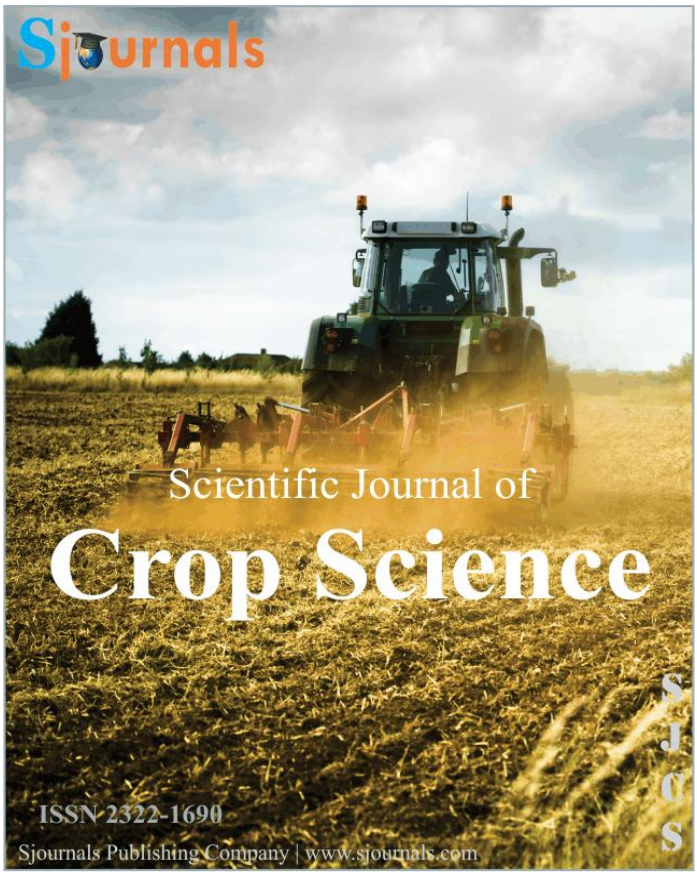

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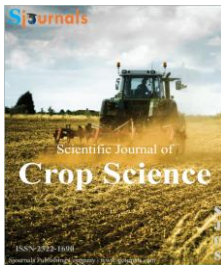

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Original article

Effect of planting arrangement on vegetative growth, yield components and yield of green castor (*Ricinus communis* L.)

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ABSTRACT

Plant spacing of castor (*Ricinus communis* L.) is very important to obtain optimum seed yield. This study was conducted to find out the effects of inter row and intra row spacing on different traits of green castor at the Kabotarabad Agriculture Research Station of Esfahan in the spring 2006, using a randomized complete block design with split plot arrangement and four replications. Main plots were three inter rows spacing (60, 80 and 100 cm) and sub plots were three intra rows spacing (30, 50 and 70 cm). The effect of inter row spacing on plant height, plant dry weight, stem diameter and plot yield was significant. The highest dees yield was obtained in 60 cm inter row spacing. The effect of intra row spacing was significant on plant dry weight, number of candle per plant, number of seeds per candle, number of seeds per plant and plot yield. The highest yield was obtained in 70 cm intra row spacing. The interaction between inter row and intra row spacing was not significant for any of the traits. The highest plot seed yield (1175 kg/ha) was obtained in 60 cm inter row and 70 cm intra row spacing.

1. Introduction

Castor is belonging to the family of Euphurbiaceae, is native of tropical region and its main homeland is probably Ethiopia (Vollman and Rajcan, 2009). It has perennial and one-year-old varieties and its domestic varieties are usually one-year-old. Castor is resistant to drought and is relatively resistant to salt (Weis, 2000). Oil is the most important ingredient of castor and its amount in commercial varieties is usually between 40-60%. The unique property of castor oil is its ability to dissolving in alcohol (Weis, 2000). Castor oil is used in pharmacy and industry. Castor is often cultivated in marginal areas (Vollman and Rajcan, 2009).

The most important problem in relation to the production of castor seed after realizing a variety due to its plant height and volume and consequently the intense competition of plants to receive light, is to determine the proper planting arrangement of this plant. In a study at the Kabotarabaad Agriculture Research Station of Esfahan showed that the green castor was superior to the red castor and in tsrfi eht period of mass selection its seed yield was improved (Shahsavari and Maghol, 1999).

