

The Effect of Intercropping system of Wheat and Lentil Crops , and sowing Methods on yield and its components under Rain Fed Area in Fayda location.

Alrijabo, Islam Abdulsattar Asmair, and Talal Abed Khattab Al- Healy

¹(College of Agriculture and Forestry/ Mosul University, IRAQ)

²(College of Agriculture and Forestry/ Mosul University, IRAQ)

ABSTRACT: A field study was implemented at Fayda location which is MRA, (40 km from Mosul city), bread wheat seeds (*Triticum aestivum* L.) of certified class- Jehan variety and lentils crop (*Lens culinaris* Medik.) commercial class Ninevah local variety were sown on 14/11/2019. Using (Ras alromh) zero tillage seeder with 2 meter working width and 30 cm distance between each tine. The experiment design was RCBD with one Main factor but included three sub-factors, 1st the Wheat-Lentils intercropping system . (60%W.+ 40%L.) (72 kg.ha-1.W.+32 kg.ha-1. L.), (40%W.+ 60% L.) (48 kg.ha-1. W. + 48 kg.ha-1. L.), (100% W.=120 kg. ha-1), and (100% L=80 kg.ha-1). The 2nd subfactor two sowing methods liner sowing (30 cm) and cross sowing (30*30 cm), and the 3rd -factor (+)(-) Pallas-45 herbicide using. All the three subfactors were under control of the main single factor. The results indicated that cross sowing either for the individual sowing or intercropping sowing significantly enhanced the plants growth, yield and its components traits, such as, chlorophyll content index, flag leaf, No. of spikes, biological yield, straw yield gm.m-2, grains yield, and protein percentage. Using Pallas-45 herbicide increased grains yield, and some of yield components traits. Protein% trait increased under both levels of cross sowing compared with single sowing 100% wheat crop. Moreover, the intercropping system using cross sowing enhanced yield and its components for both crops , the percentage of yield increasing was more than 30% of the default yield for single sowing of both crops in the same area..(10 Italic)

KEYWORDS– intercropping ,cross sowing, linear sowing, Pallas-45, wheat-lentil

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I. INTRODUCTION

Intercropping is an advanced technique in which two or more crops are grown on the same plot of land at the same time, through which the maximum benefit can be obtained on a sustainable basis [1].

And one of the most famous applications of the phenomenon of integration is the cultivation of grains-legumes by the intercropping method, where legumes contribute to a large extent in the larger installment of integration to be a major determinant of better productivity for such intercropped crops [2]. To ensure food production and environmental security, we need to adopt best agricultural practices and choose appropriate farming systems that have the ability to use sunlight and earth resources efficiently with minimal input. This can be achieved through intercropping systems [3].

Zero-tillage definition is as carrying out the seeding process without prior cultivation of the field while minimizing soil agitation to a minimum level when sowing, and it is a modern scientific view of an ancient application of the agricultural process practiced by humans relying on the ecological balance without damage or waste of resources: Natural soil, water and soil organic and biological contents. [4].

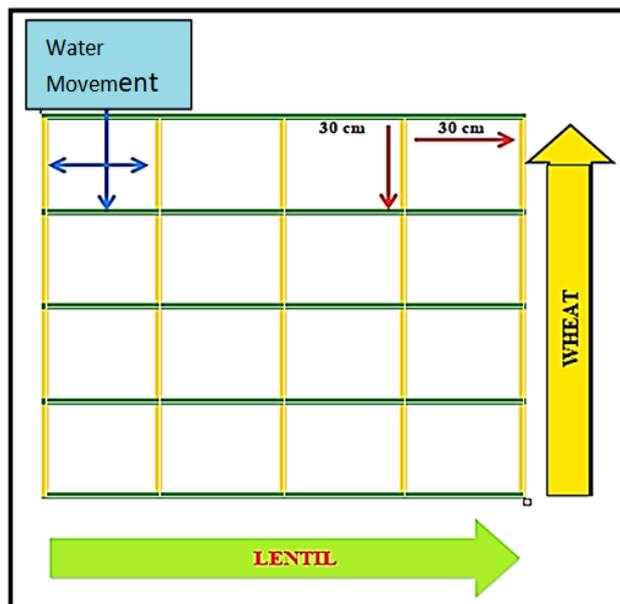
Through many studies, it is clear that the highest value of the number of spikes and grain yield is achieved with cross-cultivation, and the reason for this may be due to the efficiency of this method in rainwater harvesting as well as the ideal distribution of plants per unit area without crowding between plants, which reduces competition between them.[5] .

