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Full Length Research Paper

Irrigation and nitrogen level affect lettuce yield in greenhouse condition

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This study was conducted to investigate the effect of different irrigation and nitrogen levels on lettuce yield characteristics in greenhouse condition from December 2006 to March 2007. Irrigation levels of 100% of total class A pan (S1), 80% of total class A pan (S2), 60% of total class A pan (S3) and nitrogen levels of 0 kg ha^{-1} (N1), 100 kg ha^{-1} (N2), 200 kg ha^{-1} (N3), and 300 kg ha^{-1} (N4) were applied by drip system. Irrigation levels did not show any significant effect on head weight, marketable head weight, number of leaves, height of plants, head circle, root length, and root extent except core length and total soluble solid, TSS. The highest head and marketable head weight were found as 355.17 and 334.78 g in S1 application, respectively. Nitrogen levels had no significant effect on measured parameters. These values were the highest as 365.06 and 342.93 g in N3 application.

Key words: Lettuce, drip irrigation, nitrogen applications, greenhouse, head weight.

INTRODUCTION

Efficient water use by irrigation systems is becoming increasingly important especially in arid and semi-arid regions with limited water resources. In agricultural practice, the sufficient and balanced application of irrigation water and nutrients are important methodology to obtain maximum yield per unit area. Sanchez (2000) demonstrated that lettuce yield increased in response to water and nitrogen. On the other hand, excessive application of irrigation water and nutrients result in some serious problems (Türkmen et al., 2004). To make optimal use of water resources, contribute to sustainable agriculture and to decrease or to eliminate the negative effects of irrigation to the ecology, the main objective of irrigation is to apply the water only as a plant needs for optimal use and to apply it on time to the active root zone depth with minimal water loss. Drip irrigation is considered to have many advantages over other types of irrigation (Sanders et al., 1989; Tan, 1995; Thompson and Doerge, 1996a; Thompson and Doerge, 1996b). In this method, when planning and operation are good, no runoff occur and evaporation and deep percolation losses are very low and it achieves very high irrigation efficiency and uses water very effectively (Nakayama and Bucks, 1986). Drip irrigation generally also facilitates higher and better quality crop yields, uniform soil moisture distribution in the root zone continuously at an optimum level, introduces fertilizers effectively into the root zone with irrigation water. Irrigation also increases the effectiveness of some agricultural inputs like fertilizer. Nitrogen is very essential fertilizer for obtaining optimum yields from most cultivated crops. It recently is very important goal of all horticulturists to obtain optimum yields without application of excess nitrogen. Excessive nitrogen applications to croplands may cause serious health problems in human as a result of high intake of nitrogen in its nitrate form with surface and groundwater contaminations.

The aim of the present study was to determine the effects of different irrigation and nitrogen levels on some yield and yield components of greenhouse lettuce. Therefore, suitable irrigation and nitrogen levels of greenhouse lettuce were investigated in sandy clay loam soil conditions.

MATERIALS AND METHODS

The experiment was conducted on the lettuce (*Lactuca sativa* var. *longifolia*) cultivar ACN-393 in a naturally ventilated greenhouse, not heated mostly and covered by glass, of Horticultural Department at the University of Selçuk, Konya-Turkey. The study region is

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Table 1. Irrigation water properties used in treatments.

Irrigation water class	EC (µmhos cm^{-1})	pH	Cations, meq L^{-1}			Anions, meq L^{-1}		
			$Ca^{++}+Mg^{++}$	Na^+	K^+	HCO_3^-	SO_4^{-2}	Cl^-
C_{2-} S_1	500	7.79	5.22	0.66	0.08	2.4	1.01	2.1

Table 2. Air temperature and relative humidity inside the greenhouse.

Period	Mean air temperature (°C)	Mean relative humidity (%)
December 22–31	4.85	48.78
January 1- 9	8.63	48.94
January 10–19	11.69	51.65
January 20–29	12.05	51.83
January 30-February 8	7.68	54.13
February 9–18	13.51	54.00
February 19–28	15.11	49.01
March 1–9	17.53	47.80
Average	**11.38**	**50.77**

characterized as savanna ecology. The soil sample taken from 0 - 50 cm soil depth had Sandy-Clay-Loam (SCL) and bulk density of 1.48 g cm^{-3} with available water capacity of 165 mm m^{-1}, EC 2.16 dS m^{-1}, pH 7.52, total organic matter content 2.95%, $CaCO_3$ 14.50%, total Na 2.8 mg kg^{-1}, 11.60 mg kg^{-1} P_2O_5, 434 mg kg^{-1} K_2O, 3750 mg kg^{-1} Ca, 355 mg kg^{-1} Mg, 4.2 mg kg^{-1} Fe, 0.75 mg kg^{-1} Zn, 14.5 mg kg^{-1} Mn and 2.25 mg kg^{-1} Cu.

