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The performance of potato and fababean when grown in association or as sole crops under two irrigation methods with and without P & K addition.

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ABSTRACT

Two experiments were conducted to evaluate the intercropping potential of potatoes and fababeans under different P and K fertilizer rates using furrow and sprinkler irrigation systems. In each experiment, a split-plot design with three replicates was used. Five P and K treatment combinations along with no fertilizers were applied to the main plots, and intercropped potato/ fababean, potato sole and fababean sole were the treatments applied to the sub plots. Intercropping system resulted in a significant increase in both potato and fababean yield under each of irrigation systems. The increase ranged from 5 to 44%. The land equivalent ratio (LER) was greater than 1 in almost all cases evaluated, which further confirms the superiority of intercropping. Due to high initial amount of soil P and K fertilizer application had no consistent effect on yield, but seemed to have more effect under sprinkler irrigation for both crops than under furrow irrigation. Monetary returns from intercropping were in general greater than that from sole cropping specially under no or low fertilizer rates.

Key words : Potato, Fababean, Irrigation, Intercropping.

INTRODUCTION

Intercropping has been practiced by farmers in many parts of the world. It gives a substantial increase in crop yield over single crops and provides farmers with more income stability from season to season (Andrews and kassam 1976) . Several recent studies in Jordan suggest the beneficial effect of row intercropping to the Jordanian farmer. The crops evaluated were fababean, cabbage, corn and potato (Sharaina, 1985 and Sharaina and Haddad,1985). It was found that the greatest return was obtained with 2:1 cabbage/fababean row combination which resulted in an increase of 1990 and 1280 Jordan Dinar per hectar over the sole crop of fababean and cabbage, respectively.

Most studies with intercropping have dealt with the most suitable crop combination, plant population or crop development with very little work on fertilization or water requirment (Uriyo et al., 1980). However, some results concerning the fertilizer requirements under intercropping have been reported (ICRISAT, 1979 , and Uriyo et al., 1980). The major work has been concentrated on investigating the ability of the legume crop to transfer the fixed nitrogen to the non legume crop (Rao et al., 1979 and Reddy et al., 1983).

Phosphorus application increased significantly the yield of monocropped maize but had no significant effect in intercropped maize or monocropped beans (Uriyo, 1980). Similarly, phosphorus had no significant effect on nutrient uptake, dry matter

yield or grain yield of maize and cowpeas when grown in association (Mongy et al., 1980). However, increasing the fertility level (N,P and K) in two multiple cropping patterns caused an increase in yield of beans and corn and a decrease in sweet potato (Oelsigle, 1979). Farmers in the Jordan Valley heavily fertilize their crops,very few of them occasionally test their soil before adding fertilizers. The objectives of this study were to evaluate the potential of row intercropping of potat and fababean grown under two irrigation methods, when P and K fertilizers were added and their effects on yield and nutrient status in the soil and plant parts.

MATERIALS AND METHODS

Two experiments were conducted simultaneously in 1982/83 growing season at the University of Jordan Research Station in the Jordan Valley. The station is located at altitude of 32 17' North with an elevation of 270 m below the sea level. The climate is characterized by hot summer and moderate winter. The soil of the experimental site is a sandy loam, calcareous (29% CaCo3) and has a pH of 8.1.

Treatment and Layout

A split-plot design was used with three replicates. Six combinations of two phosphorus treatment (P0 and P1) and three potassium fertilization treatments (K0, K1, and K2) were applied to main plots. Fertilizers rates used were K1=50 kg K_2 0 ha-1 and K_2 =100 Kg K_2 o ha-1.P1=80 Kg P_2 05 ha-1, whereas P0 and K0= untreated control. Triple

superphosphate and potassium chloride were the fertilizers used. The fertilizer amounts assigned for each experimental plot were mixed, hand broadcasted and incorporated in the soil prior to planting.

Three treatments applied to the sub plot consisted of intercropping combinations of 2 row potato: 1 row fababean, potato sole crop and fababean sole crop. The potato variety used was "sponta", and the large seeded Cyprus local was the fababean variety.

The set of the previous treatments were tested in two separate experiments simultaneously in close-by location. In the first experiment furrow irrigation was used while sprinkler irrigation was used in the second. The experimental plots in each experiment were irrigated to maintain a soil moisture tension between 0.03 to 0.04 MPa. Tensiometers were installed at 15 and 30 cm depths between the plant rows of all treatments.

