Growth and Yield of Two Potato Cultivars as Affected by Irrigation and Fertilization under Libyan Conditions

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ABSTRACT

A field-plot experiment was conducted at the University of Tripoli in 1973 to test the effect of both irrigation and fertilization on the growth and yield of two potato cultivars Up-To-Date and Arran Banner. Sprinkler irrigation was applied after sprout emergence at three matric potential −15, −25 and −35 Joules/kg. Fertilization included application of 12–24–12 fertilizer at 4 rates 0, 200, 400 and 600 kg/hectar. Both vegetative and yield characters were tested.

Results showed that growth measured as weight of shoots, and number of aerial stems per plot, and yield measured as weight and number of tubers per plot increased by fertilizer application. This held true in both cultivars tested.

Irrigation at relatively high suction (low matric potential) resulted in lowering the growth as well as the yield of potatoes.

Both the growth and yield of the Up-To-Date cultivar were better than those of Arran Banner.

INTRODUCTION

Agricultural expansion in new lands have created the need for more efficient use of the available water resources. Irrigation of crops only when water is needed has, therefore, become mandatory. This, of course, depends on the type of crop, fertility status of the soil, environment and other factors. Potato is one of the crops described to possess high water requirements (3,10,11,12). This, however, was questioned by other investigators (1,4,14).

Water-use efficiency is closely related to the fertilization policy practiced for a certain crop. Viets (13) stated that the water-use efficiency, expressed as yield per acre-inch of water, increased when there was a yield response to the fertilizer.

This paper presents an investigation on the irrigation, and fertilization relationship with the growth and yield of two potato cultivars.

MATERIALS AND METHODS

A field-plot experiment was conducted at the College of Agriculture Experimental Farm in Tripoli, Libya in 1973. The experiment consisted of three main blocks separated

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from each other by a 3 metre-wide strip. Blocks were then divided into plots each of which was 6 × 5 metres.

Irrigation Treatments

Plots within each block received one irrigation treatment. Four tensiometers were properly inserted into the soil of each block at equal depths and in different spots. Blocks were thus irrigated at different time-intervals according to the tension reading of the tensiometer. Three tension readings: 150, 250 and 350 millibars of suction (− 15, − 25, and − 35 Joules/kg potential) were tested. Sprinkler irrigation was used by maintaining a fixed system through which only one block was irrigated as desired.

Fertilizer Treatments

Plots were fertilized with a compound fertilizer (12–24–12) including four rates: 0, 200, 400 and 600 kg fertilizer per hectar. Fertilizer application was divided into two doses: after sprout emergence, and 4 weeks later. Fertilizer treatments were distributed at random within each irrigation system. Two potato cultivars, Up-To-Date and Arran Banner, were tested. Each plot was divided into two sub-plots 3 m × 5 m, each planted with one variety. All treatments were replicated three times.

Potato tubers were planted at the beginning of March, and all blocks received similar irrigation until sprout emergence. Thereafter, irrigation and fertilizer treatments were started.

At the end of the growing season, both shoots and tubers of each sub-plot were harvested, and the data for the vegetative and yield characters were recorded. These characters included weight of shoots, number of aerial stems, weight of tubers and number of tubers per sub-plot.

All data were subjected to the analysis of variance, and the Duncan Multiple Range test was used to compare means.

RESULTS AND DISCUSSION

The fertilization-irrigation interrelationship is of importance especially with regard to the growth and yield of certain crops. If a relationship is to be established between soil moisture regime and growth, it would be different at different levels of fertility (13).

Results obtained in this investigation are, therefore, discussed in view of the irrigation-fertilization interaction.

Vegetative Characters

Table 1 presents the data obtained for the fresh weight of shoots and the number of aerial stems for both cultivars tested. The weight of shoots within each irrigation treatment, reveals a highly significant effect due to fertilizer application. This was true under all irrigation treatments and in both cultivars. The vegetative growth of potato plants was evidently stimulated by fertilizer application. Maximum growth was obtained under application of 600 kg fertilizer per hectare, with medium irrigation treatment (250 millibars of suction). Murphy and Goven (7) reported best growth and highest yields of Kennebec potatoes from applications of 90–120–120 lbs per acre. Such a rate corresponds partially with the highest fertilization rate used in this investigation. According to other investigators (2,8), higher rates of fertilization were found noneffective.

Table 1 Effect of soil moisture stress and fertilizer application on the vegetative characters of potatoes[1].

Treatments		Arran Banner		Up-To-Data	
Irrig. millibar	Fert. kg/ha	wt of shoots kg/plot	no. of haulms/ plot	wt of shoots kg/plot	no. of haulms/ plot
150	0	0.80 bc	52	1.53 bcd	30
	200	1.39 abc	31	1.93 abcd	35
	400	1.40 abc	32	2.65 ab	40
	600	1.87 a	46	2.53 ab	34
	Average	1.36	40	2.16	35
250	0	0.88 abc	30	1.18 cd	35
	200	0.84 bc	30	1.58 bcd	37
	400	1.58 abc	37	2.23 abc	38
	600	1.75 ab	43	2.93 a	44
	Average	1.26	35	1.98	38
350	0	0.60 c	27	1.03 d	28
	200	0.89 abc	34	1.26 cd	32
	400	1.37 abc	41	1.56 bcd	42
	600	1.46 abc	49	1.71 bcd	41
	Average	1.08	38	1.31	36
"F" values					
Fertilizer		6.04**	$1.78^{n.s}$	5.95**	$0.93^{n.s}$
Irrig. × Fert.		$0.35^{n.s}$	$1.01^{n.s}$	$0.54^{n.s}$	$0.17^{n.s}$

[1]Each value represents the mean of three replicates. Values with similar letters are not significantly different.