Irrigation water used in study was obtained from pipe Networks of Selçuk University Campus. The water samples were analyzed and classified by using the standard procedure of Anonymous (1954). According to the results, irrigation water is C_2S_1 class and has no serious harmful effect on lettuce growing (Table 1).

During the experiment, air temperature and relative humidity inside the greenhouse were measured by digital microlog and are given in Table 2. Environmental data in greenhouse showed that the air temperature and relative humidity in the greenhouse were average of 11.38C^o and 50.77% respectively during the lettuce growth period. The relative humidity inside the greenhouse was a favorable microclimate for greenhouse lettuce.

Seeds were sown in a seed bed under greenhouse conditions on October 20th in 2006 and seedlings were transplanted with recommended spacing of 50 x 25 cm -the distance between rows was 50 cm and in-row spacing was 25 cm with 12 plants in plot- on December 16th in 2006. The experiment was designated as randomized Block Design with four replications.

After stand establishment, first irrigation was applied to all treatments using drip irrigation system to bring the soil water content in 0 – 50 cm soil depth up to level of field capacity. Irrigations were started when the water content of soil decreased to 30% of available soil water. Subsequent irrigations were done by using following equation (Öktem, 2006);

$$I = A.E_{pan}.K_{cp}.CAI$$

Where; I is the amount of irrigation water (mm); A is the plot area (m^2); E_{pan} is the cumulative water depth from Class A pan based on irrigation frequency (mm); K_{cp} is the crop pan coefficient determined as 100% of total Class A Pan (S1), 80% of total Class A Pan (S2), 60% of total Class A Pan (S3), CAI is the canopy area index which was assumed to be 1. Daily evaporation was measured by screened Class A pan (Campbell and Phene, 1976). The drip irrigation was done on the basis of pan evaporation value of 4 days.

Water was distributed to the plots uniformly and simultaneously using a drip irrigation system, consisting of 35 m long PE distribution lines, 16 mm in diameter, 25 cm drippers away, each delivering 2 L h^{-1} of irrigation capacity at 100 kPa pressure. Drip irrigation lines were 50 cm apart, equally spaced in the lettuce rows. The control unit of the system contained a fertilizer tank (75 L), a disk filter, control valves and a water flow meter.

Four nitrogen levels [0 kg ha^{-1} (N1), 100 kg ha^{-1} (N2), 200 kg ha^{-1} (N3) and 300 kg ha^{-1} (N4)] were applied to the plots twice: one in a transplanting and other after one month of transplanting. The recommended fertilizers of 200 kg ha^{-1} K_2O and P_2O_5 were applied during the transplanting time.

For root length and extent measurements, plants were harvested with most care. The side of the plants, 50 cm from each side was dug 45 cm deep and the plant was lifted, then roots were measured (Karataş, 1995). The mean head weight, marketable head weight, number of leaves, plant height, head circle, core length, root length, root extent and total soluble solid (TSS) content were determined using standard procedure. Data were analyzed statistically by the Minitab program and compared by Tukey test.

RESULTS AND DISCUSSION

Mean yield components are given in Table 3 and there was not a significant variation in head and marketable head weights in all irrigation levels. The head weights were 355.17, 340.3 and 338.43 g from S1, S2 and S3 water applications, respectively. Karataş (1995) reported that lettuce head weight for fall season growing varied from 374.8 to 484.7 g in tunnel system. The study result was slightly lower than those findings of Karataş (1995). The differences might be resulted from selected lettuce cultivar, growing period and growth conditions. The highest marketable head weight as 334.78 g was obtained

Table 3. Effects of irrigation applications on mean yield components of lettuce.

Irriga. Levels	Head weight (g/plant)	Mark. head weight (g/plant)	Leaf number	Head height (cm)	Head circle (cm)	Core length (cm)	Root length (cm)	Root extent (cm)	Total Soluble Solid, TSS (brix°)
S1	355.17	334.78	41.82±7.06	31.00±3.09	40.23±5.53	2.76±0.42b	17.75±2.43	25.94±1.73	3.32±0.58a
S2	340.31	321.67	39.63±4.95	30.19±2.65	45.09±6.98	3.13±0.21a	18.36±2.48	26.65±4.17	2.91±0.40b
S3	338.43	308.49	43.95±7.20	30.50±1.64	39.60±5.51	3.31±0.24a	17.26±1.97	25.19±2.39	2.57±0.28c
$LSD_{0.05}$	N.S	N.S	N.S	N.S	N.S	0.22	N.S	N.S	0.29

The mean values by the different are significant (P<0.05).
N.S = Not significant.

Table 4. Effect of N doses on mean yield components of lettuce.

