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The best planting density for three chicory (*Cichorium endivia* L.) varieties

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ABSTRACT

One way to introduce a new crop to a new region is to find an adaptable variety. Moreover, a suitable planting density is one of the key factors which directly affect yield production. Cichorium endivia is one of plants which grow well in soils with residual nitrogen from the pervious cropping season. The objective of this study was to assess the influence of different varieties and planting densities on the growth and yield production of Cichorium endivia L. To do this, a split plot experiment in the form of a randomized complete block design was used with three replications. The three varieties (Witloof Zoom F_1, Witloof Flash F_1 and Witloof Mechelse Middelvraeg) were in the main plots and the three planting densities (with intra row spacing of 20, 25 and 30 cm) were in sub plots. Traits were measured in two stages; the first stage in field phase and the second stage in greenhouse phase. Finally, the results indicated that Witloof Flash F1 with 30 cm spacing was the best variety with the heighest yield.

Keywords: chicon, chicory, density, medicinal plants.

INTRODUCTION

Chicory (*Cichorium endivia* L., a member of Asteraceae family) is a long day plant and the optimal temperature for chicory growth is 15-18^{o}C. The growth period of the plant is about 70-100 days and high sunlight stimulates the flowering [7]. Chicory is gaining increasing interests because of the culinary features, nutritional values and medicinal characteristics it has [2]. *Cichorium endivia* is one of plants which grow well in soils with residual nitrogen from pervious cropping seasons. This plant has at least two consumable products from its shoots and roots. *Cichorium endivia* is one of the most important plants for the production of inulin and it is an industrial plant [10]. Different parts of chicory are used as human food. The leaves are usually consumed freshly and the roots are used to extract inulin as there is 17% inulin in chicories roots. On the other hand, chicory could be used as forage for livestock because it has high digestibility, low fiber and moreover, it has proper tolerance to drought stress [1, 8, 11, 13].

Different areas have different climatic conditions so it is necessary to have special varieties adopted for various climatic conditions. A carefully selected variety helps to take the best advantages of climatic factors such as available water temperature and [9]. On the other hand, proper planting density is not the same for different varieties of a same species. In higher planting densities, plants grow taller and the stem would be thin. This increase the risk of lodging, so using varieties with strong shoots is important. High planting density also influences the root and its contents. In intensive farming, root system of each plant is smaller and the amount of available nutrients for each plant may not be enough [6]. Ravid (1998) reported that to obtain maximum yield of *Cichorium endivia* L., suitable and best planting density must be select [14]. He concluded that root yield is correlated to planting density, and the proper density (7-8 plants/m^2) increased root yield by 30-40%.

Reviewing the available literature showed that only a few experiments have studied the effect of different varieties and planting densities on the growth and yield production of chicory. Moreover, there are different varieties of *Cichorium endivia* L. in Iran, but there is no study about them. The objective of this experiment was to assess the effect of different varieties and planting densities on the growth and yield production of *Cichorium endivia* L.

MATERIALS AND METHODS

The experiment was conducted in 2008 in the research field of Islamic Azad University Abhar branch, Iran (47° 4' E and 38° 29 N). The research was conducted in a split plot experiment in the form of a randomized complete block design with three replications. The treatments of the experiment included three chicory varieties in main plots (Witloof Zoom F_1, Witloof Flash F_1 and Witloof Mechelse Middelvraeg) and three planting densities in sub plots (on row spacing of 20, 25 and 30 cm).

Prior to field preparation, 150 kg/ha ammonium phosphate and 100 kg/ha urea were used to provide the required soil nutrients. These fertilizers were broadcasted on the soil surface and quickly incorporated into the soil by disking. Another 100 kg/ha urea was topderessed at 5-6 leaves stage. After field preparation and before planting the seed, the field was irrigated to ensure proper germination. Then, on May 12th, seeds were planted and to prevent drought stress during the growth period, irrigation was repeated regularly.

Traits were measured in two stages. The first stage was in field condition and included leaf width, root length, the total number of leaves, leaf and root weight. The second stage was in greenhouse condition and included the measurement of chicon weight and length, and the total number of leaves at chicon stage. Finally, data were analyzed by MSTATC, using the Duncan's multiple range test method.

RESULTS AND DISCUSSION

Root length. Results showed that variety, density and their interaction had no significant effect on chicory root length (Table1).

Mean comparison (Table 2) indicated that although the effect of different chicory varieties was not significant on root length, but the maximum root length was occurred in Witloof Flash F1 (17.49 cm) and the lowest root length was occurred in Witloof Zoom F1 (16.64 cm). Among three planting densities, 20 cm was the best one with the maximum root length (17.77 cm) and the lowest root length (16.13 cm) was occurred in 25 cm treatment.