II. MATERIALS AND METHODS:

A field study was implemented at Fayda location which is MRA, (40 km from Mosul city), bread wheat seeds (*Triticum aestivum* L.) of certified class- Jehan variety and lentils crop (*Lens culinaris* Medik.) commercial class Ninevah local variety were sown on 14/11/2019. Using (Ras alromh) zero tillage seeder with 2 meter working width and 30 cm distance between each tine.

The experiment design was RCBD with one Main factor but included three sub-factors, 1st the Wheat-Lentils intercropping system . (60%W.+ 40%L.) (72 kg.ha-1W.+32 kg.ha-1 L.), (40%W.+ 60% L.) (48 kg.ha-1 W. + 48 kg.ha-1 L.), (100% W.=120 kg. ha-1), and (100% L=80 kg.ha-1). The 2nd subfactor two sowing

methods liner sowing (30 cm) and cross sowing (30*30 cm), and the 3rd subfactor (+)(-) Pallas-45 herbicide using. All the three subfactors were under control of the main single factor.



Figure(1) cross sowing.

The total combination of subfactors implicit in the experiment are:

- 1- 100% wheat - cross-sowing, (+) herbicide.
- 2- 100% wheat -linear sowing (+) herbicide.
- 3- 100% wheat - cross-sowing, (-) herbicide.
- 4-100% wheat - linear sowing, (-) herbicide.
- 5- 60% wheat + 40% lentils Intercropping cross-sowing.
- 6- 60% wheat + 40% lentils Intercropping linear sowing.
- 7- 40% wheat + 60% lentils Intercropping cross-sowing.
- 8- 40% wheat + 60% lentils Intercropping linear sowing.
- 9-100% lentils cross-sowing.
- 10-100% lentils linear sowing.

The studied wheat traits were: flag leaf area , Chlorophyll Content Index CCI, ,No. of tillers m-2, No. spikes m-2, No. grains spike-1,1000 grains weight, biological yield, grain yield, straw weight , and protein %.

Rain Precipitation rates and soil analysis:

Table(1) Monthly rainfall ppt. (mm) and soil analysis in Fayda (2019-2020):

Month – year	Fayda rain ppt. (mm.)	Soil characters	results
October	43.3	Clay%	30.50
November	19.3	Silt%	26.50
December	137.8	sand%	43.00
January	110.7	Soil texture	Clay-loam
February	101.7	Nitrogen ppm	44.77
March	282.0	Phosphorous DTPA ppm	15.39
April	68.5	Potassium DTA ppm	171.42
May	16.2	Organic matter %	2.11
		PH	7.07
		Ec. (ds /m)	0.26

III. RESULTS AND DISCUSSION:

The effect of the study treatments on Flag leaf area, Chlorophyll Content Index CCI, The number of tillers m-2, The number of spikes m-2 :

Flag leaf area Cm 2: From table (2) It is obvious that no significant differences observed between all treatments.

Chlorophyll Content Index CCI: Table (2) indicated that the superiority of CCI trait was in the treatment of 100% wheat cross-sowing (-) herbicide comparing with all other treatments, while the lowest significant value was in 100% wheat linear-sowing (+) herbicide and 40% wheat linear sowing, the values of the remaining treatments were significantly equal among them. That treatment of wheat 100% cross-sowing (-) herbicide was distinguished significantly on all the other treatments may be due to the possibility of the relatively negative effect of the herbicide on the chlorophyll content in the leaves of the wheat crop, where we notice the superiority of the linear and cross treatments of 100% (-) herbicide wheat over the linear and cross treatments 100% wheat (+) herbicide.

The number of tillers m-2: The treatment of 100% wheat cross-sowing (+) herbicide surpassed all other treatments, with a value of (291.26 tiller m-2), followed by linear sowing of 100% wheat (+) herbicide, and cross sowing of 100% wheat (-) herbicide. While the lowest significant value (143.75 tiller m-2) was in 40% wheat linear sowing.