The experimental plot consisted of six rows, 6m long and 0.6 m apart. Planting was done on October 3, gap filling and thinning was carried out subsequently to achieve optimum stand.

At maturity, three rows were left as border (two on one side, and one on the other) and the middle four meters of the three middle rows were harvested. Fababean was picked as fresh pods between 16 to 30 March, whereas potato was harvested on April 25.

Nitrogen fertilizer as ammonium sulfate was

applied for the entire experiments at a rate of 50 Kg N ha-1 in two dosages; one prior to planting and the second four weeks later. Weeds and diseases were kept under control.

Soil and Plant Analysis

Soil samples representing each plot were collected after crop harvesting. Soil samples were air dried, crushed to pass through a 2-mm sieve, then phosphorus and potassium were determined.

At crop physiological maturity, five competitive plants from each sub-plot with their roots were sampled at random, washed, cut and dried at 65° C in a forced-draft oven; then grouned to pass a 40-mesh screen and wet digested. The total N was then determined by the microkjeldahle method. Phosphorus in the soil and in the plant tissue was determined using ascorbic acid method. On the other hand, the NH4-acetate extractable potassium was determined by the flamephotometer. These methods are described in Methods of Soil Analysis (Page, 1982).

Procedure for Results Evaluation

Statistical analysis for split-plot was applied for each experiment separately and for all characters studied following Steel and Torrie (1980). Duncan's multiple range test was used for sub-plot mean separation. The main effect of fertilizer was evaluated using single degree of freedom comparison.

For the purpose of evaluating the intercropping

treatments with the sole crop treatments at the different fertilizer rates, the land equivalent ratio (LER) concept was used. This concept was described by Willey (Willey, 1979) who expressed the intercrop yields on a relative basis to the sole crop yield (i.e. sole crop LER = 1).

The LER is defined, however, as the relative land area under sole cropping that is required to produce the yield achieved in intercropping.

Economic return was calculated using the local market prices at the time of harvesting.

Results and Discussion

Yield

Fababean and potato yields obtained under the different treatments are presented in table 1. Intercropping fababean with potato resulted in greater yield than growing them as sole crops. Under furrow irrigation, intercropped fababean and potato resulted in 26% and 12% increase in yield over their sole crop yields respectively. Under sprinkler irrigation, intercropped fababean gave 44% more yield than sole fababean and 5% increase over sole potato.

These results came in a good agreement with the results of several studies that showed the benefit of growing crops in association, specially legume and non legumes as compared to their sole cropping (Edge

Table (1) Effect of P and K fertilizres on yield (10 x kg ha^{-1}) of potato and fababean when grown under 2:1 potato/fababean row intercropping and as sole crops, using furrow and sprinkler irrigation methods.

+ Fertilizer treatment	Furrow				Sprinkler			
	Fababean		Potato		Fababean		Potato	
	Intercropped	Sole	Intercropped	Sole	Intercropped	Sole	Intercropped	Sole
POKO	1279 ab*	821 b	2870 a	2198 ab	2167 a	1174 bcd	1804 ab	1819 ab
POKL	1525 ab	1039 b	2363 ab	2242 ab	1821 ab	1546 abc	1783 abc	1863 ab
POK2	833 b	1285 ab	2292 ab	2585 ab	2071 a	1585 abc	1963 a	1508 d
PLKO	1854 a	1175 b	2146 ab	1692 ab	1218 bcd	1002 bcd	1938 a	1715 c
PLKL	1038 b	877 b	2379 ab	2219 ab	1276 bcd	857 d	1496 d	1546 d
PLK2	1374 ab	1063 b	1888 ab	1527 b	1743 ab	973 cd	1613 cd	1598 d
MEAN	1317 a	1043 b	2323 a	2077 b	1716 a	1189 b	1766 a	1675 a

+ Kl : 50 and k2: 100 Kg K_2O ha^{-1}, Pl: 80, and p2:160 kg P_2O_5 ha^{-1}

* For each crop and for each irrigation method, means with the same letters do not differ significantly at 5% probability following Duncan's Multiple Range Test (DMRT)

and Laing, 1980; Rao and Willey, 1978; Sharaiha, 1985; Sharaiha and Haddad, 1985 and Willey, 1979).

The effect of fertilizer treatment on crop yield was not consistent with increasing fertilizer rates (tables 1 and 2). However, the treatment that gave the greatest yield of fababean was when the fababean intercropped at no fertilization treatment (P0 K0) under sprinkler irrigation (table 1). As for potato, the increase in yield in response to fertilizer application was not pronounced. However, potato sole under furrow showed insignificant response to K fertilization.

