Shallot root distribution and bulb yield as influenced by irrigation frequency

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SUMMARY

The effect of irrigation frequency on lateral and vertical root growth, and bulb yield of shallots (*Allium cepa* var. *ascalonicum* cv. Tropix) was investigated in the field (polytunnel). The experimental treatments were dry (85 l of water; frequency = 12), medium (135 l of water; frequency = 20), and wet (220 l of water; frequency = 36). The wet treatment recorded the highest lateral root growth. Vertical root growth (root depth) was unaffected by irrigation frequency to any significant extent. Number of bulbs per plant was the same in all the three irrigation treatments. The wet- treated shallots had the highest bulb diameter, bulb weight, and bulb yield.

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RÉSUMÉ

ABBEY, L. & FORDHAM, R.: *La distribution de racine d'échalote et le rendement de bulbe comme influencé par la fréquence d' irrigation.* L'effet de la fréquence d' irrigation sur la croissance latérale et verticale de racine et de rendement de bulbe d'échalotes (*Allium cepa* var. *ascalonicum* cv. Tropix) était enquêté dans le terrain (polytunnel). Les traitements expérimentaux étaient sec (85 litres d'eau; la fréquence = 12), moyen (135 litres d'eau; la fréquence = 20), et humide (220 litres d'eau: la fréquence = 36). Le traitement humide engregistrait la croissance latérale de racine la plus elevée. La croissance verticale de racine (profondeur de racine) n'était pas influencée par la fréquence d' irrigation à aucune étendue considérable. Le nombre des bulbes par plante était le même dans tous les trois traitements d' irrigation. Les échalotes traitées-humides avaient les plus elevés de diamètre de bulbe, de poids de bulbe et de rendement de bulbe.

Introduction

Shallots are important crops used as spice and vegetable in most parts of the world. Onions and shallots are plants of open, sunny, dry areas, and are grown throughout the temperate and tropical regions (Brewster, 1994). The optimum temperature for vegetative growth is between 16 and 20 °C. However, tropical varieties can grow between 22 and 30 °C when adequately watered (Messiaen, 1994). Generally, alliums have less ability to compensate for low root water potential by decreasing the water potential of leaf tissues. This is attributed to their shallow root system which makes alliums more sensitive to water stress (Millar, Gardner & Goltz, 1971).

At slightly negative plant tissue water potential, hydrolytic enzymes increase. This results in osmotic regulation to resist the drought, and thus inhibit shoot growth while root growth is improved to increase water absorption (Salisbury & Ross, 1992). Brewster (1990a) indicated that the difference in water potential between onion leaves and roots increased steadily from 0 to -0.4 mPa as transpiration rate increased. Onion bulb yields are highest in crops irrigated to field capacity whenever the moisture tension at 15 cm depth exceeds 0.04 mPa (Brewster, 1990b).

Brewster (1990b) observed that increased yield from irrigation resulted from larger onion bulbs rather than from higher plant populations. At a

rate of 140 l water per metre row, the yield and grade of onion bulbs increased significantly (Kratky, Bowen & I-Pai Wu, 1990). Karim, Khan & Rahman (1981) reported that when irrigation was applied to onion plants up to 16 occasions (about 520 mm water use), as the frequency of irrigation reduced to zero (8, 6, 4, 2, 0), yield gradually decreased. A report by IAR (1980) showed that optimum onion bulb was obtained when irrigation was applied to the crop throughout the growing season until harvest or 1 week before harvest in Nigeria.

Bari (1974), however, found that the frequency of irrigation (0 to 3) had no influence on onion bulb yield. Brewster (1990b) noticed that irrigation frequently delayed onion bulb maturity, and, therefore, excessive late growth and bulb splitting can be prevented by ceasing irrigation 3 weeks before harvest.

Generally, the soil moisture regime favourable for high onion bulb yields is not optimum for good quality bulb. Therefore, there is the need to adopt an irrigation schedule which would consider bulb yield quality (Rana & Sharma, 1994).

This study aimed to determine the extent to which different irrigation frequencies affect shallot root distribution in the soil, and also how they influence bulb yield.

Materials and methods

The shallot seeds were sown on 4 April 95, in drills of 25 cm between rows in a poly-tunnel (a structure covered with high density polyethyene to exclude rainfall). Thinning was done to about 8 cm between plants 3 weeks after planting. Each plot was a square metre bed (1.28 m × 0.78 m) of three rows, with a total plant population of 60.

Soil moisture characteristics which were predetermined by Panagiotopoulos (1988) were as follows: field capacity = 24.5 per cent w/w; permanent wilting point = 13 per cent w/w; and available water capacity/metre depth = 162 mm.

The experimental layout was a 3 × 3 randomized complete block design. Five litres of water was applied uniformly to each square metre of plot at each irrigation, during the first month of crop growth. Thereafter, the following experimental treatments were imposed:

The experiment was laid in a randomized complete block design with three replications. The irrigation treatments applied to the plant starting 30 days after planting were as follows:

i. Treatment 1 = wet treatment which received a total of 220 l of water (frequency = 36).
ii. Treatment 2 = moist treatment which received a total of 135 l of water (frequency = 20).
iii. Treatment 3 = dry treatment which received a total of 85 l of water (frequency = 12).