The superiority of 100% wheat cross-sowing (+) herbicide may be due to the absence of weeds in the field, However, the presence of the weeds in the non-used herbicide treatment compared with 100% wheat cross sowing (+) herbicide gave preference to the number of tillers for the (+) herbicide treatment because the field is relatively free of weeds.

The number of spikes m-2: The 100% wheat cross sowing (+) and(-)herbicide achieved the highest values in the number of spikes m -2 with values (265.12 and 259.74 spikes. M-2) respectively, without any significant difference from the linear sowing of 100% wheat (+) and(-)herbicide, with a significant difference from the rest of the study treatments. While the lowest significant value (132.77 spikes m-2) was in 40% wheat linear sowing treatment. The superiority of all 100% wheat treatments over all other treatments is due to the fact that the percentage of wheat in the rest treatments is 60% and only 40%, which gives the confirmed superiority of the percentage of 100% in this trait.

These results are consistent with what was found that cross-cultivation (20 x 20 cm) gave the highest significant value to the trait of the number of tillers m-2.[6]. and agree with that cross sowing recorded the highest significant values in the traits of plant height, and the number of tillers m-2.[7], while [8] explained that cross-sowing excelled in the trait of flag leaf area , the number of tillers and spikes.

Table (2) Flag leaf area, Chlorophyll Content Index, Number of tillers, and spikes traits .

Treat. Traits	Flag leaf area cm2	Chlorophyll Content Index CCI	No. Tillers m-2	No. Spikes m-2
wheat 100% cross-sowing(+) herbicide.	A 25.45	B 17.50	A 291.26	A 265.12
wheat 100% linear sowing(+) herbicide.	A 23.61	C 13.40	AB 280.00	A 238.29
wheat 100% cross-sowing (-) herbicide	A 27.82	A 24.01	AB 260.51	A 259.74
wheat 100% , linear sowing (-) herbicide.	A 22.28	B 16.16	B 255.97	A 240.45
60% wheat + 40% lentils cross-sowing.	A 24.92	B 18.76	C 202.61	B 185.75
60% wheat + 40% lentils linear sowing.	A 22.89	B 16.88	C 204.67	B 177.64
40% wheat + 60% lentils cross-sowing.	A 24.50	BC 15.41	C 183.82	BC 159.22
40% wheat + 60% lentils linear sowing.	A 22.45	C 13.42	D 143.75	C 132.77

The effect of treatments on weight of 1000 grains , the number of grains spikes-1, and protein%:

Weight of 1000 grains gm.: Table (3) indicated that there is no significant differences were achieved between the treatments in weight of 1000 grains, this result will make the weight of the grain yield correlates with only two traits of the yield components traits which are the number of spikes m-1 and the number of grains spike-1 .

Table (3) Weight of 1000 grains gm., No. grains spike-1 , and Protein % traits.

Treat. \ Traits	Weight of 1000 grains gm.	No. grains spike-1	Protein %
wheat 100% cross-sowing(+) herbicide.	A 33.05	AB 39.33	C 12.76
wheat 100% linear sowing(+) herbicide.	A 33.07	AB 38.66	D 12.06
wheat 100% cross-sowing (-) herbicide	A 34.84	AB 38.33	ABC 13.36
wheat 100% , linear sowing (-) herbicide.	A 33.45	B 36.00	C 13.00
60% wheat + 40% lentils cross-sowing.	A 32.93	AB 38.33	A 14.00
60% wheat + 40% lentils linear sowing.	A 34.05	AB 38.66	BC 13.13
40% wheat + 60% lentils cross-sowing.	A 31.68	AB 39.66	AB 13.73
40% wheat + 60% lentils linear sowing.	A 32.65	A 42.66	C 12.90

No .grains spike-1: It is clear from table (3) that there are no significant differences between the study treatments in the trait of the number of grains spike-1, except the significant decrease in the treatment of linear sowing of 100% wheat (-)herbicide which was (36.00 grains), with a significant difference from the treatment of linear sowing 40% wheat that achieved the highest number of grains spike-1 (42.66 grains) . It seems that this is due to the low percentage of wheat in the field which led to the lack of competition between the crop plants due to the abundance of mineral supplies with the presence of leguminous crops enriched to the soil, which is lentils by 60% in the field.