Table 1. Analysis of variance for the measured traits

SOV	df	Root length	Leaf weight	Root weight	Leaf width	Total number of leaves	Chicon length	Total number of leaves at chicon stage	Chicon weight
Replication	2	ns	ns	ns	ns	ns	ns	ns	ns
Variety	2	ns	**	**	ns	*	**	*	**
Density	2	ns	**	**	**	*	ns	**	**
Interaction	4	ns	**	**	**	**	**	**	**
Error	12	4.283	192.819	161.978	2.606	5.302	9.969	12.207	62.016
CV (%)	-	12.22	5.14	3.44	3.42	4.42	14.82	7.16	8.38

*ns, nonsignificant; **, significant at 0.01; *, significant at 0.05.*

Table 2. The effects of varieties and planting densities, and their interactions on the measured traits

Treatments	Root length (cm)	Leaf weight (g)	Root weight (g)	Leaf width (mm)	Total number of leaves	Chicon length (cm)	Total number of leaves at chicon stage	Chicon weight (kg)
WZ F_1	16.64a	233.2b	337.0b	45.89a	51.06b	21.30a	46.84b	79.11b
WMM	16.67a	253.8b	377.5a	47.65a	46.34b	17.20b	47.97b	75.47b
WF F_1	17.49a	322.6a	396.6a	48.19a	59.06a	23.41a	51.49a	127.4a
20	17.77a	221.2c	289.1c	48.82a	54.22a	20.79a	46.49b	75.45c
25	16.13a	283.2b	356.0b	47.48a	51.94ab	21.45a	46.97b	98.37b
30	16.90a	305.2a	457.0a	45.42b	50.29b	21.66a	52.85a	108.2a
WZ F_1 × 20	17.33a	215.5f	241.5e	48.33bc	55.50b	20.79b	47.67c	51.38f
WZ F_1 × 25	16.23a	231.2ef	325.1d	45.37cde	49.70c	21.45b	46.33c	84.78d
WZ F_1 × 30	16.35a	252.9ed	444.5b	43.97e	47.97c	21.66b	46.52c	101.2c
WMM × 20	17.63a	268.1d	369.6c	45.71cde	43.22d	10.52d	54.93ab	64.70ef
WMM × 25	15.20a	189.7g	376.5c	49.98ab	48.65c	20.03b	36.87d	67.95e
WMM × 30	17.17a	303.7c	386.5c	47.25bcd	47.15cd	21.05b	52.12bc	93.77cd
WF F_1 × 20	18.35a	180.1g	256.2e	52.43a	63.93a	14.08c	46.40c	107.0bc
WF F_1 × 25	16.95a	359.1b	393.4c	47.10bcde	57.47b	28.27a	48.17c	116.6b
WF F_1 × 30	17.17a	428.8a	540.2a	45.03de	55.77b	27.89a	59.92a	158.6a

WZ F_1, Witloof Zoom F_1; WMM, Witloof Mechelse Middelvraeg; WF F_1, Witloof Flash F_1
Means in a column followed by the same letter are not significantly different at P≤0.01.

Leaf weight. Analysis of variances indicated the significant effect of variety, planting density and their interactions on leaf weight (Table 1; P≤0.01).

Mean comparison by Duncan's multiple range test shows that among three varieties, the maximum leaf weight was happened in Witloof Flash F1 (322.6 g). Although there was no significant difference between two other varieties but, Witloof Zoom F1 had the lowest leaf weight (Table2). Mean comparison of the effect of three planting densities demonstrates that increased planting density has increased leaf weight so 30 cm treatment had the highest leaf weight (305.2 g). Studying the interaction of varieties × planting densities showed that Witloof Flash F1 × 30 cm had the best leaf weight (428.8 g), and Witloof Flash F1 × 20 cm had the worst (180.1 g). Rozek (2007) showed that higher planting density (15 × 20) significantly increases leaves yield of leaf celery (*Apium graveolens* L.) compared with the lower density (20 × 25) [5]. In their experiment, leaves weight of Safir variety was 6.12 kg/m^2 in 20 × 25 cm, but 7.36 kg/m^2 in 15 × 20 cm planting density. Rekowska and Skupien (2007) also found that an increased planting density resulted in significant improvement of garlic green leaf yield [4].

Root weight. According to analysis of variances, variety, planting density and their interaction significantly affected chicory root weight at P≤0.01 (Table1).