Interaction between plant yield and number of plants per unit area has a determining factor for success in agriculture (Azari and Khajehpour, 2003). A difference in the structure of single plant by density changes is one of the main factors in the determination of seed yield. In this regard, it is important to determine that any effective factor in the seed yield of a single plant with a change in the density of the plants. Two parameters determine the seed yield in a canopy: number of plants per unit area and single plant seed yield. Therefore, it should be determined how a change in planting arrangement affects the performance of a single plant or the quantity and quality of building construction of yield. Therefore, to evaluate the biological structure of a canopy, it is necessary to investigate the problems of single plant operation and the effect of effective parameters on density (Ghlavand, 1998). In order to do this, the magnitude of the effect of each of the parameters affecting seed yield should be investigated (Ghlavand, 1998; Asadi Yekta et al., 2006; Valadabadi et al., 2011). No significant work has been done on castor planting arrangement, especially in Iran.

Since castor is often cultivated as marginal crops, thus to obtain optimal seed yield, the relationship between rainfall, planting date and plant density is very important (Ueda, 2005; Weis, 2000). Generally, rows of one meter wide, which are acceptable for many tropical plants that cultivated in rows, can be used for short castor. This width may cause significant damage to the branches and surface and horizontal roots during the plowing. If mechanical drills were to be used, we might have a lack of local data to determine the spacing on the rows. A distance of 25-30 cm for a short, 30-40 cm for larger hybrids, or about 25000 to 30000 castor plants per hectare, for plants that grows at 750-900 mm precipitation will be our guide (Robbelen et al., 2003). In an experiment that was conducted to evaluate the genetic diversity of native castors in the research farm of the Seed and Plant Improvement Institute, inter and intra row spacing of 180 and 50 cm were considered respectively (Hassan Zadea et al., 1998). The purpose of this study was to determine the proper arrangement of green castor that obtained from recurrent selection.

2. Materials and methods

In this experiment, green castor seeds were selected from a period of mass selection in three inter row spacing (60, 80, 100cm) and three intra row spacing (30, 50, 70cm) in a randomized complete block design with split plot distribution in four replications were studied. The inter row spacing as main plot and intra row spacing were considered as sub plot. Each experiment plot consisted of four rows and each row with a length of 10 meters. Fertilization was performed based on the nutritional needs of castor and soil testing. The cultivation was carried out on May 31st 2006. The first irrigation was carried out 2 to 3 days after planting. The next irrigation was based on irrigation period and depended on the air temperature. Weeds control after planting was done with hand.

At the full maturity stage and after removal of one plant from each side of the middle rows of each plot for 5 successive plants that were randomly selected, the following traits were measured. 1- Plant height in cm. 2- Stem diameter in the thickest section of the stem in mm. 3- Number of nodes. 4- Inter node distance based on stem plant length to number of nodes in cm. 5- Number of candles. 6- Candle length in cm. 7- Number of seeds per candle. 8- Number of leaves in the stem. 9- Number of seeds per plant. 10- Seed yield per plant in gr and based on 13% moisture content. Mean of one plant for every trait was calculated.

Yield of each plot in kg/ha based on 13% moisture content determined after harvesting of 20 plants from two intermediate rows of each plot. Also, the 1000-seed weight of each plot in grams, based on 13% moisture content,

was determined by three times sampling of seeds harvested for each plot. Data were subjected to analyses of variance and means were compared by Duncan's multiple range test.

