Effects of Planting Date and Irrigation Water Level on Onion (*Allium cepa* L.) Production Under Central Saudi Arabian conditions

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Abstract:

The effects of four planting dates (15/10, 1/11, 15/11 and 1/12) and three irrigation water levels (38, 47 and 57 $m^3 h^{-1}$), on onion growth and production, were studied during autumn seasons of 2000/2001 and 2001/2002 in an experiment carried out on a sandy soil in a semi-arid at Al-Qassim, Central Saudi Arabia.

Early planting showed significantly higher growth values than the later planting in the two growing seasons. Early planted onion gave a high total bulb yield, but the plants tended to produce more flower stalks and doubled bulbs. The applied irrigation levels had significant effects on the growth of onion plants. As soil water supply increased, plant growth parameters and total yield were significantly increased, while marketable yield was reduced.

Key words: Onion, *Allium cepa,* irrigation level, vegetative growth, planting date, bulb yield.

Introduction:

Onion in Saudi Arabia ranks fourth among most important grown vegetable crops in terms of planted area and total production (MAW, 1997). Its production rose to more than 100.000 tons per year (FAO, 2001). In Central Saudi Arabia, onion is usually planted in rows at a density of 50,000 plants/hectare, during Autumn and lasts for five months. Many agricultural practices may affect onion productivity such as planting and harvesting dates (Brewster, 1990; Pendy *et al.*, 1992; Singh, 1993; Koreim, 1994, Galmarini, 1995 and Maw *et al*, 1997), and water application (Abu-Gerab, 1987; Abu-Awwad, 1996; Saha, *et al.*, 1997 and Wright and Grant, 1997). On irrigated lands, the onion crop is regarded as a fairly large consumer of water, which limits its expansion to areas of limited water resources. However, a number of experiments carried out in the past (Battilani *et al*., 1986 and Hedge, 1988) have led us to assume that it is possible retain watering on a highly selective

basis at particular phonological stages with negligible losses in terms of quantity and quality of final output.

Therefore, this study was designed to provide information about the suitable time for planting as well as water application levels to assess the feasibility of onion production under the conditions of central region of Saudi Arabia.

Materials And Methods

This study was conducted during the autumn season of 2001/2002 and 2002/2003 at the Experimental Farm of the College of Agriculture and Veterinary Medicine, Al-Qassim University, situated in central Saudi Arabia. It coordinates area: latitude 26° 18′N and longitude 43° 58′E. Its altitude is 725m above sea level. The soil texture was sandy (96.3% sand, 1.8% silt and 1.9% clay), pH ranged from 8.2 to 8.6, the ranges of the available N, P and K were 13-17, 15-18 and 31-43 mg/l, respectively. The irrigation water had a pH of 7.11 and total soluble salts of 945 mg/l, SAR value was 2.66. Seeds of onion (cv. Texas Early Grano) were sown on 15th August, 1st and 15th September and 1st October. They were sone in trays filled with peatmose and were watered as necesery. Transplanting was performed two months later. Irrigation was added by a single line source sprinkler delivering 38, 47 and 57 $m^3 h^{-1}$ twice a week intervals. This experiment consisted of 12 treatments, which were four planting dates and three irrigation water levels and their interactions. Each planting date and irrigation water level was represented with three replicates and arranged in a complete randomized block design. The plot was 4.5 X 4.5m. These plots in this experiment included six rows placed 0.5m apart with a distance of 0.1m between plants. This density is a typical practice of farmers.

All other agricultural practices were done according to the Ministry of Agriculture and water recommendations for onion production. Two samples of six plants from each plot were taken 60 days after transplanting dates in both growing seasons for measuring some growth parameters. Plant growth measurements include plant hight, plant fresh weight, plant dry weight, fresh and dry weight of bulb, number of leaves per plant, neck diameter, bulb diameter and total yield. The crop yield was taken on whole plot basis. To determine the dry weight of leaf and bulb; the plant material was dried in an oven at 65-70^{o} C to a constant weight. The data obtained were statistically analyzed. Mean separations were calculated using the least significant differences (LSD) (P= 0.05) Steel and Torrie (1982).

Results:

Vegetative growth planting date effects.

Delaying planting date caused a reduction in plant height at all sampling dates in both growing seasons (Tables 1 and 2). Higher number of green leaves was formed during the 1st and 2nd planting dates than the 3rd and 4th planting dates. This increment was insignificant in the first season (Tables 1 and 2). Similarly, bulb diameter showed a similar trend; as onion plants were sown earlier, bulb diameter increased significantly, and the latest planting date resulted in smaller bulb diameters. The opposite was true with the neck diameters, as the neck diameter of plants significantly increased as planting date was delayed. No significant difference was observed in bulbing ratio among the early planting dates. However, it showed significant higher values than the last planting date in the two growing seasons (Tables 1 and 2).