Comparison of the same data with respect to the effect of irrigation treatments shows some effect due to irrigation at different soil moisture tensions. Relatively higher moisture tensions resulted in decreasing the vegetative growth of potato plants to variable extents depending on rate of fertilizer applied and cultivar tested. Irrigation at a matrix potential of – 15 Joules/kg (150 millibars suction), gave better growth of potatoes than at higher tensions. This agrees with data reported by several investigators (3,5,6).

The weight of shoots at time of harvest was generally higher in the cultivar Up-To-Date than in Arran Banner. This was noted under all levels of irrigation and fertilization tested. This varietal differences may be attributed to the type of growth in both cultivars. In seed potato catalogues, Arran Banner is listed as medium to late maturing cultivar, while Up-To-Date is considered a late cultivar. However under our conditions, both cultivars showed maturity symptoms simultaneously.

Data given in Table 1 for the number of aerial stems per plot are not consistent and show no significant effect for either irrigation or fertilization. The increase in fresh weight of shoots by better moisture and fertilizer levels was apparently due to better growth of haulms rather than increase in number of haulms. This agrees with Van der Zoag (12) who stated that the number of haulms per plant depends mainly on the cultivar and the physiological age of seed tubers. In the present investigation the two cultivars tested showed no difference in number of haulms per plant.

Yield Characters

The effect of both fertilizer application and irrigation on potato yield was tested by measuring the weight as well as the number of tubers per plot. Data presented in Table 2

Table 2 Effect of soil moisture stress and fertilizer application on yield characters of potatoes[1].

Treatments		Arran Banner		Up-To-Date	
Irrig. millibar	Fert. kg/ha	wt of tubers kg/plot	no. of tubers/ plot	wt of tubers kg/plot	no. of tubers/ plot
150	0	1.64 b	43	2.36 de	81 bc
	200	3.14 ab	59	3.31 bcde	80 bc
	400	3.13 ab	63	5.41 a	120 abc
	600	4.70 a	76	4.11 bc	105 ab
	Average	3.16	61	3.79	92
250	0	1.93 b	56	2.25 de	75 c
	200	2.09 b	49	2.65 de	80 bc
	400	3.61 ab	72	3.96 bc	107 ab
	600	3.86 ab	72	4.25 b	124 a
	Average	2.87	64	3.28	97
350	0	1.59 b	61	2.07 e	81 bc
	200	2.29 ab	74	2.48 de	88 bc
	400	2.29 ab	66	3.51 bcd	96 bc
	600	2.22 b	67	2.93 cde	106 ab
	Average	2.10	67	2.75	93
"F" values					
Fertilizer		3.73*	$1.73^{n.s}$	17.68**	10.69**
Irrig. × Fert.		$0.75^{n.s}$	$0.69^{n.s}$	$1.41^{n.s}$	6.20**

[1]Each value represents the mean of three replicates. Values with similar letters are not significantly different.

indicate that the rate of fertilizer application resulted in a gradual increase in the weight of tubers per plot. However, the rate of 400 kg/ha tended to give best yields. This, in general, held true at all irrigation treatments and in both cultivars tested. If these results are examined in conjunction with the trends described above for the vegetative growth, one may see that not only growth but yield of tubers was also encouraged by fertilizer application. Potato tubers accumulate their stored starch from the premanufactured carbohydrates in the aerial shoots. As the size of the latter is increased, a larger leaf area is obtained and accordingly more carbohydrates are synthesized leading to more storage of starch in the tubers. Many investigators (7,8,9) have pointed to better potato yields under fertilization with nitrogen, phosphorus and potassium.

The data also show that irrigation at different matric potentials has significantly affected the yield of potatoes. As the moisture tension increased, potato yield was reduced. This was evident in both cultivars tested. Therefore, the growth and yield of potatoes seem to be similarly affected by irrigation.

Evidently, fertilizer applications have significantly increased the number of tubers per plot. This was found under almost all irrigation treatments and in both varieties. It seems that fertilization was not only beneficial for shoot development and carbohydrate synthesis but it was also effective in encouraging stolon development and tuberization. The effect due to irrigation under the levels tested in the present investigation was, however, slight and inconsistent.

The yield of tubers in the cultivar Up-To-Date was generally higher than in Arran Banner. As the vegetative growth in these two cultivars showed the same trend, it could be concluded that the cultivar Up-To-Date had a higher yielding potential than the cultivar

Arran Banner under the conditions of the present investigation. This could be due to larger number of tubers noticed in Up-To-Date cultivar. Van der Zaag (12) showed, that yield of tubers is highly related with higher numbers of tubers per plant.

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