Effect of Irrigation and Organic Manuring on Growth and Yield of Arran Banner Potato

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ABSTRACT

An experiment was conducted in 1974 at the farm of the Faculty of Agriculture, University of Tripoli to study the effect of sprinkler irrigation at different levels of soil moisture tension and the application of different amounts of farmyard manure on the growth and yield of potato (cultivar Arran Banner). The experimental design was a split-plot with irrigation treatments as main plots and manuring as subplots. The irrigation treatments consisted of three levels. These were to deplete soil moisture in the root zone to predetermined values of 70% (dry), 50% (medium) and 30% (moist) of the available moisture before starting the next irrigation to bring the moisture content in the effective root depth to the field capacity. The organic manuring had three levels 0, 100 and 200 m^3 per hectar. A compound fertilizer 12–24–12 was applied to all plots at the rate of 300 kg per hectar.

Results showed that yield of tubers was significantly increased at higher moisture levels. On the other hand, organic manuring did not give significant increase in yield of tubers. The greatest yield of tubers was obtained at highest levels of both irrigation and manure application. At lower levels of irrigation, organic manuring partially compensated the low yield encountered in the dry irrigation levels.

Fresh weight of the shoot system was significantly increased by higher levels of both irrigation and manuring. Length of stems was significantly increased by higher levels of irrigation and by manure application. Number of haulms per plant was not significantly affected by either irrigation or manuring levels. Apparently the better vegetative growth obtained by higher levels of irrigation and manure application was mainly due to the lateral branching of the main haulms but not due to the number of haulms. There was an association between vigorous vegetative growth and high yield of tubers.

INTRODUCTION

A knowledge of the soil and its moisture characteristics and the relationship between these characters and plant growth is needed for the efficient use of water in supplemental

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irrigation. Possibly more economic use of water could be obtained by irrigation at definite soil moisture and plant relationships rather than applying set amounts of water at pre-arranged intervals during the growing season.

High yields of potato were obtained by keeping the water content of the soil at a high level throughout the growing season by maintaining a soil moisture regime in the upper half of available moisture (11). Applying soil moisture regime below this level, water use and yields were reduced, and the amount of water consumed per pound of tubers was increased (3). It was also reported by Stockton (13) that irrigation at tensions above or below 40–60 centibars can reduce yield and quality of potatoes. Applying water when soil moisture tension was below 40 centibars reduced yields probably because of poor aeration. When the tension reached 70, wilting was apparent and there was a definite deficit in soil moisture.

The reaction of different potato cultivars to adverse moisture conditions is fairly understood. The cultivar Arran Banner is well known for its ability to resist drought (2), and therefore is recommended for arid and semi arid areas such as Tripoli.

In sandy and sandy loam soils, the water holding capacity can be improved by additions of organic matter. One of the most important soil problems in particularly all potato regions, except those with mucks and peat is that of applying and maintaining soil organic matter (7). In warm long growing areas, decomposition of organic matter in the soils is rapid and almost continuous. In cooler regions decomposition is less rapid.

In an attempt to find out whether the beneficial effect of manure application was due to improving soil moisture conditions or to nutrients contained in the manure, Salter and Williams (10) conducted an experiment on a sandy loam soil in Wellesbourn, Warwick, England. They applied either farmyard manure or peat to the soil and studied the effects of these soil additives on soil moisture characteristics and crop yield in 9 vegetable crops. In all vegetables tested, the highest yields were always obtained from the manure treated plots. The differences in yields between the peat and control were generally small and without consistent trend. They concluded that the increased yields which followed application of manure to that soil were primarily caused by the nutrient content of the manure.

The purpose of the present investigation is to study the effects of irrigation at different soil moisture tensions in combination with the application of different levels of farmyard manure on the growth and yield of Arran Banner potato.

MATERIALS AND METHODS

The experiment was conducted on a sandy loam soil of the farm of Faculty of Agriculture in Tripoli during the spring season of 1974. The field plots were selected in an area of the farm which had been in arable production for several years but received no organic manure during the last four years. The design used was a split plot with irrigation treatments as main plots and mauring as subplots, with three replications. The irrigation treatments consisted of three levels. These were to deplete soil moisture content to pre-determined values of 30, 50, and 70 % of available moisture before commencing the next irrigation to bring the moisture content to field capacity in the effective root depth. These were achieved by scheduling different frequency and irrigation periods for each plot. A controlled sprinkler irrigation system was used for each irrigation. Tensiometers were placed at 30 cm depth to check their readings at the scheduled time of irrigation (1).