Fresh and dry weights of the plants were reduced at the later dates. The reduction being noticeable especially in the 4th planting date. This reduction was planting dates dependent, except the 2nd planting date, which had some higher values than the 1st planting date. No significant difference was observed between the 1st and 2nd planting dates, especially in dry matter contents.

Irrigation water level effects

Data presented in Tables 1 and 2 indicate that the applied water level had a significant effect on the growth of onion plants. With increasing soil water supply, recorded plant growth parameters; i.e. plant height, number of green leaves and bulb diameter were significantly increased in the tested growing seasons. The effect was not significant in the 2nd season between the highest and medium levels of irrigation water, especially for the plant height, green leaves per plant and bulb diameter. Obtained results in Tables 1 and 2 also showed that higher level of applied water resulted in a significantly thicker neck of the formed bulbs, especially in the first growing season, but in the second season insignificant increase was found.

Except for plant height, fresh and dry weight of onion plants, the interaction between planting dates and water irrigation levels showed insignificant effect on the tested growth parameters (Tables 1 and 2).

Yield components planting date effects:

Yield could be considered the net value of all growth features of plants, therefore it may be advisable to investigate yield as the net expression for the response of onion plants to irrigation water level and planting date.

Table (1)
Effect of planting date and irrigation water level on onion plant growth two months after transplants in the first season

Treatments	Plant height (mm)	No. of leaves/ plant	Neck diameter (mm)	Bulb diameter (mm)	Bulbing ratio ***	Fresh wt./ plant (g)	Dry wt./ plant (g)
A. Planting dates							
1st planting date	586a	8.33a	13.9b	26.5a	1.89a	83.4a	8.05a
2nd planting date	613a	8.27a	15.2a	26.7a	1.75a	89.2a	9.07a
3rd planting date	412b	6.05b	10.1c	8.3b	1.81a	38.4b	3.68b
4th planting date	399b	5.55c	8.7d	2.9c	1.48b	21.2c	2.21c
B. Irrigation water levels							
Level 1 (w_1)	554a	7.70a	13.8a	23.2a	1.68a	74.3a	7.16a
Level 2 (w_2)	517b	7.33a	12.0b	21.6b	1.79a	61.6b	6.29b
Level 3 (w_3)	436c	6.12b	10.2c	18.4c	1.81a	38.2c	3.98c
Interaction A x B	*	NS	NS	NS	NS	**	*

Means followed by the same letter are not significantly different (P= 0.05) according to Duncan's multiple range test.
***Significant at P= 0.05.**
**** Significant at P= 0.01.**
NS = Not significant.
***** Bulbing ratio: i.e. the ratio of the greatest diameter of bulb to the minimum neck diameter (Mann, 1952).**

Table (2)
Effect of planting date and irrigation water level on onion plant growth at harvest in the second season

Treatments	Plant height (mm)	No. of leaves plant	Neck diameter (mm)	Bulb diameter (mm)	Bulbing ratio*	Fresh wt./ bulb (g)	Fresh wt of green leaves/ plant	Dry wt./ bulb (g)	Dry wt./ green leaves (g)
A. Planting dates									
1st planting date	645 a	9.66 a	17.3 b	51.5 a	2.97 a	201.7 a	117.2a	22.63a	13.07a
2nd planting date	653a	10.38a	18.5ab	56.5a	3.00a	229.4a	128.6a	24.13a	13.98a
3rd planting date	674a	10.33a	19.0a	56.2a	2.95a	208.2a	119.8a	22.97a	13.48a
4th planting date	514b	9.50a	15.7c	43.7b	2.78b	146.4b	75.5b	16.81b	8.44b
B. Irrigation water levels									
Level 1 (w_1)	648a	10.54a	19.2a	55.3a	2.87b	195.9a	128.3a	21.9ab	13.94a
Level 2 (w_2)	661a	1033a	18.8a	54.3a	2.88b	212.1a	124.4a	23.79a	14.09a
Level 3 (w_3)	555b	9.04b	14.8b	46.1b	3.11a	181.2a	78.2b	19.18b	8.71b
Interaction A x b	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter are not significantly different (P= 0.05) according to Duncan's multiple range test.
NS = Not significant.
***** Bulbing ratio: i.e. the ratio of the greatest diameter of bulb to the minimum neck diameter (Mann, 1952).**

Except for the earliest planting date, total yield of the bulbs showed a significant reduction as sowing date was delayed, although insignificant effect was observed in both growing seasons (Tables 3 and 4). In both seasons the second planting date produced the highest total yield, while the lowest yield was recorded in the 4th and first planting dates for the 2nd and 1st seasons, respectively.

