 a	29.70 bc	28.72 cd
1 row Squash 2 rows Okra	25.58 d	23.09 e	22. 83 e
2 rows Squash 1 row Okra	26.84 d	27.05 d	26.92 d
Sole crop Squash	28.41 cd	28.37 cd	27.82 cd

Furthermore, when squash was intercropped with bean in 1:2 and 2:1 row arrangement, higher been yields were obtained under all soil moisture levels than squash sole crop under the same soil moisture level. However, the greatest significant yields were obtained in 60% and 80% of FC as compared with squash sole crop grown under the same soil moisture level. Moreover, when squash was intercropped with okra, no significant differences in squash yields were obtained under all soil moisture levels compared to sole squash yield grown under the same moisture level.

An exception was recorded when squash was planted with okra in 1:2 row arrangement, under 40% and 60% of Fc where it gave a significant decrease in yield of 21.2% and 22.9% over the yield of squash sole crop grown under the same row arrangement. This variation in squash yields might indicate that the different amounts of water applied under the three soil moisture levels, the two different patterns and the associated crops might play an important role in modification of microclimate and consequently reflect on the yield of squash. Similar results were obtained by Sharaiha, R. and A. Battikhi (2002), in their study on potato / corn intercropping - Microclimate modification and yield advantages and by Sharaiha R. and Hadidi N. (2007) in their work on environmental impact on yield of peas and okra grown under intercropping.

Okra Yield

The combined analysis of variance for okra yield showed significant variation for its yield when it was grown under sole cropping and intercropping with bean and squash under three soil moisture levels (40%, 60% and 80% of Fc) Table (3). However, when okra was planted as a sole crop under 80 % of FC, a significant increase in yield of 91% and 94.8% over the yield of okra sole crop grown under 40 % and 60% of FC, respectively. Similar results were obtained by Fapohunda H.O. (1992) in his study on irrigation frequency and amount for okra and tomato using a point source sprinkler system, and in full agreement with Ganesh B. I. *et al*, (2015).

Additionally, the same trend was with okra grown in association with bean under 80% of FC, where it gave an average increase in yield of 48% and 42% over the average yields obtained under 60% and 40% of FC, respectively, regardless to the row arrangement patterns.

However, the same trend was observed when okra was grown with squash under 80 % of FC, where an average increase in okra yield of 32% and 55.8 % over the average yields of okra grown with squash under 60% and 40% of FC, respectively. This fact has been postulated by Hassan *et al*, (2011), who explained that the shorter intervals between irrigations gave the highest fruit yield and greatest number of roots than longer intervals.

On the other hand, when okra was grown in association with squash and bean in 1:2 and 2:1

row arrangement under the three treatments of soil moisture levels, significant higher yields were obtained compared to okra sole crop grown under the same soil moisture level. These results might suggest that the associated crops (squash and bean) have beneficial effect on okra.

However, the beneficial effect of bean on okra generally was much better than squash on okra under the same soil moisture levels (40%, 60% and 80% of Fc), and under the same two patterns of row arrangements (1:2 and 2:1). This could be explained that the fixation of atmospheric nitrogen in the soil by bean crop, hence, nitrogen contribution to okra plants during the same growing season. This fact has been indicated by many researchers (Olasantan, F. (1998); (Sharaiha, R. and R. Kluson, 1994); (Ruschel *et al*, 1979); and (Lal *et al*, 1978).

Moreover, okra grown with squash also gave significant higher yield than the yield of okra sole crop regardless of the soil moisture levels. The beneficial effect of squash on bean provided from the efficient use of light due to the wider spaces between rows of bean created by the creeping stems of squash in 1:2 and 2:1 row arrangement that might create different micro-environments and reflect positively on okra yield. These results appeared to be in full agreement with the findings of Trenbath, B. R. (1976) who elucidated that a plant with usually long shoot, such as okra, in a dens sole crop would negatively affect lighting and, consequently leads to a poor root / shoot ratio due to the scarce of photosynthesis.

Furthermore, Table (3), showed that when okra was intercropped with bean in 1:2 and 2:1 row arrangement, no significant differences in yields were obtained between the two row arrangement under the same soil moisture level. In contrast, significant difference in okra yields were obtained within each row arrangement among the three soil moisture levels. These results might indicate that the effect of soil moisture levels on okra yield is stronger than the effect of row arrangement, (in case of okra was planted with bean). However, when okra was planted with squash, this conclusion was not observed since there is a significant difference in okra yield between the two row arrangements under 60% of FC.