Protein%: Table (3) indicated that the highest value achieved in this trait was (14.00%) in cross-sowing 60% wheat, and without a significant difference from the two treatments of cross-sowing of 100% wheat (-)herbicide (13.36%), and cross-sowing 40% wheat (13.73%). While the percentage of protein decreased in the remaining treatments, it is also evident that the intercropping of wheat and lentils has outperformed the individual sowing of wheat yield in this trait.

These results which indicated the superiority of intercropping treatments in achieving a higher grains protein % , are agree with the results that intercropping planting enhanced the crude protein concentration in wheat crops compared with individual planting of wheat.[9] . The results is agreed also with [10], [11], [12].

Protein% in cross-sowing was relatively higher than in linear sowing, and this may be due to the homogeneity in the distribution of plants in field compared with linear sowing, this result agree with results that higher percentage of lentil in the intercropping system per unit area, led to a higher amount of nitrogen in soil. [13].

The effect of the study treatments on biological yield, grain yield, and straw weight traits:

It is clear from table (4) that all treatments of sowing wheat by 100% achieved the highest significant values of biological yield, grain yield, and straw weight compared to the rest of the treatments. The treatments of cross-sowing 100% wheat (+) herbicide achieved the highest values in biological yield, grain yield, and straw weight which were (846.07, 321.66, and 524.41gm.m-2) respectively. The least significant values in the three traits were in the treatment of 40% wheat linear sowing, this due to being the least wheat plant density. This result is related to the percentage of wheat sowing in the field which was superior in treatments of 100% wheat compared with the rest of the treatments in which the percentage of wheat sowing was 60% and 40%.

Table (4) Biological yield, grain yield , and straw weight (gm. m-2):

Treat. Traits	Biological yield gm.m-2	Grain yield gm.m-2	Straw weight gm.m-2
wheat 100% cross-sowing(+) herbicide.	A 846.07	A 321.66	A 524.41
wheat 100% linear sowing(+) herbicide.	A 795.85	AB 306.48	A 489.37
wheat 100% cross-sowing (-) herbicide	A 816.56	A 316.04	A 500.52
wheat 100% , linear sowing (-) herbicide.	A 802.64	B 290.66	A 511.98
60% wheat + 40% lentils cross-sowing.	B 597.64	C 225.99	B 371.65
60% wheat + 40% lentils linear sowing.	B 592.75	C 217.01	B 375.74
40% wheat + 60% lentils cross-sowing.	C 537.63	D 194.39	B 343.24
40% wheat + 60% lentils linear sowing.	D 479.79	D 178.63	C 301.16

These results are consistent with previous results which indicated that the intercropping system produced significant changes in many traits of wheat and lentil crops, even though the grain yield of wheat in it was less than the grain yield in the individual sowing of wheat, but the economic analysis showed that the higher total economic return was in intercropping compared to individual sowing of wheat, and this was the most important agricultural advantage to compensate for the decrease in the yield of wheat grains under the intercropping system.[14].

Intercropping results analysis on wheat grain yield percentage: From grain yield result the wheat cultivation with 40% cross and linear sowing achieved a yield of 60.43% and 55.53%, respectively (an increase of 20.43% and 15.53% over the default yield) compared to cross sowing of 100 %wheat (+) herbicide, and a percentage of 63.42% and 58.28%, respectively (an increase of 23.42% and 18.28% over the default yield) compared to linear sowing of 100 %wheat (+) herbicide. 40% wheat cross and linear sowing achieved grain yield of 61.5% and 56.52% respectively (an increase of 21.5% and 16.525% over the default yield) compared to cross sowing with a 100%wheat (-)herbicide, yielding 66.87% and 61.45% respectively(by an increase of 26.87% and 21.45% over the default yield) compared to linear sowing of 100% wheat (-)herbicide.

Figure (2) shows the percentages of the increase in wheat yield based on the highest actual yield achieved in the actual outcome of 100% wheat cross-sowing treatment.

