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Effect of Phosphorus and Potassium Fertilization on Yield of Two Potato Cultivars

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ABSTRACT

A field plot experiment was conducted in the experimental farm of the Faculty of Agriculture, Alfateh University in Tripoli to study the effect of four levels of phosphorus application (0, 50, 100 and 150 Kg P_2O_5/ha) and four levels of potassium application (0, 80, 160 and 240 Kg K_2O/ha) on yield of tubers in the potato cultivars Kenva and Arran Banner, during the spring season 1975 and the fall season 1975–76. The results have shown that potassium application at the rate of 80 Kg/ha K_2O gave significant increase in yield of tubers in both cultivars. Higher levels of potassium application generally reduced the yield of tubers. The response of yield to potassium application was manifested in both number of tubers per plant and average weight of tuber.

Phosphorus application resulted in increases in yield of tubers. The response to phosphorus application was more significant in the fall planting than in the spring planting for both cultivars. Tuber weight showed gradual increase with increasing phosphorus application up to 100 Kg/ha of P_2O_5, but increasing P above that level in the spring planting showed slight decrease in weight of tubers in both cultivars.

Since the results have shown that applying high levels of potassium fertilizer had a deleterious effect on the yield, only low levels of potassium should be recommended for potato fertilization in soils of the same chemical and physical structure as the soil in the Tripoli area.

INTRODUCTION

The growth and yield of the potato crop are largely affected by the nutritional level of the plant. Previous investigations at our experiment station (2) have shown that the application of a complete fertilizer (12–24–12) at the rates of 200, 400 and 600 Kg/hectar resulted in significant increases in both vegetative growth and yield of tubers. The increase in yield was proportional to the amount of fertilizer added within the range tested. It is necessary, however, to have more specific information on the effect of simple fertilizer applications on the yield of this crop. Such information would be valuable in assessing the amount of major elements required to be added for obtaining maximum yield under local soil conditions.

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It is well known that tuber crops need ample supply of potassium for obtaining optimum growth and high yield (9). However, several investigators have indicated that the response of the potato plant to potassium fertilization depends mainly on the potassium content in the soil (5,6). Potassium application in soils with relatively high potassium content was found to give no increase in yield, and it was shown that heavy potassium applications in such soils resulted in reduction of the yield.

Phosphate is not absorbed very readily by the potato plant, consequently it is important to ensure that it is present in a form readily available (10). In calcarious soils, which is the case in Tripoli area, high levels of calcium makes phosphorus less available. Potato yields respond well to phosphorus fertilization and the increase in yield is mainly due to increase in number of tubers rather than to increase in size of tuber.

The present investigation was conducted to study the effect of applying different levels of phosphorus and potassium on the yield of tubers in the cultivars kenva and Arran Banner.

MATERIALS AND METHODS

A field-plot experiment was conducted at the experimental farm of Faculty of Agriculture, Alfateh University in Tripoli during the spring season 1975 and the fall season 1975–76. Planting for the spring experiment was on March 2, 1975 and harvesting was on June 6, 1975 while planting for the fall experiment was on October 5, 1975 and harvesting was on February 3, 1976. The soil of the farm is sandy loam with pH around 8. The part of the farm in which the experiment was carried out has been in arable condition for several years but it did not receive any organic manure during the last two years and was not previously used for fertilizer experiments. The fall and spring experiments were conducted in different locations of the same farm. The design used was split plot with phosphorus levels as main plots and potassium levels as subplots with four replications. Phosphorus was added as a preplanting treatment in the form of superphosphate (20% P_2O_5). Four levels of phosphorus application: 0, 50, 100 and 150 Kg P_2O_5/hectar were tested. Potassium was also applied before planting in the form of potassium sulfate (50% K_2O) at four levels: 0, 80, 160 and 240 Kg K_2O/hectar. Nitrogen was given as an overall treatment to all plots in the form of ammonium sulfate (21% N) at the rate of 180 Kg N/hectar. This amount was divided into three parts as follows: 45 Kg N/ha before planting, 67.5 Kg N/ha side-dressing after complete emergence of the plants, and 67.5 Kg N/ha 3 weeks later and just before the last earthing up. Each subplot consisted of two rows 5 meters long and 65 cm wide. Tubers were planted at a distance of 30 cm within the row, thus each subplot contained 34 plants. Enough distance was kept around the main plots to eliminate any drift of the fertilizers. Recommended methods of irrigation, as well as of weed and pest control were followed throughout the growing season. When the plants showed maturity symptoms, the crop was harvested and the weight and number of tubers per plot was recorded. The average weight of the tuber was calculated by dividing the weight of tubers per plot by their number. The data were statistically analysed using the L.S.D. method as described by Steel and Torrie (8).