Nitrogen levels	Head weight (g/plant)	Mark. head weight (g/plant)	Leaf number	Head height (cm)	Head circle (cm)	Core length (cm)	Root length (cm)	Root extent (cm)	Total Soluble Solid, TSS (brix°)
N1	321.19	297.91	40.84±7.21	30.14±1.81	41.40±6.60	2.95±0.38	18.10±2.32	25.73±3.28	2.83±0.41
N2	331.13	310.51	41.10±5.06	29.54±2.59	40.22±5.94	3.06±0.37	18.86±1.68	27.27±2.25	3.04±0.51
N3	365.06	342.93	42.43±6.36	31.70±2.47	42.18±6.55	3.17±0.35	16.60±2.15	25.65±3.65	2.90±0.57
N4	361.16	335.23	42.82±8.04	30.87±2.79	42.75±7.08	3.10±0.40	17.60±2.62	25.07±2.25	2.97±0.55
$LSD_{0.05}$	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

The mean values by the different are significant (P<0.05).
N.S = Not significant.

tained from S1 water application. Karam et al. (2002) reported that water deficit produced significant differences in fresh weight of individual heads (P<0.05). At 66 days after transplanting, fresh weight of the well-irrigated plants (I-100 designated to receive 100% of the soil water depletion) averaged 757 g, whereas treatments I-80 and I-60 (designated to receive 80 and 60% of the soil water depletion) showed reductions of 14 and 39%, respectively. This was higher in comparison with our study results. Under these conditions, S3 irrigation water application was seen more practical for sustainable water resources especially arid regions of the world.

Different irrigation levels did not significantly affect mean leaf number, head height and head circle. Karataş (1995) demonstrated that average height of lettuce for fall season growing was 27.4 cm and our result was higher than Karataş (1995). When the quantity of water through the drip irrigation was reduced, lettuce leaf number and plant head height did not increase significantly. It was also observed that increases in the leaf number and plant head height under drip irrigation system might have resulted due to the better water utilization (Manfrinato, 1971) and excellent soil-water-air relationship with higher oxygen concentration in the root zone (Gornat et al., 1993). Under this condition, S3 irrigation dose may be recommended for water economy.

Core lengths at S1, S2, and S3 water applications were found as 2.76, 3.13 and 3.31 cm, respectively. The highest core length was 3.10 cm at S3 water application. Karataş (1995) reported that average core length was 2.3 cm for different lettuce cultivars and this was lower than our study result.

Mean root lengths and root extent also did not vary significantly with increasing water amounts. The highest root length and extent were measured as 18.36 and 26.65 cm in S2 irrigation treatment, respectively.

Different irrigation levels had significant effect on TSS. The data revealed that drip irrigation at S1 treatment gave the highest TSS as 3.32 brix° and followed by S2 (2.91 brix°) and S3 (2.57 brix°), respectively. The result of Polat et al. (2008) was higher than our study result. The differences might be resulted from ecological conditions of both experimental regions.

The highest head weight (365.06 g) and marketable head weight (342.93 g) were obtained from N3 applied plot (Table 4). As the N levels increased both head weights did not increase significantly. Shahbazie (2005) reported that by increasing the nitrogen level from 0 kg N ha^{-1}, yield of lettuce increased, but among 100, 150, 200 kg N ha^{-1} applications no significant difference was observed. The present study results were in line with those findings of Shahbazie (2005). Also Boroujerdnia et al. (2007) stated that the highest lettuce yield was obtainned as 7000 kg ha^{-1} from 120 kg N ha^{-1} application, but the lowest yield was obtained as 2830 kg ha^{-1} from the zero N application. Increasing the N levels of the fertilizers to 120 kg ha^{-1} significantly increased yield of lettuce, while yield decreased at the higher nitrogen doses.

Decreasing the yield might be due to toxicity of plant or non attraction of nitrogen by plant that resulted from consumption of excess nitrogen fertilizer (Tabatabie and Malakotie, 1997). Soundy et al. (2005) reported that as N concentration (0 to 90 mg L^{-1}) increased lettuce head weight also increased from 400 to 688 g. The study results were lower than the threshold level of Soundy et al. (2005). The possible reason might be that lettuce cultivar used and environmental conditions of greenhouse.

Different N levels did not significantly affect the measured other yield parameters. As shown in Table 4, the highest TSS was found in N2 as 3.04 brix°.

Conclusions

The experiment results indicated that different irrigation and N levels had no significant effect on majority of yield components. Due to the having not significant effects of irrigation levels on majority yield components, S3 was suitable and might be recommended to tolerate the negative effects of excess water application to the ecology and water economy especially in arid regions of the world. It was also observed that low amount of nitrogen applications should be more beneficial according to the present study.

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