Water Requirements for the Onion as Influenced by Soil Moisture Content and Soil Moisture Tension

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INTRODUCTION

The time is rapidly approaching in the Libyan Arab Republic where only the most efficient and reproductive uses of water will be tolerated. Agriculture will not escape this demand. In fact, in Libya, where water is in short supply, farmers are already having to learn to use water in the most efficient way possible to get maximum production from each unit of water and each unit of land. Very careful consideration of irrigated crops and determining their actual irrigation needs is essential to maintain optimum and efficient use of water in the farm.

Quantities of irrigation water used at present, for onions, need to be investigated by well-controlled field experiments. Onions, have limited root systems and a high demand for water. The purpose of this study is to determine by controlled experiment soil water depletion and the potential to be maintained for maximum yield of onions, and the corresponding quantities of water to be applied. This will furnish suggestions for a better scheduling of irrigation for onions to be made. Determination of the crop factor will also be attempted depending upon actual moisture depletion and climatic factors measured in situ.

MATERIALS AND METHODS

The experiment was carried out at the Faculty of Agriculture Farm in Sidi-Misri, Tripoli. It consisted of 3 blocks, each divided into 3 plots (6×7.5 meters), where 3 treatments were applied at random. The treatment here is the level of moisture depletion in percentage corresponding to a certain soil-moisture tension.

The soil in the area is classified as sandy loam soil. The physical properties were determined in the field and in the laboratory, together with its retential characteristics.

Onion (Grane) in all plots was irrigated equally till the bulb development and enlargement stage. It was then subjected to 3 levels of moisture in the soil before applying specified amounts of water to bring the effective root depth to field capacity level. These water depletion levels were 60%, 50% and 40% of the available moisture content. These will be referred to as T_1, T_2 and T_3 respectively. Onions were transplanted from seedbeds in the neighbouring sites and planted immediately in the plots. All plants were given equal amounts of water directly after they had been set. Due to frequent precipitation conditions, these equal amounts were given as compensation till the period of bulb development and enlargement. The plots were then irrigated according to the different

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levels of treatment until they were nearly mature. The preassigned amounts of water delivered were controlled by: size of nozzle, spacing, operating pressure and scheduling of irrigation used. Climatological information was obtained from the farm weather station and from the weather agencies. Soil moisture contents were determined for samples taken from each sub-plot at 20 cm depth (the most effective depth) before, after, and in-between intervals of irrigation. When the plant was mature, irrigation was discontinued. Plants from representative samples of an area 2.00 × 1.80 meters from each plot were collected. Vegetative parts, scallion and definite weight were measured.

RESULTS AND DISCUSSION

The soil moisture properties together with the schedule and amount of applied irrigation water are shown in Table 1. Figure 1 shows the characteristic curve for values obtained in situ together with those measured in the laboratory for undisturbed samples. Table 2 shows moisture added by irrigation and depleted by onion and plant factor K for the three treatments together with the corresponding soil moisture potential. Figure 2 shows net water consumed (in percent by volume) during the period of bulb development and enlargement for the three treatments. This period was chosen as it was reported by Singh and Alder (10) to be the most sensitive to moisture stress in onion growth. Marketable and total yield obtained are shown in Fig. 3, versus level of moisture content and soil-moisture potential. In order to eliminate variations due to soil or distribution of water by sprinklers, values reported are taken as the average for each of the three plots, treated alike.

A gradual change in evapotranspiration was observed for the progressive depletion of soil moisture and the corresponding soil moisture stress, and plotted in Fig. 3. This is in contrast with Veihmeyer and Hendrickson (14) who long contended that evapotranspiration does not decrease materially until soil moisture falls almost to the permanent-wilting percentage. Similar results, however, were obtained by Stanhill (11) and Hagan and Vaadia (4). They have shown such an effect to happen earlier. Values given in Fig. 3, clearly indicate a change in evapotranspiration with variation in moisture content and soil moisture tension. These variations could be attributed to changes in stomata openings due to changes in plant moisture stress which are related to soil moisture stress (6, 7).