Two cultivars, Kenva and Arran Banner, were used in the present investigation. Kenva is a new cultivar produced by Denmark and proved to be very promising for production in Libya. It is a medium-late variety which produces long oval tubers with yellow flesh. The second cultivar, Arran Banner, is a classic standard variety in Libya. It is a medium early variety which produces round tubers with white flesh. Whole tubers of size 28–35 mm were used for seed.

RESULTS AND DISCUSSION

A. Cultivar Kenva

Table 1 summarizes the data of tuber yield in cultivar Kenva at different levels of phosphorus and potassium fertilization during the spring and fall plantings. Analysis of variance indicated a highly significant response to potassium application in both spring and fall plantings. On the other hand, significant differences in yield due to phosphorus application were observed only in the fall planting and slight and insignificant change in yield was found in the spring planting.

A highly significant P × K interaction on the yield was found in the fall planting. In general, there was a proportional increase in tuber yield with increasing phosphorus fertilizer from 0 to 150 Kg/ha of P_2O_5 during the fall planting (Fig. 1). Compared to the control (no phosphate application), the addition of 50, 100, and 150 Kg of P_2O_5 at time of planting increased the yield of tubers by 8, 21, and 61%, respectively. As an average of all potassium levels the yields were 12.12, 13.08, 15.45 and 19.55 tons/ha for the corresponding P_2O_5 doses of 0, 50, 100 and 150 Kg/ha. For the spring planting, however, the application of 50, 100 and 150 Kg/ha of P_2O_5 resulted in a slight improvement in yield of 8, 3 and 5% over the control. The highest yield of 38.75 tons/ha was obtained with 50 Kg/ha of P_2O_5.

As shown from Table 2 and Figure 2, the highest number of tubers per plant in the spring planting was obtained when 50 Kg/ha of P_2O_5 were applied. Higher levels of phosphorus decreased the number of tubers per plant. On the other hand, the response of tuber weight to phosphorus application was less pronounced. Gradual increase in tuber weight was obtained by phosphate application up to 100 Kg/ha of P_2O_5, but

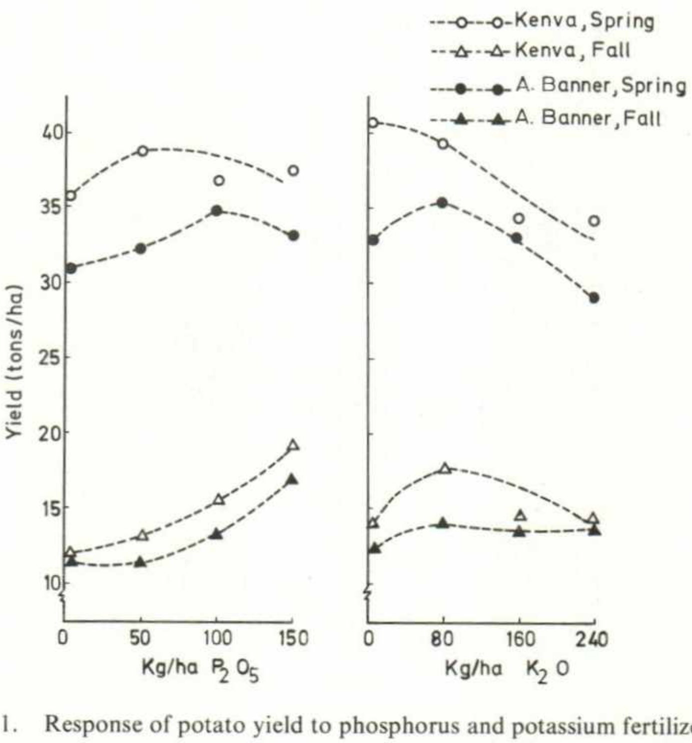

Fig. 1. Response of potato yield to phosphorus and potassium fertilizers.

Table 1 Effect of phosphorus and potassium fertilizer on potato yield (tons/ha), cultivar Kenva.