Concerning the marketable yield, which is considered more important than total yield, the presented data showed that the 4th planting date in the first season had the highest percent value and amount of marketable yield. But in the second season, although it had the highest percentage of marketable yield, it tended to have lower yield than the 2nd sowing date.

The obtained results in this study clearly indicated that the bolting phenomena mainly relates to planting dates during the two seasons. The results showed that early sowen onion seeds produce flower stalks more than when they were sown later. First planting date resulted in higher bolting percentage. The latest planting date showed a highly significant lower percentage of bolting in the two seasons (Tables 3 and 4).

Obtained data also showed that percent doubled bulbs was significantly affected by planting date, with the earlier planting date significantly increased the percentage of doubled bulbs. Then it decreased as sowing date was delayed, in the 2nd growing season; but the percentages was markedly higher in the first season than in the second one.

Regarding the effect of planting date on bulb weight, the presented data did not follow a clear trend, but it seems that the 2nd planting date produced bigger bulbs than the other planting dates and 1st planting date gave the lowest weight of bulbs in the 1st growing season (Tables 3 and 4).

Irrigation water level effects:

It is evident from data in Tables 3 and 4 that total bulb yield increased from 21.2 t/ha to 24.4 t/ha as water irrigation increased from w_3 to w_1 in the first season and from 18.3 t/ha to 22.9 t/ha in the 2nd season. The highest values were obtained with lower water supply. The total marketable yield showed a significant increase as water level was higher in the 2nd growing season, while no significant effect being recorded in the first season.

On the other hand, the percentage of doubled and bolted bulbs seemed to increase as soil water supply increased. Significant effect being recorded in the

two growing seasons, except doubling in the first season. This result reflects the opposite trend of total yield and marketable yield values. Bulb weight was decreased as water irrigation level decreased in both tested growing seasons (Tables 3 and 4).

The interaction of the two tested treatments showed an insignificant effect on the yield components during the two seasons, except for bulb weight which showed that the lowest weight values were obtained in the 4th planting date which received the lowest water level.

Table (3)
Effect of planting date and irrigation water level on onion yield in the first season

Treatments	Total yield (ton/ha)	Marketable yield (%)	Marketable yield (ton/ha)	Bolted bulbs (%)	Doubled bulbs (%)	Av. bulb wt. (g)
A. Planting dates						
1st planting date	22.5a	16.1b	13.4b	14.3b	22.1b	243b
2nd planting date	26.3a	44.8c	11.0b	26.3a	28.9a	345a
3rd planting date	22.7a	78.9a	17.7a	8.7c	28.6a	255b
4th planting date	23.1a	90.7a	20.5a	3.5d	2.8c	270b
A. Irrigation water levels						
Level 1 (w_1)	24.4a	61.5b	15.0a	20.8a	17.1a	317a
Level 2 (w_2)	22.5ab	68.2ab	15.3a	15.3a	16.0a	280b
Level 3 (w_3)	21.2b	73.1a	15.4a	9.8b	16.3a	250b
Interaction A x b	NS	NS	NS	NS	NS	NS

Means followed by the same letter are not significantly different (P= 0.05) according to Duncan's multiple range test.
NS = Not significant.

Table (4)
Effect of planting date and irrigation water level on onion yield in the second season

Treatments	Total yield (ton/ha)	Marketable yield (%)	Marketable yield (ton/ha)	Bolted bulbs (%)	Doubled bulbs (%)	Av. bulb wt. (g)
A. Planting dates						
1st planting date	22.52ab	63.08c	14.20b	23.2a	12.8a	187b
2nd planting date	24.60a	72.1b	17.70a	15.3c	9.7b	265a
3rd planting date	23.32ab	69.0c	16.90ab	19.3b	10.0b	235a
4th planting date	17.67b	98.2a	16.96ab	0.07d	1.5c	165b
B. Irrigation water levels						
Level 1(w_1)	22.9a	63.4b	14.96a	21.3a	14.6a	125.5a
Level 2(w_2)	19.8b	66.5b	13.46ab	20.5a	12.5ab	177.5b
Level 3(w_3)	18.3b	74.2a	12.27b	10.9b	11.3b	164.5b
Interaction A x b	NS	NS	NS	NS	NS	*

Means followed by the same letter are not significantly different (P= 0.05) according to Duncan's multiple range test.
***Significant at P= 0.05.**
NS = Not significant.