Three levels of manure (0, 100, and 200 m^3 per hectar) were tested. Well fermented

farmyard manure in the quantity assigned to each plot was spread on the surface of the ploughed soil, then incorporated in the upper 15 cm layer of the soil by rotavation to obtain thorough mixing. Manure was applied about 2 weeks before planting. The main plots were 80 × 10 m, while the subplots were 25 × 10 m and the crop yields were recorded from a central area of 6 × 10 m of the subplots. The main plots were separated by 10 m borders to avoid drift during irrigation.

The cultivar used in the present investigation was Arran Banner. Grade A seed tubers of this cultivar imported from Northern Ireland were planted at the rate of 2 tons per hectar. Seed tubers were planted in rows 65 cm apart and spaced at 30 cm in the row using a tractor-hauled potato planter. The crop received a complete fertilizer 12–24–12 as a side dressing at the rate of 300 kg per hectar as an overall treatment after the complete emergence of the plants. Weeding and pest control were followed as commonly practiced.

When the plants attained full growth and started to show maturity symptoms, 5 plant samples were taken from each plot to examine stem length, number of haulms (stems) and fresh weight of tops. Plants were lifted and tuber yields were recorded when the plants showed signs of complete maturity and the vines started to die.

Analysis of variance for data obtained on yield and vegetative growth was done and the means of different treatments were compared using the least significant difference method as described by Steel and Torrie (12).

RESULTS

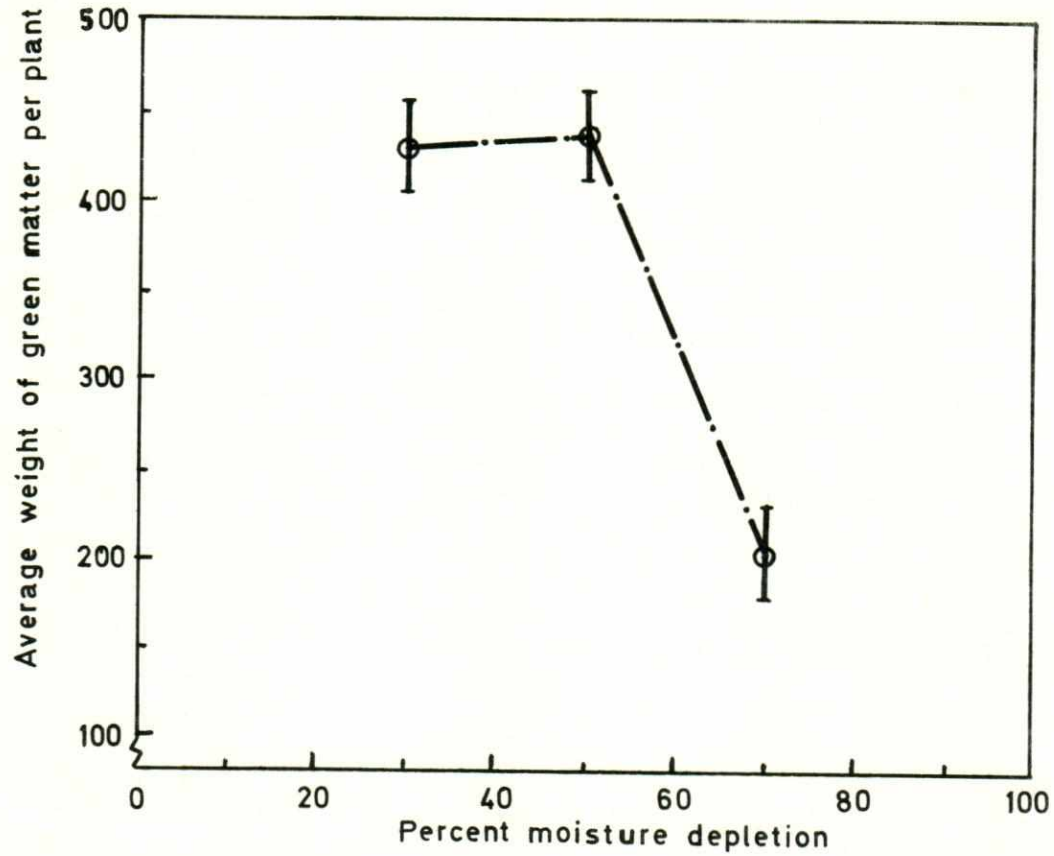
Table 1 shows the 'F' values for the data obtained on the effect of moisture tension and manuring levels on yield of tubers and vegetative growth. Irrigation at low moisture tension levels had a significantly favourable effect on both yield of tubers and fresh weight of vines. Application of organic manure had no significant effect on yield of tubers although it had a highly significant stimulating effect on fresh weight of vines and length of stems. No interaction was obtained between irrigation and manure treatments.