Kg K_2O/ha	Spring 1975					Fall 1975–76				
Kg P_2O_5/ha	0	80	160	240	Average	0	80	160	240	Average
0	36.43	37.82	30.92	38.01	35.80	10.74	13.65	12.32	11.76	12.12
50	43.21	41.50	35.42	34.88	38.75	12.82	16.56	11.56	11.38	13.08
100	41.62	40.03	34.10	31.74	36.87	15.05	16.94	16.31	13.48	15.45
150	42.59	38.75	36.63	32.51	37.62	17.40	23.17	18.27	19.36	19.55
Average	40.96	39.53	34.27	34.29		14.00	17.58	14.62	14.00	

L.S.D. at 5% for potassium level = 3.36
L.S.D. at 1% for potassium level = 4.5

L.S.D. at 5% for phosphorus levels = 2.64
L.S.D. at 1% for phosphorus levels = 3.78
L.S.D. at 5% for potassium levels = 0.53
L.S.D. at 1% for potassium levels = 0.71
L.S.D. at 5% for interaction = 1.07
L.S.D. at 1% for interaction = 1.44

Table 2 Effect of phosphorus and potassium fertilizers on number of tubers per plant and average weight of tubers in cultivar Kenva, spring planting 1975.

Treatment Kg/ha	Number of tubers per plant					Average weight of tubers				
K_2O / P_2O_5	0	80	160	240	Average	0	80	160	240	Average
0	9.00	10.75	9.33	9.75	9.71	74.58	70.08	63.00	74.05	70.43
50	9.70	10.75	9.73	9.30	9.87	84.93	73.35	69.60	70.30	74.54
100	9.93	9.45	8.35	8.50	9.06	80.95	80.23	77.20	70.35	77.18
150	9.15	10.03	9.70	8.88	9.44	85.55	73.35	71.53	67.85	74.57
Average	9.44	10.24	9.28	9.11		81.50	74.25	70.33	70.64	

L.S.D. at 5% for P = 0.763
L.S.D. at 5% for K = 0.871

L.S.D. at 5% for P = 4.407
L.S.D. at 5% for K = 6.001
L.S.D. at 1% for K = 8.052

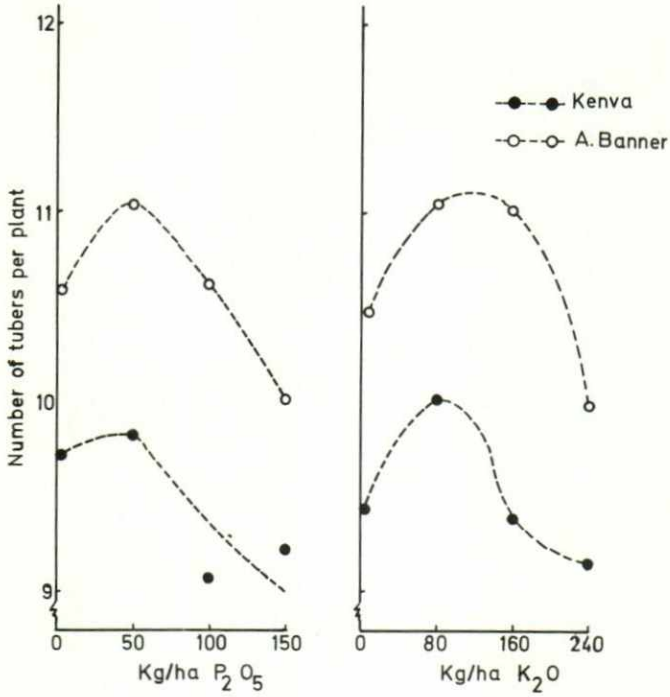

Fig. 2. Response of number of tubers per plant to phosphorus and potassium fertilization in the spring planting.

increasing the phosphorus level to 150 Kg gave slightly smaller tuber weight than the 100 Kg level.

The response of yield of the cultivar Kenva to potassium application, irrespective of phosphorus levels, is shown in Table 1 and illustrated in Figure 1. There was a significant reduction in yield with the application of potassium beyond 80 Kg/ha of K_2O in both spring and fall plantings. It appears that the addition of 80 Kg/ha K_2O represents an optimum value under the conditions of this experiment. However, this optimum type of response of yield to K application was more pronounced in the fall planting. Furthermore, the presence of P × K interaction on the yield in the fall planting may also indicate, to a certain degree, the sensitivity of the cultivar Kenva to the balance of the internal nutrient constitutents. Such nutrient balance could be the net result of the nutrients level in the soil, the plant characters and behaviour, and the climatic conditions prevailing during the fall period.

The pronounced decrease in yield obtained when applying potassium levels above 80 Kg/ha K_2O was mainly due to the decrease in the number of tubers per plant rather than in the average weight of tubers as shown from Table 2 and Figures 2 and 3.