Judging the main effect of fertilizer by comparing the main value of crop yields obtained in response to P and K application (table 2) indicates that the addition of P fertilizer generally decreased the yield of both crops probably due to high initial soil P. This absence of response to phosphorous might be due to the high amount of available P originally present in the soil, which was measured to be around 37 ppm, this amount seemed to be adequate to satisfy the plant needs. However, it has been found that freshly applied P in calcareous soil is more available than residual P, but there is a decrease in the yield response to freshly applied phosphorous when the residual P level is high (Hagin et al., 1972).

The response to K application was different according to the cropping system used; addition of K to intercropped fababean and potato generally resulted in yield decrease, however, with sole cropping a yield increase was observed in most

Table (2) The main effect of P and K on Yield (10x kg ha^{-1}) potato and fababean when grown under 2:1 potato/fababean row intercropping and as sole crops using furrow and sprinkler irrigation methods.

Fertilizer Treatment	Furrow				Sprinkler			
	Fababean		Potato		Fababean		Potato	
	Intercropped	Sole	Intercropped	Sole	Intercropped	Sole	Intercropped	Sole
+					*			
PO	1212	1048	2508	2342	2020 a	1435 a	1850	1730
Versus								
P1	1422	1038	2138	1813	1413 b	994 b	1682	1619
KO	1566	998	2508	1945	1693	1088	1871	1767
Versus								
K1+K2	1192	1066	2230	2143	1728	1240	1714	1629

+ PL : 80 kg ha^{-1} P_2O_5, KL: 50 and K2: 100 Kg $ha^{-1}K_2O$

* Significant differences at 5% probability were observed between PO and P1 for fababean under sprinkler irrigation only. The comparison were conducted between means in the same column

cases. This result agrees with results obtained at ICRISAT with maize / groundnut intercropping, where their results suggested that intercropping may be more advantageous in low fertility situation. Nevertheless, this was not clear with phosphorous application in the present study.

Eventhough the study was not designed to compare irrigation methods, it is evident that fertilization seems to have more effect on both crops under sprinkler than under furrow irrigation.

It is possible that uniform distribution of water was achieved under sprinkler irrigation, while in furrow, the application of water was confined to the furrow, thus increasing the deep percolation. This in turn could leach down some of the nutrients.

Moreover, the irrigation method had affected yield of both crops and under both cropping systems. From tables 1 and 2, it appears that yield of fababean under sprinkler irrigation is greater than that under furrow irrigation. The differences were quite pronounced when fababean was grown in association with potato. On the contrary, potato yield under sprinkler irrigation is less than under furrow irrigation. This observation was noted at large scale by many farmers in the Jordan Valley. This may be due to the cultivation practice that was used, where in furrow the soil is heaped around the potato plants.

On the other hand, experiment in Texas, USA (Samis, 1980) showed no difference in potato yield that was obtained under the two methods of

irrigation. However, this point needs further investigation

Nutrient Status in Soil and in Plant Parts : N, P and K

Available nutrients in the soil and in plant parts were measured directly after crop harvesting. Results are presented in tables 3 and 4.

Amount of available P in the soil was not affected either by the cropping system or the crop used. Available P remained in the soil after harvesting was almost the same under both, intercropped or sole of both potato and fababean. The general clear conclusion from the data in tables 3 and 4, is that potato or fababean plants had lower N, P, K concentration than in those under sole cropping. The total uptake of those nutrients by both plants could be higher in the case of intercropping than sole cropping since yield was higher in the first case than in the second.

The concentration of P in the potato tops and tubers under sprinkler irrigation (table 4) was 20% higher than that under furrow irrigation (table 3), eventhough, more available P was initially in the soil under furrow than sprinkler. This might be explained by the better plant growth under sprinkler irrigation that resulted in better plant utilization of the nutrient in the soil. The calculated total P uptake by potato tubers was 62 kg ha-1 under sprinkler, whereas it was 57 kg ha-1 under furrow irrigation.

Table (3) Nutrient status in soil after harvest and plant parts of both potato and fababean when grown in association or as sole crops using furrow irrigation.