As shown in Table 2 and Fig. 1, irrigation at 50% soil moisture depletion gave significantly lower yield of tubers than irrigation at 30% soil moisture depletion. Allowing the soil to lose 70% of available moisture before irrigation resulted in a further significant reduction in yield of tubers. Manuring at both rates used in the present investigation did not show any effect on yield of tubers at the moist irrigation treatment (30% soil moisture depletion). However, in medium and dry levels of irrigation (50% and 70% soil moisture tension) manuring had a beneficial effect on yield of tubers and the benefit was proportional to the amount of manure applied.

Table 1 F-values for yield and growth measurements.

Source of variation	F-values			
	Yield of tubers/plot	Weight of vines	Length of stem	Number of stems
Irrigation	13.8[1]	14.25[1]	1.33 N.S.	0.29 N.S.
Manuring	1.2 N.S.	21.66[2]	165.66[2]	3.43 N.S.
Interaction	0.52 N.S.	0.96 N.S.	2.46 N.S.	2.44 N.S.

N.S. = non significant.
[1]significant at the 5% level.
[2]significant at the 1% level.



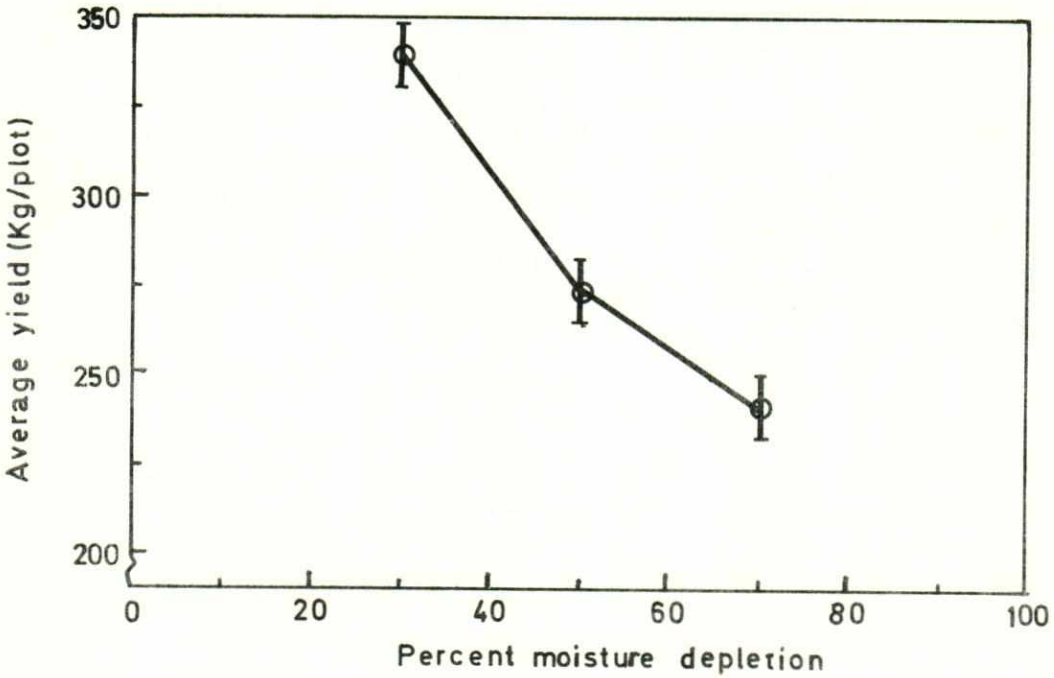


Fig. 1. Effect of percent moisture depletion on vegetative growth and yield of tubers.

Table 2 Effect of manuring and soil moisture depletion levels on yield of tubers.

	Average yield at different soil moisture depletion levels (kg/plot)			
Manuring level	30%	50%	70%	Mean
No manure	117.56	85.80	64.53	89.30
100 m^3 per hectar	104.86	89.53	80.56	91.65
200 m^3 per hectar	117.80	98.66	91.50	102.65
Mean	113.41	91.33	78.87	

L.S.D. (.05) for irrigation = 17.71 kg
L.S.D. (.05) for manuring = N.S.

The fresh weight of tops as shown in Table 3 was significantly affected by both irrigation and manure levels, high soil moisture tension decreased the weight of shoots. Nevertheless, the increase in soil moisture tension from 30% to 50% soil moisture depletion did not have a pronounced deleterious effect on vegetative growth but further depletion of soil moisture to 70% before irrigation resulted in a drastic stunting of vegetative growth in all levels of manuring.

A similar trend was noted for the effect of manuring on vegetative growth. Manure application resulted in a higher fresh weight of tops under all levels of irrigation.

Length of stems (Table 4) was significantly increased by higher irrigation levels but was not affected by manure application.

As shown from Table 5, number of haulms per plant was not significantly affected by either irrigation or manuring treatments in the present investigation.

DISCUSSION

The results obtained in the present investigation would emphasize the importance of keeping a sufficient and relatively steady moisture supply for potato plants to obtain maximum yield of tubers. This could be achieved mainly by proper irrigation and partially by manure application.