Table 3

Effect of soil moisture levels, crop combination and intercropping row arrangements on yield of okra (ton ha^{-1})

Treatments	Soil moisture level		
	0.40 FC	0.60 FC	0.80 FC
1 row Okra 2 rows Bean	13.64 a	9.37 cd	9.26 cd
2rows Okra 1 row Bean	12.99 a	8.59 d	9.44 cd
1 row Okra 2 rows Squash	10,58 b	8.42 d	6.47 e
2 rows Okra 1 row Squash	9.93 bc	7.02 e	6.69 e
Sole crop Okra	8.92 d	4.58 f	4.67 f

Therefore, the varied results of okra yields are due to soil moisture level, intercropping combination (as it was grown in association with bush bean and squash), and intercropping pattern (1:2 and 2:1). Similar results were obtained by Sharaiha R. *et al*, (2012) in their work on intercropping of potato, faba bean and corn under different intercropping levels of irrigation.

Land Equivalent Ratio

Land equivalent ratio (LER) is the measure of production efficiency of different systems by convening the production in terms of land. The FAO defines land equivalent ratio (LER) as the ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level. Therefore, it is the sum of the fractions of the intercropped yields divided by the sole-crop yields. It has been used by many researchers; Willey (1979); Natrajan and Wiley (1980); Gliessman (1998), Sharaiha and Battikhi (2004), and Aliyeh *et al*, (2018).

When the value of LER is greater than one, it indicates the efficiency of intercropping system over the sole cropping system. Thus, *table 4* verified that all intercropping combinations under two patterns and three soil moisture levels gave a LER more than one. This could be credited to better use of resources by the two crops that are grown in association. The total LER and the relative LER values were variable and affected by the soil moisture levels, crop combinations and intercropping patterns (row arrangements).

This was expected, since each combination and row arrangement pattern under different soil moisture levels, create a different local climate that might change the competition for light moisture and nutrients. Furthermore, when soil moisture levels are considered, the lowest values of LER were obtained under 80% of FC, regardless to crop combinations and row arrangements.

However, this was not found to be true in 1:2 bean / squash intercropping row arrangement *Table 4*, where the highest LER value (1.23) was obtained with more contribution of squash. Squash gave 18% more than it was expected from a sole squash crop planted in 2/3 of the land, while the contribution of bean was only 6%, but more than it was expected from sole bean crop planted in 1/3 of the land.

Table 4

Relative land equivalent ratio (LER), total LER of bean, squash and okra grown in different row arrangements (1:2 and 2:1) and soil moisture levels (SML)

Treatments	SML 0.40 FC		Total LER	SML 0.60 FC		Total LER	SML 0.80 FC		Total LER
	R Y	R LER		R Y	R LER		R Y	R LER	
1 row Bean 2 rows Squash	3.21 19.15	0.47 0.68	1.15	3.40 19.80	0.49 0.70	1.19	3.27 23.85	0.39 0,84	1.23
2 rows Bean 1 rows Squash	6.13 9.52	0.90 0.34	1.24	6.34 12.35	0.91 0.43	1.34	6.38 10.27	0.76 0.36	1.12
1 row Bean 2 rows Okra	2.43 6.29	0.36 1,35	1.71	2.81 5.73	0.40 1.25	1.65	2.69 8,66	0.32 0.97	1.29
2 rows Bean 1 row Okra	5.09 3.09	0.75 0.66	1.41	5.80 3,12	0.84 0.68	1.52	4.90 4.55	0.58 0.51	1.09
1 row Okra 2 rows Squash	2.15 17.95	0.46 0.64	1.10	2,81 18.03	0.61 0.64	1.25	3.53 17.89	0,39 0.63	1.02
2 rows Okra 1 row Squash	4.46 7.61	0.95 0.27	1.22	4,68 7.70	1.02 0.27	1.29	6.62 8.53	0.74 0.30	1.04

Note: Yields of bean ton ha^{-1} sole crop at: 0.40 FC = 6.79; 0.60 FC = 6.93; 0.80 FC Bean= 8.43
Yields of squash ton ha^{-1} sole crop at: 0.40 FC = 27.82; 0.60 FC = 6.93; 0.80 FC Bean= 8.43
Yields of okra ton ha^{-1} sole crop at: 0.40 FC= 4.67; 0.60 FC = 6.93; 0.80 FC Bean= 8.4

Both crops were benefited from each other but to varying degrees in favor of squash and this was termed by Willey (1979); and Gliessman (1988); as mutual cooperation. Similar results were obtained by Sharaiha and Battikhi (2002) in their study on potato / corn intercropping: Microclimate modification and yield advantages.