Nutrient	Potato		Fababean	
	Intercropping	Sole cropping	Intercropping	Sole cropping
P (ppm) soil	41.00	41.20	41.00	39.60
K (ppm) soil	252.00	221.00	252.00	215.00 b
K (%) Tops	2.80 b*	3.14 a	1.59 a	1.61 b
Tubers or roots	1.82	1.80	0.99	0.99
N (%) Tops	2.04	2.08	3.20	3.27
Tubers or roots	1.41	1.31	2.39	2.31
P (%) Tops	0.187 b*	0.221 a	0.286	0.289
Tubers or roots	0.279	0.289	0.163	0.208

* In each row and for each crop, means with different letters, differ significantly at 5% probability using DMRT.

Differences for other rows are not significant.

Table (4) Nutrient status in soil and plant parts of both potato and fababean when grown in association or as sole crops using sprinkler irrigation.

Nutrient	Potato		Fababean	
	Intercropping	Sole cropping	Intercropping	Sole cropping
P (ppm) soil	23.30	21.20	23.30	25.10
K (ppm) soil	345.00	369.00	345.00 b *	387.00 a
K (%) Tops	3.16	2.84	1.21	1.38
Tubers or roots	1.83	1.83	1.17	1.22
N (%) Tops	2.05	2.11	2.90	2.77
Tubers or roots	0.84	0.75	1.97	1.88
P (%) Tops	0.217 b	0.330 a	0.256	0.249
Tubers or roots	0.310	0.344	0.254	0.211

* In each row and for each crop, means with different letters, differ significantly at 5% probability using DMRT.

Differences for other rows are not significant.

Potassium concentration in fababean was lower than that in potato (table 3 and 4), which is reasonable since potato is considered a high K consuming crop. The concentration of K in potato tubers was the same under both irrigation methods, but fababean under sprinkler had lower K concentration than that under furrow.

However, K uptake by potato tubers was 398 kg ha-1 under sprinkler irrigation whereas the amount under furrow irrigation was only 315 kg ha-1.

No significant differences in N concentration was observed for the different treatments used. Nitrogen was provided in adequate amount. However, the N uptake by tubers was higher under furrow irrigation (300 kg ha-1), than under sprinkler (137 kg ha-1).

Moreover, intercropping caused more N uptake, which might be due to more N fixed by the fababean legume plants.

Land Equivalent Ratio (LER) and monetary returne :

As indicated earlier, LER is the relative land area under sole cropping that is required to produce the yield achieved in intercropping. For example, when a 2:1 potato fababean row combination is grown in association this mean that potato is occupying 2/3 and fababean 1/3 of the land, and thus a LER of 0.67 for potato and 0.33 for fababean or a total of LER =1, will indicate that sole cropping is as good as

intercropping. However, when the LER total is greater than one more land is required for sole cropping to produce what is producing under intercropping which inturn indicates the superiority of intercropping.

Land equivalent ratios calculated for the two experiments are presented in table 5. The LER exceeded 1 in almost all cases with only one exception. Under furrow irrigation, intercropping potato / fababean at the higher rate of K and no P fertilizer resulted in a very low LER value which might indicate unfavourable conditions for intercropping. Greater LER values were obtained under low K applications. It is obvious from table 5 that the LER value of fababean under sprinkler is greater than that under furrow irrigation. However, the opposite was true in the case of potato; intercropping potato with fababean under furrow was more favourable for potato than under sprinkler irrigation. However, the two crops performed better under intercropping than under sole cropping as indicated by the total LER under both irrigation systems.

Monetary returns calculated for the different systems and treatments are presented in table 6. The calculations were in Jordan Dinar (JD) which is equivalent to three US dollars.

It is obvious that the highest return was obtained when potato was grown under furrow and when fababean was grown under sprinkler irrigation. However, the greatest income in intercropping was obtained when potato was intercropped with

Table (5) Land equivalent ratio (LER) of potato and fababean grown in 2:1 potato : fababean row combination using six fertilizers treatments under two irrigation methods.

Fertilizer Treatment	Furrow			Sprinkler		
	Fababean	Potato	Total LER	Fababean	Potato	Total LER
POk 0	0.52	0.87	1.39	0.61	0.66	1.27
POk 1	0.49	0.70	1.19	0.39	0.64	1.03
POk 2	0.22	0.59	0.81	0.43	0.87	1.30
PIk 0	0.53	0.84	1.37	0.40	0.75	1.15
PIk 1	0.39	0.71	1.10	0.50	0.64	1.14
PIk $_2$	0.43	0.82	1.25	0.60	0.67	1.27

Table (6) Monetary returns (JD/ha) of fababean and potato when grown in association (2:1 row potato : fababean) and sole crops, using six fertilizer treatments under two irrigation methods.