Table 3 Effect of manuring and soil moisture depletion levels on fresh weight of tops.

	Fresh weight of tops (gm/plant) at different soil moisture depletion levels			
Manuring level	30%	50%	70%	Mean
No manure	137.8	129.8	66.2	111.3
100 m^3 per hectar	206.4	217.4	81.0	168.3
200 m^3 per hectar	303.0	307.0	151.5	253.8
Mean	215.3	218.1	80.6	

L.S.D. (.05) for irrigation = 93.93 g
L.S.D. (.05) for manuring = 52.34 g

Table 4 Effect of manuring and soil moisture depletion levels on length of haulms.

	Length of haulms(cm) at different soil moisture depletion levels			
Manuring level	30%	50%	70%	Mean
No manure	30.6	29.3	26.4	28.8
100 m^3 per hectar	36.9	33.5	30.5	33.6
200 m^3 per hectar	47.3	48.5	39.8	45.2
Mean	38.3	37.1	32.2	

L.S.D. (.05) for irrigation N.S.
L.S.D. (.05) for manuring = 2.27 cm

Struchtemeyer (14) concluded that moisture tension in the soil affected the yield of tubers. A shortage of soil moisture either early or late in the growth cycle of the potato plant reduced yield although the reduction was more marked when the shortage occured in the last half. Studies of Haworth (4), and Haworth *et al.* (5) have indicated that addition of farmyard manure together with inorganic fertilizers gave considerable increases in the yield of potato and other vegetable crops over those receiving inorganic fertilizers alone. The relative increases in yields from the manured plots were generally greater in dry than in wet years. Studies on the effect of farmyard manure on moisture characteristics of the soil showed that the additions of manure to sandy loam soil increased the available water capacity (8), and altered the moisture release characteristics (9) so that the moisture conditions in the manured soil were likely to be more favourable for plant growth than those in the non manured soil. Such improvement in soil characteristics of manured soil may account for the better yield and vegetative growth in manured plots compared to non manured plots in the high moisture tension treatments of the present investigation.

The beneficial effect of manuring on vegetative growth and tuber yield can be due to the supply of some nutrients necessary for the growth of the plant especially under high levels of manure application as suggested by Salter and Williams (10). Yet, the less appreciable response of yield could be due to that at time of tuber setting and develop-

Table 5 Effect of organic manuring and soil moisture depletion levels on number of haulms per plant.

	Number of haulms per plant at different soil moisture depletion levels			
Manuring level	30%	50%	70%	Mean
No manure	2.5	3.1	3.0	2.8
100 m^3 per hectar	2.3	2.7	2.5	2.5
200 m^3 per hectar	2.9	2.5	2.8	2.7
Mean	2.6	2.8	2.8	

L.S.D. (.05) for irrigation N.S.
L.S.D. (.05) for manuring N.S.

ment a high level of available moisture should be maintained to obtain maximum yield. To achieve the optimum moisture level in the soil required for the highest yield, there is no other alternative of irrigation.

The non significant effect of irrigation on the length of stems would indicate that higher levels of irrigation stimulated vegetative growth through branching of the main stems rather than their elongation. The lateral expansion of the shoot system through branching gives a larger leaf area and therefore increases the sites of photosynthesis which will be reflected favourably on the tuber yield.

The non significant effect of both irrigation and manuring treatments on the number of haulms per plant agrees with Van der Zaag (16) who stated that the number of haulms per plant is mainly affected by the cultivar and the physiological age of tubers and is less affected by fertility or moisture levels of the soil.

As a general conclusion, we can recommend in sandy loam soils and in semi-dry areas such as Tripoli, that for the production of good yields and the economic use of water, sprinkler irrigation should be applied when available moisture in the soil is depleted by 30%. At present time there are simplified procedures for determining soil moisture tension that the ordinary farmer can even use. Also manuring would be advisable for good growth of potato. According to Thompson and Troch (15), the largest yield increases per ton of manure are at relatively low rates of application. But, the largest profit per hectar resulting from manuring comes from covering maximum acreage at relatively low rates rather than using higher rates on a smaller acreage and additional nutrients needed would be applied as inorganic fertilizers. Herron and Erhast (6) mentioned that high quality farmyard manure can be a good source of N in irrigated areas. They found that during the crop year when manure was applied, each ton of manure produced a yield increase equivalent to increase from 11 lbs of N. Residual value decreased by approximately one half each year. The 4-year accumulation value for each ton of manure was equivalent to 22 lbs of N from ammonium nitrate. This is approximately 70% of the total N-content of the manure. Each ton of manure was equivalent to less than 2 lbs of N during the fourth crop year after application. Therefore, the previous additions of manure to the soil should be taken in consideration when deciding the amounts of manure to be added.

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