It is clear that a minimum moisture depletion of 40% (T_3; 250 millibars of suction) produced the relatively highest total yield per unit of water added. Treatment T_2 (230 millibars), gave the highest marketable yield per unit of water applied. So it can be suggested that irrigation should be applied to onion when soil moisture tension is between 230 and 250 millibars for maximum production. Similar work by Pew (9) suggested

Table 1 Physical properties of soil, amount of moisture added and schedule of irrigation for three levels of treatments.

Treatment	Field capacity % by wt.	wilting point % by wt.	Bulk. density d_b	Net amount of water to be replaced per one irrig. mm.	Gross amt. to be added mm.	Frequency days	Irrigation period minutes
T_3				47.8	68.6	7	30
T_2	12	5	1.40	39.7	85.1	9	50
T_1				71.6	101.6	11	70

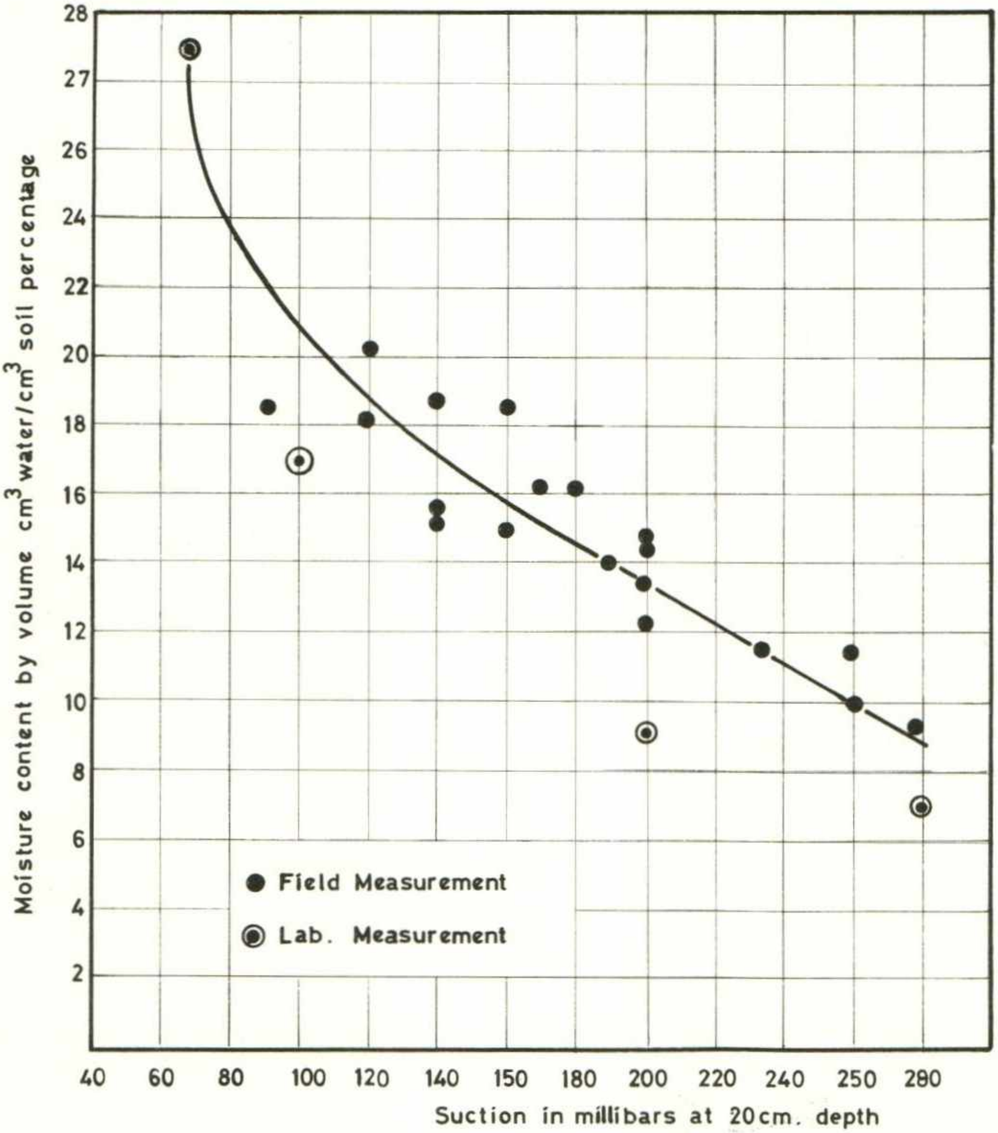

Fig. 1. Moisture characteristic curve for experimented area.

values of 450 millibars for the early part and 550 millibars for bulbing. Jones et al. (5) on the other hand indicated the need for keeping tension below one third atmosphere (less than 330 millibars) for maximum production. Recent work at the University of California, (2) using drip irrigation gave maximum production when tension was maintained at about 200 millibars. This is in close agreement with our findings. The amount of water in a soil under any given condition