Two weeks before harvest, all plots received 10 *l* of water per plot at every irrigation.

Data were collected on root depth, lateral root extension at 5-6 cm depth, bulb dry weight, bulb diameter, number of bulbs, and bulb yield. Results were tested by analysis of variance (ANOVA), and least significant difference (LSD) values used to compare treatment means (Gomez & Gomez, 1984).

Results

Eight weeks after planting, wet-irrigated shallots had significantly ($P<0.01$) the highest root extension laterally, with the dry-treated shallots having the least (Table 1). Apart from the medium irrigated shallots, the other treaments showed significant ($P<0.05$) differences in lateral root growth between the two sampling dates, i.e. 8 weeks after planting and at harvest. Thus, at

TABLE 1

Lateral Root Extension of Shallots as Affected by Different Irrigation Rates

	Lateral root extension (cm)				
Treatment	*8 WAP*	*Harvest*	*Mean*	*CV (%)*	*LSD (%)*
Dry	9.3	17.8	13.6	13.3	8.2*
Medium	11.9	15.9	13.9	13.6	NS
Wet	34.7	14.0	24.4	16.0	8.9*
Mean	18.6	15.9			
CV (%)	17.0	22.7			
LSD (%)	6.3**	NS			

*Significant at $P = 0.05$; ** Significant at $P = 0.01$;
WAP = weeks after planting.

harvest, lateral root growth increased by 100 per cent in the dry treatment, 34 per cent in the medium treatment, but decreased by 60 per cent in the wet treatment (Table 1).

There were no significant ($P<0.05$) differences among the treatments in mean vertical root growth (root depth) at all the sampling dates (Table 2). However, root depth significantly ($P<0.01$) increased by 100 per cent in all the treatments from 8 weeks after planting to time of harvest.

Visual observations show that root thickness was affected by irrigation frequency, with the wet-treated shallots having the thickest roots, followed by medium- and dry-irrigated shallots.

Mean number of bulb per plant was unaffected by the different irrigation frequencies (Table 3). Bulb weight and yield were highest in shallots which received frequent and higher amount of irrigation water (Table 3).

Shallot bulb weight and yield increased by about 50 and 44 per cent in the wet-treated shallot over the dry- and medium-irrigated shallots, respectively. There were no differences in bulb diameter, weight, and yield between the moist and dry treatments.

TABLE 2

Vertical Root Growth (Root Depth) of Shallots as Affected by Different Irrigation Rates

	Root depth (cm)				
Treatment	*8 WAP*	*Harvest*	*Mean*	*CV (%)*	*LSD (%)*
Dry	7.1	14.7	10.9	14.6	7.2**
Medium	8.3	17.0	12.7	13.2	8.7**
Wet	9.7	18.8	14.3	13.8	3.0**
Mean	9.4	16.8			
CV *(%)*	24.5	21.7			
LSD *(%)*	NS	NS			

** Significant at $P = 0.01$; WAP = weeks after planting.

TABLE 3

Shallot Bulb Diameter, Bulb Number, Bulb Weight and Yield as Influenced by Different Irrigation Rates

Treatment	*Bulb diameter (cm)*	*Bulb number per plant*	*Bulb weight (g)*	*Bulb yield (g/plant)*
Dry	2.6	4.0	14.7	59.0
Moist	2.6	4.0	14.5	58.0
Wet	2.9	3.7	29.6	102.9
Mean	2.7	3.9	16.2	73.3
CV *(%)*	4.7	-	16.0	15.5
LSD *(%)*	0.2	NS	8.6	36.4

Discussion

The percentage changes in length of lateral root from 8 WAP to harvest suggest that the wet-irrigated shallots seem to have matured and ripened earlier; thus, the roots were dying back after physiological maturity, while roots of the medium- and dry-treated shallots elongated to facilitate water absorption. This was, however, pronounced in the dry-treated shallots, as reviewed by Salisbury & Ross (1992). Similarity in the length of lateral roots of the treatments at harvest, also indicate a positive correlation between soil moisture level and rate of root extension in shallots.

Jones (1994) observed that root depth may or may not be affected by soil moisture deficits. It can therefore be affirmed, based on the results of this study, that shallot root depth is unaffected by irrigation frequency, though root thickness is adversely affected by water deficit. These observations agree with that made by Abbey (1995) on shallots grown in pots in a glasshouse to determine water stress response to growth and yield.

The mean number of bulbs per plant reflects the mean number of lateral branches per plant at harvest, and was the same in all the treatments. It suggests a genotypic control of this trait in shallots. Abbey (1995) reported that water stress did not affect the number of bulbs per plant of pot-grown shallots to any significant level, and by using the same cultivar, many bulbs were obtained (i.e. 7) compared to the field-grown shallot (i.e. 4). Thus, the highest yield recorded by the wet-treated shallots was due to favourable bulb diameter and weight.

The results of the study agree with reports

made by IAR (1980), Karim, Khan & Rahman (1981), and Kratky, Bowen & I-Pai Wu (1990) on onions. In conclusion, irrigation frequency has no significant effect on vertical root growth of shallots, but affects lateral root extension. Adequate and regular watering to maintain field capacity for good root development and plant growth are essential for good yield in shallots. However, irrigation should be stopped 1 week or 2 weeks to harvest to enhance good bulb yield and quality.

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