B. Cultivar Arran Banner

The performance of the cultivar Arran Banner, in terms of yield, under different levels of phosphorus and potassium fertilizers is shown in Table 3 and illustrated in Figure 1. As with the cultivar Kenva, the yield of tubers of the cultivar Arran Banner was much higher in the spring planting than in the fall. Analysis of variance showed no significant differences in yield due to phosphorus application in the spring planting. Nevertheless, there was a slight increase in yield over the control of 8, 12, and 7% by the addition of 50, 100, and 150 Kg/ha of P_2O_5, respectively. As shown in Table 4 and Figure 3, the average tuber weight showed gradual increase with increasing phosphorus application upto 100 Kg/ha of P_2O_5 in both cultivars. However, increasing phosphorus above that level resulted in slight decrease in the average weight of tubers.

On the other hand, there was a proportional and significant increase in yield during the fall planting with the application of phosphorus. Compared with the control, the addition of 100 and 150 Kg/ha of P_2O_5 increased the yield of tubers by 13 and 45%, respectively. This striking response to phosphorus in the fall planting may also indicate the sensitivity of cultivar Arran Banner, as with the cultivar Kenva, to nutritional balance. Positive responses to phosphorus applications have been reported by several investigators (1,5,7). Schoonnveldt *et al.* (7) found in sandy heath soil in Holland that marketable yield and number of tubers showed positive responses to phosphorus fertilization. Application of 1,000 Kg/ha of superphosphate gave better responses than 500 Kg/ha. They also found no varietal differences in response to phosphorus.

Differences in yield due to potassium application in the cultivar Arran Banner were significant only in the spring planting. The addition of potassium at the rate of 80 Kg/ha K_2O increased the yield, whereas further applications above that level significantly reduced the yield. The highest yield of 35.37 tons/ha in spring planting and 13.97 tons/ha in fall planting were attained with 80 Kg/ha K_2O. This performance illustrates an optimum type of relationship between yield and K as with the cultivar

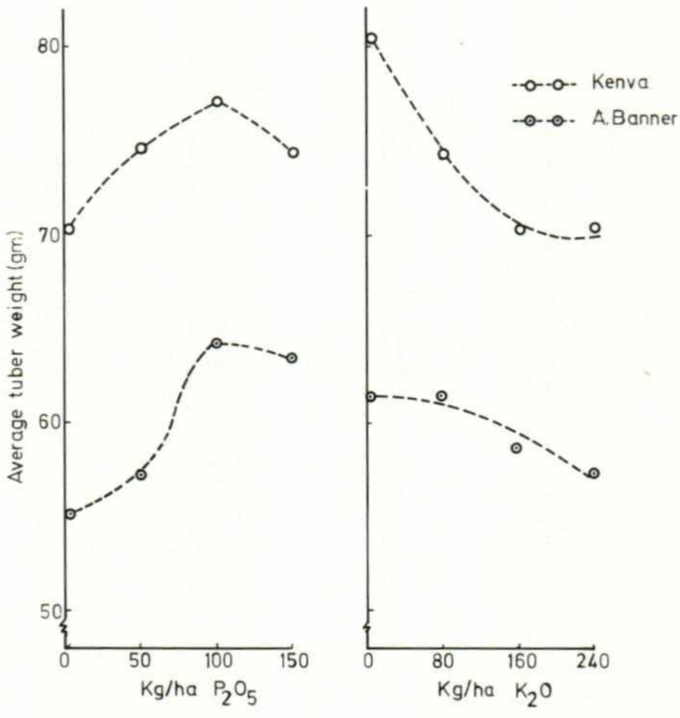

Fig. 3. Response of average tuber weight to phosphorus and potassium fertilization in the spring planting.

Table 3 Effects of phosphorus and potassium fertilizer on potato yield (tons/ha), cultivar Arran Banner.

Kg K_2O/ha	Spring 1975					Fall 1975–76				
Kg P_2O_5/ha	0	80	160	240	Average	0	80	160	240	Average
0	29.88	31.87	36.93	25.15	30.96	10.24	12.00	11.45	13.16	11.71
50	35.34	36.15	33.36	29.37	33.56	10.39	12.39	11.94	11.41	11.53
100	32.74	38.40	32.51	35.34	34.75	11.29	14.88	13.61	13.35	13.28
150	37.63	35.07	32.59	26.79	33.02	17.47	16.62	17.64	16.10	16.96
Average	33.90	35.37	33.85	29.16		12.35	13.97	13.66	13.51	

L.S.D. at 5% for potassium levels = 3.87

L.S.D. at 5% for phosphorus levels = 1.65
L.S.D. at 1% for phosphorus levels = 2.37

Table 4 Effect of phosphorus and potassium fertilizers on number of tubers per plant and average weight of tubers in cultivar Arran Banner, spring planting 1975.