is related to the potential of water in the soil. The soil conductivity to water and plant water potentials are directly related to the soil water potential (3,12). Low soil water potential, and consequently low plant water potential, result in reducing tissue hydration. This may affect plant growth in several ways. The most important of these are: retardations of enzyme reactions, partial closure of stomata, decrease in cell expansion and reduction in leaf area (13, 15). This can explain the variations reported.

Table 2 Moisture added by Irrigation and depleted by onion, and plant factor K together with application efficiency for three levels of treatment T_1, T_2, T_3.

			Treatment		
			T_1	T_2	T_3
Moisture in m.m. in Irrigation	1	stored per period	24.21	21.50	15.80
		depleted per day	2.39	2.83	2.35
	2	stored per period	23.5	20.0	17.80
		depleted per day	2.58	3.30	3.65
	3	stored per period	26.0	23.5	16.70
		depleted per day	3.12	3.58	4.00
	4	stored per period	—	—	18.70
		depleted per day	—	—	3.85
Average moist depleted mm/day	April		2.50	3.10	3.30
	May		3.10	3.50	3.80
Actual amount of water m.m.	stored		73.70	65.00	69.00
	added		111.50	99.50	108.00
Mean month-temp. °F	April		64.50	61.50	64.50
	May		69.50	69.50	69.50

Percent day light hours	April	8.72	8.72	8.72
	May	9.53	9.5	9.53
Plant factor K	April	.53	0.65	0.70
	May	.57	0.65	0.70
Irrigation efficiency in percent		66	65	64