Moreover, bean planted with squash gave higher values of relative LER than bean planted with okra under the same soil moisture levels and row arrangements. This could be attributed to okra plant because it became more competitive and depressed the associated crop bean yields to a greater degree with decreasing soil moisture levels.

Accordingly, the contribution of bean planted with squash was much better than the contribution when it was planted with okra under all soil moisture levels used. This was expected due to the contrasting nature of the two associated crops (okra and bean) that reflected on their yield production and consequently on the relative values of LER.

This trend was observed when okra was planted with squash as compared to bean planted with squash, and hence, the contribution of squash was much better with bean than with okra. The negative effect of okra on the relative LER of squash was stronger than on the relative LER of bean. This is because the values of relative LER for squash grown with okra were less than expected from a sole squash crop planted in 2/3 and/or 1/3 of the land, under all soil moisture levels and row arrangements.

From the above discussion, it seems that LER was affected to a certain degree by the interaction among soil moisture levels, crop combination and by cropping pattern. Thus, each factor affects and is affected by, all the other.

CONCLUSSIONS

1. The results of this work indicated that the yields of bean, squash and Okra grown under intercropping were more affected by soil moisture levels as compared with the corresponding sole crops.

2. Bean and squash gave higher yields under a soil moisture level of 0.60 FC when they are grown under 1:2 intercropping row arrangement, while that of okra was at 0.80 FC under 1:2 okra / bean intercropping row arrangement.

3. Bean seems to have more beneficial effect on okra and squash than that of each other.

4. The efficiency of intercropping as it was judged by LERs was higher than that of sole cropping, but their values depended on soil moisture level, crop combinations and raw arrangements.

REFERENCES

Aliyeh S., Sina F., Reinhard N., Bano M., Hans P. K., 2018 - *Growth analysis and land equivalent ratio of fenugreek buckwheat intercrops at different fertilizer types*. Journal of Land Management, Food and Environment Volume 69, Issue 2, 105-119.

Al-Qahwaji A., 1995 - *Production Function Determination of Row Intercropping between Broad Bean and Potato under Different Water Amounts under Central Jordan Valley Condition*. M.Sc. Thesis, Univ. of Jordan, Amman.

Ananthi T., Amanullah M. M., Al-Tawaha A. M. 2017 - *A Review on Maize- Legume Intercropping for Enhancing the Productivity and Soil Fertility for Sustainable Agriculture in India*. Advances in Environmental Biology, 49 - 63.

Bucur D. ed., 2019 - *Advanced Evapotranspiration Methods and Applications*, IntechOpen, London, DOI: 10.5772/intechopen.73720, 128 pages, ISBN: 978-1-78985-811-2 https://www.intechopen.com/books/current-perspective-to-predict-actual-evapotranspiration.

Bucur D. ed., **2017** - *Current Perspective to Predict Actual Evapotranspiration*, InTech, Rijeka, ISBN 978-953-51-3173-1, 114 pages.

Francis C.A., 1985 - *Variety Development for Multiple Cropping Systems*. CRC. Critical Review LN Pl. Sc. 3, (2):133- 138

Gaballa M.S., Quda S. A., Khalil F. A. l., 2008 - *Effect of Water Stress on The Yield of Soybean and Maize Grown Under Different Intercropping Patterns*. Twelfth International Water Technology Conference, IWTC12, Alexandria Egypt. 611-624.

Ganesh R. B., Bhaskara I.R.A., Raja K.N. R., 2015 - *Response of Okra to Different Levels of Drip Irrigation on Growth, Yield and Water Use Efficiency*. International Journal of Agricultural Engineering, Volume 8, Issue 1, 47-53.

Gliessman S. R., 1988 - *Agroecology: Ecological Process in Sustainable Agriculture*. Chap. 14. Genetic Res. In agroecosystem. Edit. Eric Engles. Ann Arbor Press: 193 - 212.