3. Results and discussion

The effect of inter row spacing on plant height was significant. With increasing inter row spacing, plant height decreased. The lowest and highest plant height was at 100 and 60 cm inter row spacing respectively (Table 1). The effect of the inter row spacing on the number of nodes was not significant, but the variation of number of nodes was esrevni the variation of height in different inter row spacing, so that the plants at the distance of 60 and 100 cm had the lowest and the highest number of nodes respectively (Table 1). Such as the number of nodes, the effect of inter row spacing on inter node length was not significant and the trend of this trait in accordance with the trends of plant height. The longest and shortest inter-node length were at the distance of 60 and 100 cm inter row spacing, that with considering the trend of height changes is expected. The results of other research (Kirby and Faris, 1970; Ciha, 1983; Razmi, 2011) indicate that in higher density, competition for access to light and food is increased It has found that this has a profound effect on suppressing the balance of growth regulators, and as a result, the amount of gibralin hormones in the plant is high and causes elongation of the stem. The effect of inter row spacing on the number of nodes in the stem was not significant and the number of leaves and its changes were exactly the same as the number of nodes in the stem, which is quite expected (Table 1). The effect of the inter row spacing on stem diameter was significant and the trend of changes in this trait was precisely correlated with the trend of plant height changes, so that the maximum diameter of the stem belonged to the lines of 100 cm and the lowest diameter of the stem belonged to the lines of 60 cm (Table 1). Increasing the number of nodes followed by the number of leaves in the plant and increasing the diameter of the stem from the lines of 60 to 100 cm caused a significant increase in plant dry weight, so that the highest dry weight of the plant at the distance of 100 cm lines and the lowest dry weight of the plant at 60 cm was obtained (Table 1). The effect of inter row spacing on number of candle per stem, candle length, number of seeds per candle and number of seeds per plant was not significant, but four traits were increased from 60 to 100 cm (Table 1). The effect of inter row spacing on 1000-seed weight was not significant. This trait did not show any trend but the highest and lowest 1000-weight was obtained at the distance between the lines of 80 and 60 cm respectively (Table 1).

Table 1

Means* comparison of intra row spacing for stem length, number of nodes, internode length, number of leaves, stem diameter, plant dry weight, number of candles, number of seeds per candle, number of seeds per plant, 1000 seed weight and seed yield Green castor.

Intra row spacing(cm)	Plant height(cm)	No. node	Inter node length (cm)	No. leaf per stem	Stem diameter (mm)	Plant dry matter(gr)	No. candle	Candle length(cm)	no. of seed per candle	No. of seed per plant	1000 seed weight(gr)	Yield plot(kg/ha)
60	120.3^{a}	15.8^{a}	7.6^{a}	15.8^{a}	21.3^{b}	163.3^{c}	1.45^{a}	42.4^{a}	185.1^{a}	185^{a}	245.8^{a}	1058^{a}
80	117.2^{a}	16.1^{a}	7.3^{a}	16.1^{a}	23.3^{a}	205.1^{b}	1.32^{a}	40.0^{a}	192.2^{a}	192^{a}	253.8^{a}	864^{b}
100	113.7^{b}	16.3^{a}	7.0^{a}	16.3^{a}	23.8^{a}	240.5^{a}	1.70^{a}	45.7^{a}	206.7^{a}	207^{a}	250.3^{a}	744^{b}

Means* compared with the Duncan multi-range test, and in each column, means with a common letter are not significant at the 5% probability level.

Table 2

Means* comparison of inter row spacing for stem length, number of nodes, internode length, number of leaves, stem diameter, plant dry weight, number of candles, number of seeds per candle, number of seeds per plant, 1000 seed weight and seed yield Green castor.

Inter row spacing(cm)	Plant height(cm)	No. node	Inter node length(cm)	No. leaf per stem	Stem diameter(mm)	Plant dry matter(gr)	No. candle	Candle length(cm)	no. of seed per candle	No. of seed per plant	1000 seed weight(gr)	Yield plot(kg/ha)
30	129.7^{a}	16.4^{a}	7.8^{a}	16.4^{a}	21.3^{b}	174.3^{c}	1.20^{b}	40.1^{a}	105.3^{c}	105.3^{c}	243.0^{a}	711^{b}
50	113.3^{a}	15.8^{a}	7.3^{a}	15.8^{a}	22.7^{ab}	206.4^{b}	1.27^{b}	44.0^{a}	210.8^{b}	210.8^{b}	251.1^{a}	970^{a}
70	109.7^{a}	16.0^{a}	6.9^{a}	16.0^{a}	24.5^{a}	228.2^{a}	2.0^{a}	44.0^{a}	267.8^{a}	267.8^{a}	255.4^{a}	1015^{a}

Means* compared with the Duncan multi-range test, and in each column, means with a common letter are not significant at the 5% probability level.