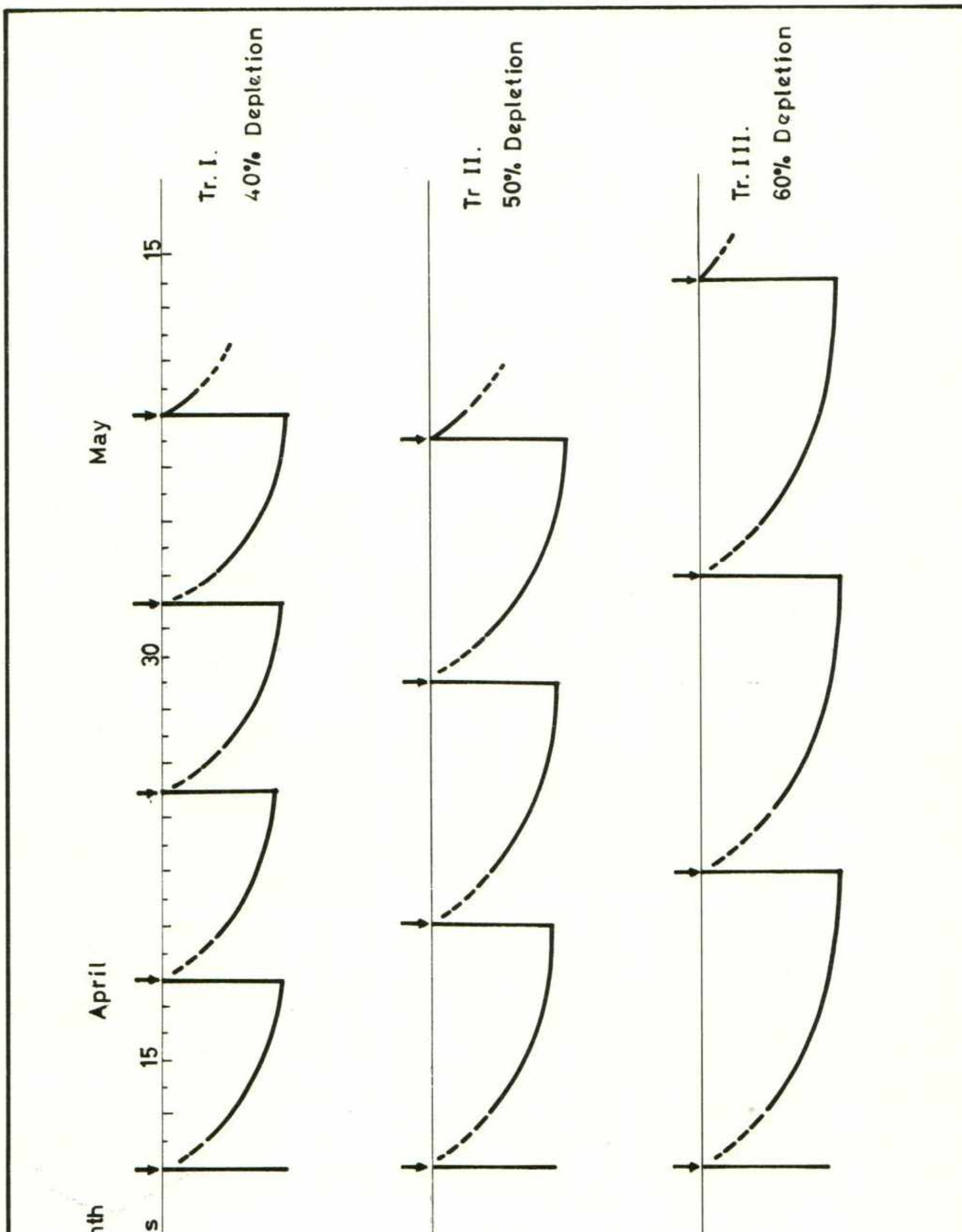

Fig. 2. Moisture content by volume vs. time for the three treatments

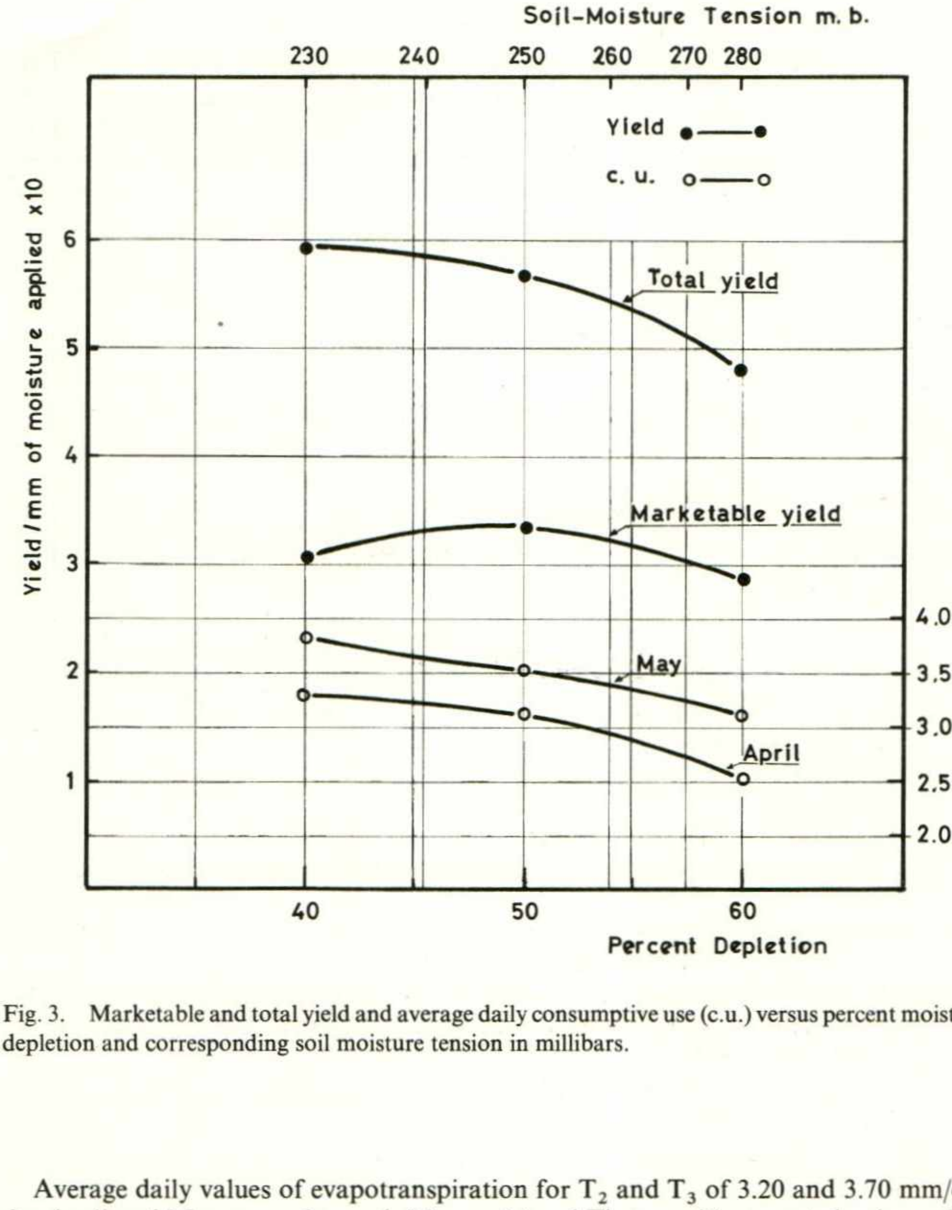

Fig. 3. Marketable and total yield and average daily consumptive use (c.u.) versus percent moisture depletion and corresponding soil moisture tension in millibars.

Average daily values of evapotranspiration for T_2 and T_3 of 3.20 and 3.70 mm/day for April and May were observed. Massocchi and Thrower (8) suggested values of 2.4 mm/day in April and 3.4 mm/day for May. The yield in this case however, was not evaluated and is expected to be lower.

The values of the crop factor K calculated by Blaney-Criddle method (1) comparing climatological factors obtained, and measured depletions of soil moisture suggest an average value of 0.65 for April and May. This gives about 0.13 in/day in May which is about 0.40 of c.u. of alfalfa accepted in similar areas in this period. This is in close agreement with values suggested by others (1).

SUMMARY

An experiment was conducted to determine the most optimum moisture content to be depleted and the corresponding soil moisture tension to be maintained for scheduling irrigation for onion (Grane). Three levels were maintained by controlling application of water by sprinkler systems. Evaluation of crop factor K was also tried. Values obtained show changes in yield and transpiration for different levels of moisture depletion and stress.

Moisture depletion between 40 and 50 % of available moisture-corresponding to a soil moisture tension of 230 to 250 millibars was suggested to be maintained for relative maximum yield per unit of water used. A plant factor K equals 0.65 is suggested to be used for the months of April and May. More work is advised where the Penman equation is to be used to evaluate evaporation. Moisture levels to be maintained under different rates of fertilizers application are pertinent before a final conclusion could be precisely followed.

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