Discussion:

Plant growth, represented as plant height, number of leaves per plant, bulb and neck diameters and fresh and dry matter contents, was clearly affected by planting dates particularly at the early and late sowing dates. It seemes that the earliest sowing date occurred under unfavorable conditions, such as drought and hot weather which affected growth parameters as compared with the second sowing date which gave higher growth values. The latest planting date showed the lowest growth parameters values, may be due to the short period allowed for growth, which confirms the findings of Gonzalez *et al*. (1997) who reported that, as onion seed sown very early under unfavorable conditions their growth was affected but the late sowing date resulted in smaller bulbs and thick necks. This could be due to high temperature during summer and due to the short period for the late sowing plants. Another study by Sargent *et al.* (2001) showed that delayed harvest resulted in significant increases in total yield and the proportion of large bulbs, weight and decrease in the respiration rate, sprouting and weight loss.

The obtained increase in total yield at the 2^{nd} planting date might be due to favorable temperatures which influence on plant growth as previously shown in tables 1 and 2. On the contrary, the very early sowing date showed lower yield, which could be attributed to unfavorable condition which affected growth, and in turn the yield (Gonzalez *et al*., 1997).

In terms of bolting, Madisa and Midmore (1994), in a three planting dates experiment, reported that percentage of bolting was highest in early planting. Also, Rizk *et al*. (1996) reported that early planting resulted in the greatest seed stalk height and diameter, umbel diameter and average number of flower per umbel

In contrast to the above, marketable yield followed an opposite trend, where the latest sowing date resulted in more marketable yield percentage. This could, in fact, be explained on several bases, some of which is the higher percentage of doubling and bolting of bulbs which were formed earlier in the season, which caused reduction of the marketable yield. A similar finding was reported by Gamie *et al*. (1996). They mentioned that percentage of doubling and average bulb weight were significantly affected by sowing date in both seasons (1993/1994 and 1994/1995).

Increasing soil water supply increased plant growth parameters and total bulb yield significantly. In Egypt Abu-Gerab (1987) indicated that widening irrigation intervals generally reduced foliage growth of onion plants.

Furthermore, as water irrigation increased, bulb weight increased. In Jordan, Abu-Awwad (1996) reported that with supplemental irrigation, winter onion production per unit area could be increased by two to three times than of non-irrigated onion. In Bangladesh, Saha *et al*. (1997) mentioned that significant improvement in onion yield attributes and bulb yield were observed with supplemental irrigation. However, marketable yield showed different response; as water application decreased, the percentage of marketable yield increased. This could be due to increment of bolting and doubling bulbs as water supply increased. Similar results were reported by several investigators; Koriem *et al*. (1994) who revealed that as water supply increased, plant growth and total yield as well as the percentage of culls increased, whereas the percentage of single bulb decreased. Also, increasing water application during field curing increased the proportion of bulbs with stained skin and rots (Wright and Grant, 1997).

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تأثير مواعيد الزراعة ومستويات مياه الري على إنتاجية محصول البصل في المنطقة الوسطى من المملكة العربية السعودية

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الملخص :

تأثير ثلاثة مواعيد للزراعة (١٠/١٥، ١١/١، ١١/١٥ و ١٢/١) مع ثلاثة مستويات من مياه الري ٣٨، ٤٧ و ٥٧ م٣/هكتار) على إنتاجية محصول البصل، درست تحت ظروف تربة رملية ومناخ شبه جاف خلال الموسم الخريفي ٢٠٠٠/٢٠٠١ و ٢٠٠١/٢٠٠٢. وذلك في منطقة القصيم من المنطقة الوسطى من المملكة العربية السعودية.

أشارت النتائج إلى أن التبكير في مواعيد الزراعة له تأثير معنوي وايجابي في نمو الأبصال فكلما كان موعد الزراعة مبكراً كلما ازداد المحصول الناتج. كما أن النباتات تبدأ بإنتاج الحوامل النورية وتكوين الأبصال المزدوجة أكثر من مواعيد الزراعة المتأخرة.

أيضاً لقد كان لإضافة مياه الري تأثير ايجابي ومعنوي على النمو الخضري للنبات، فكلما ازداد محتوى رطوبة التربة زاد نمو وإنتاجية الأبصال الكلية ولكن ذلك يؤدي إلى خفض كمية المحصول القابل للتسويق.