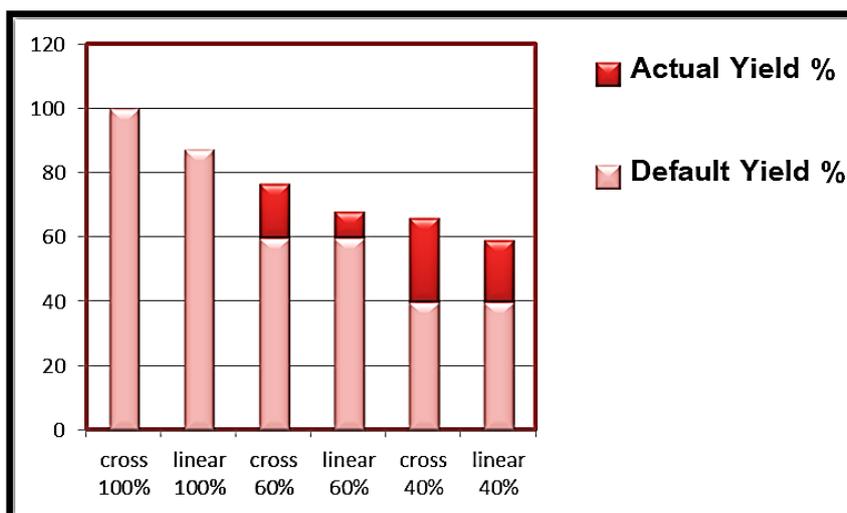


Figure (2) Increase % in grains yield of wheat based on the default yield .

Results of the Lentil yield:

The treatment of 60% linear and cross sowing of lentil achieved a seed yield of 78.36% and 78.14% compared to 100% lentil cross lentil treatment , with an increase in the yield of 18.36% in cross sowing and 18.14% in linear sowing compared to its default yield of 60% lentil. (The default yield is measured in proportion to the actual yield of an cross sowing 100% lentil). When comparing the cross and linear sowing of 60% lentils with the linear sowing of lentils at 100%, it becomes clear to us that both methods achieved a percentage (81.46 and 81.22%), respectively, with an increase (21.46 and 21.22%) over the default yield respectively. (The default yield is measured in relation to the actual yield of 100% linear sowing).

It is also clear from results that the yield percentage in 40% lentil in cross and linear sowing treatment , achieving a yield of (74.9% and 68.63%), respectively, compared to 100% lentil cross sowing, with an increase in the yield of 34.9% in cross sowing and 28.63% in linear sowing compared to its default yield of 40% lentils. (The default yield is measured in proportion to the actual yield of an 100% lentil cross sowing). When comparing cross and linear sowing of 40% lentil treatments with 100% lentil linear sowing treatment, it becomes clear that both methods have been achieved a rate of (77.86% and 71.34%) with an increase (37.86 and 31.34%) over the default yield, respectively. (The default yield is measured in relation to the actual yield of 100% lentil linear sowing).

Figure (3) shows the percentages of increase in lentil yield based on the highest actual yield achieved, which is the actual outcome of cross-sowing 100% lentil.

This may be due to that leguminous crops obtain structural support from cereal crops when they are grown together compared to the individual cultivation of legume crops. [15].