Hadidi N., Sharaiha R.K., 2011 - *Effect of Intercropping on the Performance of some Summer Crops Grown under Different Row Arrangements*. Lucrări ştiinţifice - vol. 54, Nr. 2/2011,

I.W.A.U.P., 2009 - *Irrigation Water Allocation and Use Policy*_ar.doc-

Jose G.F., Stepphen R.K., Volder A., 2018 - *Component Crop Physiology and Water Use Efficiency in Response to Intercropping*. European Journal of Agronomy 93:27-39 ·

Jianfang G., Shao X.H., Miao Q., Yang X., Gao C., 2019 - Effects of Irrigation Amount and Irrigation Frequency on Flue-Cured Tobacco Evapotranspiration and Water Use Efficiency Based on Three-Year Field Drip-Irrigated Experiments. Agronomy J. 9(10), 624.

Lal R., De R., Singh R. K., 1978 - Legume Contribution to Fertilizer Economy in Legume Cereal Rotations. India J. Agr. Sc. :48:419 = 424.

Mahmud S., Alam M.M., Rahman M.M., Amin M., Hassan M.M. H., 2018 - *Productivity and Economics of Maize-Squash Intercropping at Different Planting Systems*. J Bangladesh Agricultural Univ. 16(1): 23-26.

Natrajan M.A., Willey R.W., 1980 - *Sorghum Pigeon Pea Intercropping and The Effect of Plant Population Density to Resource Use*. J. Agr. Sc. Camb. 95: 59 - 69.

Olasantan F.O. 1998 - *Effects of Preceding Maize and Cowpea in Sole-Cropping and Intercropping on Growth Yield and Nitrogen Requirement of Okra*. J. Agric, Sc. Camp. 131:293- 298.

Philip T.F., S.R. Gliessman J.H. Langgenheim, 2007 - *Factors in The Suppression of Weeds by Squash Inter-Planted in Corn*. J. Of Weed biology and management.Vol.7 Issues2.

Ruschel A.P., E. Salati, P.B. Vosc, 1979 - *Nitrogen Enrichment of Soil and Plant by Rhizobium Phasoeoli, Phaseolus Vulgaris Sybiosis*. Plant soil 51, :425- 429.

Sharaiha R.K., H. M. Saoub, O. Kafawin, 2004 - Varietal Response of Potato, Bean and Corn Intercropping. J. Dirasat, Agr. Sc., Vol. 31, No.1

Sharaiha R.K., M. Shatanawi, N. Haddidi, 2012 - *Intercropping of Potato, Faba Bean and Corn under Different Intercropping Levels of Irrigation*. Agricola montologie cadastru, Lucrari Stiintifice. Vol. XLII. 20 - 28.

Sharaih R.K., Battikhi A.M., 2004 - A *Study on Potato Corn Intercropping-Microclimate Modification and Yield Advantages*. Dirasat Journal, Vol.29, No. (2), 97-107

Sharaiha R.K., Kluson., R. A. 1994 - *Di Nitrogen Fixation of Faba Bean as Affected by Intercropping System with Pea and lettuce*. Dirasat. Agrc. Sci., 21B. (4):127-133.

Sharaiha R.K., Hadidi N.A., 2008 - *Micro Environmental Effects on Bean and Potato Yields Grown Under Intercropping System*. Lucrări - Ştiinţifice. Editura Ion Ionescu de la Brad. Iasi. Vol. 51: 209-219.

Sharaiha R.K., N. Hadidi, 2007 - *Environmental Impact on Yield of Peas and Okra Grown Under intercropping*. Lucrări - Ştiinţifice. Editura Ion Ionescu de la Brad. Iasi. Vol. 50 :313-323.

Sisesti V. I., 1971 - *CulturIrigate, Editura Didactica Si Pedagogica-Bucuresti*.

Trenbath B.R., 1976 - *Plant Interactions in Mixed Crop Communities*. Multiple Cropping Symposium Proceedings, American Society of Agronomy. Annual Meeting. Tennessee, 24 - 29 August.

Willey R.W. 1979 - *Intercropping and Research Needs*. Part 1. Competition and yield advantages. Field crops Res. 25: 83 - 97

Yuan Y., U. Ren X.L., Wang S.Q., Zhang J. ., Palta Yi., Chen. L. 2017 - *Influence of Spatial Arrangement in Maize-Soybean Intercropping on Root Growth and Water Use Efficiency*. Plant and Soil, 415:131-144.