Fertilizer level Kg/ha	Number of tubers per plant					Average weight of tubers				
K_2O / P_2O_5	0	80	160	240	Average	0	80	160	240	Average
0	10.05	10.60	11.65	9.98	10.57	57.50	57.45	58.68	47.10	55.18
50	11.55	11.23	11.70	10.60	11.27	57.75	62.25	55.38	53.70	57.27
100	9.83	11.75	10.20	10.73	10.63	63.98	61.95	63.38	67.55	64.21
150	10.48	10.90	10.73	8.58	10.17	67.60	65.43	57.30	62.25	63.15
Average	10.48	11.12	11.07	9.97	61.71	61.78	58.68	58.68	57.65	

L.S.D. at 5% for P = 1.070
L.S.D. at 1% for P = 1.537
L.S.D. at 5% for K = 1.018

L.S.D. at 5% for P = 4.810
L.S.D. at 1% for P = 6.910
L.S.D. at 5% for K = 6.842

Kenva (Fig. 1). However, there was an apparent varietal difference in response to potassium application during the fall planting. While the yield of the cultivar Arran Banner did not change with further applications of K_2O above 80 Kg/ha, the yield of Kenva was greatly reduced at higher applications. However, the lack of response and the reduction in yield of both cultivars with potassium application in the spring and fall plantings may indicate a high potassium level in the soil. Similar results were obtained under soil conditions similar to that of the present investigation. Mounir and Khedre (6), in Libya, found that increasing the level of potassium application in soils containing more than 80 ppm released K_2O resulted in reduction of yield. Soils with lower potassium levels showed better response to potassium application. In East Germany, Wicke (11) studied the effect of heavy potash dressings on yield of potatoes and found that dressings of potash salt (40%) at rates above 166 Kg K per hectar were not economical, and yield depressions occurred with dressings over 996 Kg per hectar. He stated that additions of excess potassium have resulted in luxury consumption and was considered to be wasted. In other regions, Anderson (1) found that potassium generally increased tuber dry matter yields except at the higher rates which sometimes gave a negative response. In an experiment with nutrient solutions, Hart & Smith (3) found that P absorption in plant tops increased when K increased from 4 to 8 meq/liter, then decreased slightly when K was further increased to 12 meq. This again confirms that the high levels of potassium interferes with the absorption of other major elements.

The significant and positive linear response of yield to phosphorus application in the fall planting with both cultivars may be partially attributed to a more limited and shallower root system than in the spring planting due to the relatively low temperatures prevailing during the growing period of the fall planting. Since phosphorus is immobile and highly subjected to fixation in the upper surface due to the calcarious nature of the soil, therefore, the deeper and more extensive root system of plants in the spring planting may account, at least in part, for the lack of response to high phosphorus application. Also, this behaviour may be partially attributed to the higher rate of virus infection in the fall growing plants. Kozlowska (4) found that absorption of phosphorus in virus Y infected plants was higher than in non-infected plants. Since the spring crop is planted by imported seed of high grade that is almost free of virus infection and the fall crop is grown from locally produced seed with a varying range of virus infection, the latter crop may have a higher potential for phosphorus absorption.

The very high average yields in the spring planting of 33.0 tons/ha and 37.3 tons/ha as compared with 13.4 tons/ha and 15.1 tons/ha in the fall planting for cultivars Arran Banner and Kenva, respectively, might be attributed at least in part to the higher rate of virus infection in the fall planting. Moreover, the more humid weather during the winter months when the fall crop was growing enhanced the infection of the foliage with early blight in both cultivars. This disease resulted in earlier drying of the leaves and consequently might have resulted in the considerable reduction in yield. It should also be mentioned that the cloudy days with lower light intensity prevailing during the growing period of the fall planting might have an effect on the rate of photosynthesis and consequently on the net assimilation rate of carbohydrates which could be directly reflected on the yield.

In conclusion, it may be recommended that the P and K fertilizer requirements for maximum yield of potato under local conditions can be achieved through simple fertilizer application at the rate of 100 Kg/ha of P_2O_5 and 80 Kg/ha of K_2O. The phosphate fertilizer requirement in the fall planting is generally higher than that in the spring planting. Although the potato plant is known to have a positive response to potassium application, it has been shown in the present investigation that detrimental effects on yield were obtained when the amount of potassium applied exceeded 80 Kg/ha of K_2O. Therefore, the use of complete fertilizers with a fixed NPK ratio, generally practiced in Libya, does not seem to be advisable for proper potato fertilization. It would be rather beneficial if simple fertilizers were used to eliminate negative responses obtained from applying excess potassium to soils similar in chemical properties to the soil in the Tripoli area.

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