Fertilizer treatments	Fababean		Potato		
	Inter Cropped (1/3ha)	Sole (1ha)	Inter Cropped (2/3ha)	Sole (1ha)	Inter-Cropped 2:1 (1ha)
a) Furrow					
POk 0	768	1499	2981	3431	3749
POk 1	912	1895	2444	3492	3356
POk 2	479	2343	2362	4024	2841
PIk 0	1110	2142	2212	2624	3322
PIk1	594	1583	2448	3444	3042
PIk2	800	1920	1928	2351	2728
B) Sprinkler					
POk 0	1315	2152	1866	2836	3181
POk 1	1095	2833	1837	2898	2932
POk 2	1242	2898	2019	2334	3261
PIk 0	718	1822	1994	2660	2712
PIk 1	747	1546	1525	2388	2272
PIk 2	1028	1754	1640	2436	2668

* Crop prices and fertilizer costs were based on their local values at time of harvesting and planting ,respectively

fababeans under no fertilizer application which gave 3749 JD ha-1 compared to 4024 JD ha-1 obtained from the higher yielded sole potato treatment.

In general under the prevailing conditions the returns from intercropping are higher than those from sole cropping specially under zero or low fertilizer application.

These results agreed with result obtained by researchers in ICRISAT, who concluded that intercr-opping may be more advantageous in low fertility situations. This indicates the great beneficial effect of intercropping specially under the condition of Jordan Valley. The monetary advantage of intercr-opping was also confirmed by results obtained in several countries.

However, it should be noticed that the initial P and K in the soil were high and can not be considered as under low fertility situation.

Conclusions and Recommendations

It can be concluded from the results of this study that :

1. Intercropping system was superior to sole cropping; it resulted in greater crop yield, better land utilization and greater returns.
2. Addition of P and K fertilizers did not significantly improve the yield of both crops. Moreover, addition of P and K fertilizer when P is adequate in the soil caused reduction in yield.

3. Under the condition of the present study, potato yield was higher under furrow irrigation but fababean yield was greater under sprinkler irrigation system.
4. Similar experiments are recommended to be carried out on soils of low initial P and K contents.

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مجلة الامارات للعلوم الزراعية (١٩٩٠) ، ٢ : ٩٧-١١٨

استجابة البطاطا والفول للزراعة المتداخلة باستعمال طريقتين للرى وباضافة الاسمدة الفوسفاتية والبوتاسية.

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ملخص

أجريت دراسة لتقييم الزراعة المتداخلة الخطية للبطاطا والفول عند اضافة مستويات مختلفة من السماد الفوسفاتي والبوتاسي وذلك في محطة كلية الزراعة في غور الاردن باستعمال طريقتين للرى .

نفذت تجربتين منفصلتين حيث استعمل نظام الرى بالاثلام في احداها والرشاشات في الاخرى. استعمل تصميم القطع العشوائية المنشقة بثلاث مكررات في كل تجربة. واستعمل خمس معاملات مختلطة من السماد بالاضافة الى معاملة بدون سماد . وضعت معاملات السماد في القطع الرئيسية ، بينما وضعت معاملات الزراعة المتداخلة ٢ خط بطاطا : ١ خط فول ، البطاطا المنفرده والفول المنفرد في القطع الثانوية.

أظهرت النتائج تفوق الزراعة المتداخلة وبصورة معنوية لكل من البطاطا والفول وتحت نظامي الرى المستعملين ، حيث تراوحت الزيادة في الانتاج باتباع الزراعة المتداخلة ما بين ٥ - ٤٤ ٪ . كانت نسبة تكافؤ الارض اكثر من ١ في معظم الحالات المدروسة مما يؤكد تفوق الزراعة المتداخلة على الزراعة المنفرده. لم يكن لاضافة السماد اثر منتظم على زيادة الانتاج ، الا ان أثر السماد اكبر تحت نظام الرى بالرشاشات عن الرى بالاثلام . تبين أن المردود المادى في الزراعة المتداخلة اعلى منه في الزراعة المنفرده خاصة تحت المعاملات التي لم يضف فيها السماد او عند اضافة السماد بمعدلات قليلة.

كلمات مفتاحية : البطاطا ، الفول ، الرى ، الزراعة المتداخله .