Significant, and the number of leaves and its changes were exactly the same as the number of nodes in the stem, which is quite expected (Table 1). The effect of the inter row spacing on stem diameter was significant and the trend of changes in this trait was precisely correlated with the trend of plant height changes, so that the maximum diameter of the stem belonged to the lines of 100 cm and the lowest diameter of the stem belonged to the lines of 60 cm (Table 1). Increasing the number of nodes followed by the number of leaves in the plant and increasing the diameter of the stem from the lines of 60 to 100 cm caused a significant increase in plant dry weight, so that the highest dry weight of the plant at the distance of 100 cm lines and the lowest dry weight of the

plant at 60 cm was obtained (Table 1). The effect of inter row spacing on number of candle per stem, candle length, number of seeds per candle and number of seeds per plant was not significant, but four traits were increased from 60 to 100 cm (Table 1). The effect of inter row spacing on 1000-seed weight was not significant. This trait did not show any trend but the highest and lowest 1000-weight was obtained at the distance between the lines of 80 and 60 cm respectively (Table 1).

The effect of inter row spacing on plot yield was significant. Plot yield decreased from 60 to 100 cm. The maximum plot yield obtained from 60 cm line inter row spacing with 1058 kg/ha and the lowest yield obtained from 100 cm inter row spacing with a yield of 774 kg ha^{-1} (Table 1). Increasing the number of candles in the plant, candle length, number of seeds per candle and number of seeds per plant from the inter row spacing of 60 to 100 cm did not increase yield. It seems that the descending trend in plot yield from the inter row spacing of 60 to 100 cm is related to less number of plants from 60 to 100 cm inter row spacing. In this regard, in a study on the arrangement of sunflower cultivars of Meher during four years, it was found that the shorter distance between the lines (less than 50 cm) and the distance between the plants on the line (up to 15 cm) would be more grain yield (Arshi, 1994).

The effect of intra row spacing on plant height was not significant. Such as the inter row spacing by increasing intra row spacing, plant height decreased. The longest and shortest plant height, respectively, belonged to the distance on the line 30 and 70 cm (Table 2). The effect of intra row spacing on number of nodes, inter node length and number of leaves was not significant. The number of nodes and leaves in the stem did not show any trend with variation of intra row spacing, but the changes in the length of the inter node were similar to the plant height (Table 2). However, the number of nodes and number of leaves in the stem increased with increasing distance among the lines (Table 1). The effect of intra row spacing was significant on stem diameter, and with increasing distance on line, the stem diameter was significantly increased, so that the highest stem diameter was related to the distance of the line of 70 cm and the lowest stem diameter was related to the distance on the line of 30 cm (Table 2). The effect of intra row spacing such as stem diameter, on plant dry weight was also significant. The most diameter of the stem increased the dry weight of the plant, so that the changes in dry weight of the plant were similar to the stem diameter variation. The highest dry weight of the plant was obtained at the distance of 70 cm and the minimum dry weight of the plant was measured on the line of 30 cm (Table 2). The effect of intra row spacing was not significant on the length of the candles, but on the number of candles, the number of seeds per candle and the number of seeds per plant were significant and with increasing distance on the line, all four traits increased, so that the highest and lowest number of candles in the plant, the longest and the shortest candles, the highest and the lowest number of seeds per candle and the highest and lowest number of seeds per plant were obtained at the distance of line 70 and 30 cm respectively (Table 2). The effect of intra row spacing on 1000-seed weight was not significant, but with other yield components, the 1000-seed weight also increased with increasing distance on the lines (Table 2).

The effect of intra row spacing was significant on plot yield. The difference between yield, distance on the line of 70 cm with a distance of 30 cm caused of a significant effect of the distance on the line on the yield of the plots. The yield of the distance on the 70 cm line was 1015 kg/ha and the yield of the distance on the 30 cm line was 711 kg/ha (Table 2). Increasing stem diameter followed by plant dry weight, number of candles per plant, candle length, number of seeds per candle, number of seeds per plant and 1000-seed weight increased the line spacing from 30 to 70 cm. Be However, in a research on sunflower, the effect of increasing the distance on the line from 15 to 30 cm yield was reduced (Arshi, 1994).

Interaction between inter and intra row spacing was not significant on any of studied traits, but the highest grain yield (1175 kg/ha) was obtained in 60 × 70 cm treatment. As the final result of this experiment, we can indicate the desirability of 60 × 70 cm planting for this type of castor in the experimental conditions. Also, the reduction of the distance between the rows and the increase of the distance on the row (rectangular cultivars) is recommended for subsequent experiments.

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