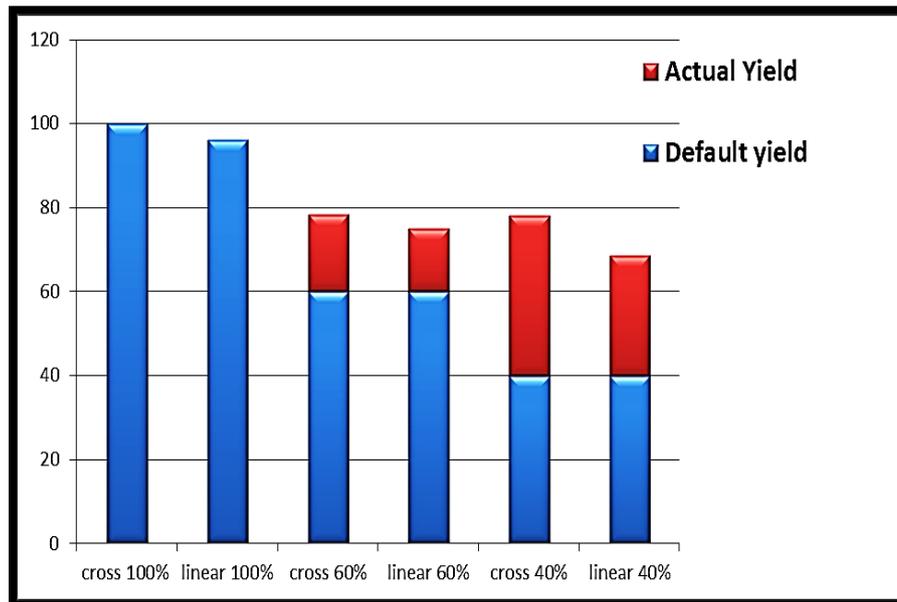


Figure (3) Percentages of increase in lentil yield based on the default yield.

Figure (3) also summarizes the total actual increases achieved in the yield of wheat and lentil at Fayda as a result of the intercropping planting between wheat and lentils, and the mixing ratios between them, and the cross and linear seeding methods, as it is clear that all intercropping treatments achieved an increase in the yield of both crops above their default yield. And that the cross-sowing was more distinguished in achieving clear increases in yield of both crops, and for both mixing ratios. The intercropping of 60% wheat and 40% lentils cross-sowing treatment was the most distinguished among other treatments.

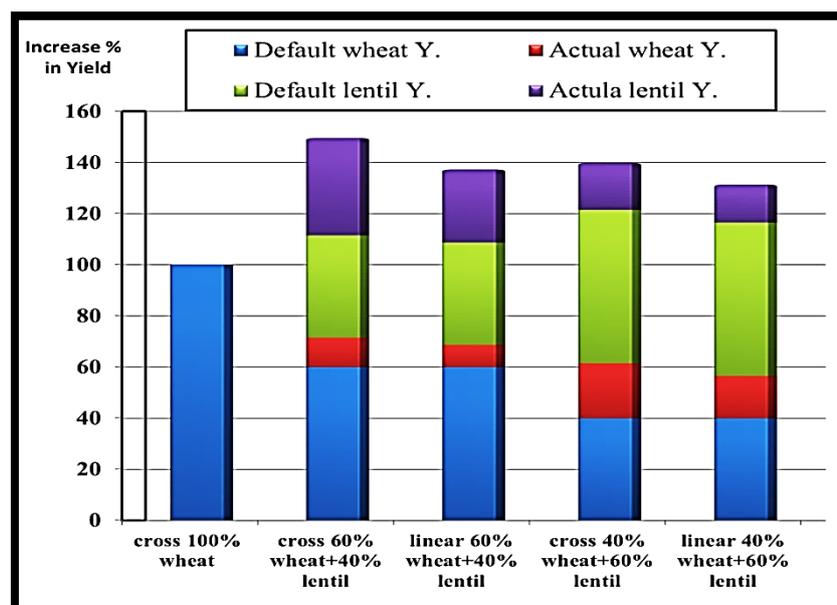


Figure (4) The percentages of the achieved increase in wheat and lentil yields compared to the default yield for each crop.

Figure (4) summarizes the total actual increases achieved in the wheat and lentil yields as a result of the intercropping between them, and according to the method of sowing and the mixing ratios for each of them. As it becomes clear that all intercropping treatments led to an increase in the yield of both crops above the default yield For them, and that the cross-sowing was the most distinguished in achieving clear increases in both crop yields and for both mixing ratios. The cross sowing of 40% wheat + 60% lentil treatment was the most distinguished among the rest of the treatments.

IV. CONCLUSION

1-Based on the positive results of the experience, we recommend to start implementing the intercropping system for grain and pulses farmers in Nineveh after organizing an extension program for the system through extension departments.

2- A recommendation for farmers to apply cross-farming, whether for individual or intercropping, because of the promising results achieved by this technique in the current study and the previous studies.

3- Proposing the application of intercropping at rates (60% wheat and 40% lentils) for wheat farmers and (40% wheat and 60% lentils) for lentil farmers for the benefits that each crop brings to the other.

4- Conducting studies to test seed distances and other seed rates that differ according to the crops intertwined in intercropping.

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