Mean comparison of the three varieties showed that there was no significant difference between Witloof Flash F1 and Witloof Mechelse Middelvraeg but, Witloof Flash F1 with 396.6 g of root weight was the best treatment. Among three planting densities, 30 cm on row spacing was the best planting density with 457 g and 20 cm was the worst treatment with 289.1 g of root weight (Table2). Researchers found that root yield of *Cichorium endivia* L. is correlated to planting density, and the proper density (7-8 plants/m^2) increased root yield by 30-40% [14]. Witloof Flash F1 × 30 cm on row spacing took the best advantages of soil nutrient and sunlight compared with other interactions and produced the most root weight (520.2 g).

Leaf width. Analysis of variances showed that the effect of variety did not significantly affected leaf width, but the effect of planting density and the interaction of variety × planting density significantly affected the trait at P≤0.01 (Table1).

Mean comparison put the three varieties in the same group, showing that there is no significant difference between varieties. Moreover, mean comparison of the three planting densities showed that leaf width was decreased when planting density decreased, however, 20 and 25 cm were statistically the same. The maximum leaf width (48.82 mm) was observed in 20 cm on row spacing and the minimum leaf width (45.42); in 30 cm. Witloof Flash F1 × planting density of 20 cm was the best interaction with the best leaf width (52.43 mm) (Table 2). Researchers concluded that increasing cowpea planting density from 20,000 to 80,000 plants/ha increased leaf area index in the 3rd weeks after planting, but reduced LAI in the 6th and 12th weeks after planting [3].

The total number of leaves. Analysis of variance showed that variety and planting density had a significant effect on the total number of leaves at P≤0.05, but their interaction significantly affected the trait at P≤0.01 (Table 1).

Mean comparison indicated that among three varieties, Witloof Flash F1 (59.06), and among three planting densities, 20 cm (54.22) had the highest numbers of leaves. Witloof Flash F1 × 20 cm and Witloof Mechelse Middelvraeg × 20 cm had the highest and the lowest number of leaves with 63.93 and 43.22 leaves, respectively. In another research, it was found that high planting density of leaf celery reduced the number of leaves within a plant [5]. The reduction of the total number of leaves in high density in the mentioned experiment is probably because of the lower sunlight transmitted to the plant canopy. In contrast, in our experiment it was observed that higher density increased the number of leaves. This disagreement of the results could be probably because of canopy arrangement in celery and chicory.

Chicon length. Results represented that only the effect of planting density was not significant on chicon length; the effect of variety and the interaction of variety × planting density significantly affected the trait at P≤0.01 (Table 1).

Mean comparison of the effect of three varieties on chicon length indicated that although both Witloof Zoom F_1 and Witloof Flash F_1 were in the same group, but Witloof Flash F_1 had the highest value of chicon length (23.41 cm; Table 2). All three planting densities were in the same group according to Duncan's multiple rage test. This result is in agreement with those of Njoku and Muoneke (2008) who found that the planting density of cowpea had no significant effect on the pods length [3].

Among the interactions, both Witloof Flash F_1 × 25 cm and Witloof Flash F_1 × 30 cm were the best treatments without any significant differences (28.27 and 27.89 cm respectively). The

shortest chicons were observed in Witloof Mechelse Middelvraeg × 20 cm with the length of about 10.52 cm (Table 2).

Chicon weight. Variety, planting density and their interactions significantly affected chicon weight at P≤0.01 (Table 1).

Mean comparison of showed that maximum the chicon weight was related to Witloof Flash F1 (127.4 kg) among the three varieties and the minimum weight is related to Witloof Mechelse Middelvraeg (75.45 kg; Table 2). Among the three planting densities, the maximum and minimum chicon weight was occurred in 30 (108.2 kg) and 20 cm (75.45) planting densities, respectively. Witloof Flash F1 × 30 cm had the highest chicon weight (158/6 kg; Table 2).

The total number of leaves at chicon stage. According to the analysis of variances, the effect of variety on this trait was significant at P≤0.01; the effect of planting density and the interaction of variety × planting density were significant at P≤0.01 (Table 1).

Results indicated that the numbers of leaves at chicon stage was the highest in Witloof Flash F1 (51.49; Table 2) among the three varieties. Among the three planting densities, the highest numbers of leaves at chicon stage was happened in 30 cm which is the low planting density (52.85; Table 2). An experiment was conducted to evaluate the effect of planting density on carrot growth and yield production. It was concluded that increased planting density resulted in a decreased number of branches [12].

Witloof Flash F1 × 30 cm was also the best interaction with the highest number of leaves (59.92).

CONCLUSION

The overall results of this experiment indicate that Witloof Flash F1 was the best selected variety, and 30 cm on row spacing was the best planting density in most cases. The interaction of Witloof Flash F1 × 30 cm (the most effective treatment) increased chicon weight by about 208% compared with Witloof Zoom F1 × 20 cm (the least effective treatment).

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