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Full Length Research Paper

Effect of pruning lateral branches on four varieties of medicinal castor bean plant (*Ricinuscommunis* L.) yield, growth and development

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In order to study the effect of pruning lateral branches on four varieties of castor bean yield, growth, and development, an experiment was conducted at the Agricultural Research Station of Saatlo in Urmia, Iran, during 2010 growing season. Experimental design was split plot, completely randomized block design with three replications. The main plots were varieties of castor bean (that is, 80-23, 80-29, 80-12-1 and 80-17), and sub plots included three types of pruning (that is, no pruning, pruning of two lateral branches, and pruning of four lateral branches). The plant characteristics were studied in terms of main panicle length, number of seeds per plant, 100 seed weight, seed weight per main panicle, weight of main panicle, grain yield, biological yield, harvest index, days from planting to maturity and oil yield. Results of the data review showed that, the effect of the varieties was significant on all of the characteristics. Also, the effects of pruning and interaction of two factors (variety and pruning) were significant on seed weight per main panicle, weight of main panicle and days from planting to maturity. Maximum grain yield (1307.78 kg ha^{-1}) was in 80-12-1 variety, and minimum yield (770.83 kg ha^{-1}) observed in 80-17 variety. According to the results, the variety of 80-12-1 and pruning of four lateral branches in this region were recommended for cultivation.

Key words: Castor bean (*Ricinuscommunis* L.), growth, pruning, varieties, yield.

INTRODUCTION

Castor bean (*Ricinuscommunis* L.) belongs to the Euphorbiaceous family and is one of the medicinally important oil seed crop (Kumari et al., 2008). Castor bean is originated from tropical Africa and is currently cultivated as an oil seed crop and also grown as an ornamental plant in many countries of Asia, Central and North America, Africa and Europe (Doan, 2004). The seeds contain approximately 60% oil and are the only commercial source of ricinoleic acid that is used as industrial lubricants, paints, coatings, and plastics (Caupin, 1997). Castor bean is being investigated as a new source for biodiesel as well as an industrial crop (Baldwina and Cossar, 2009, because of its oil quality and quantity for plant-based, environmentally friendly paints and coatings in the chemical industry (Derksen et al., 1995).

The choice of a suitable system is an important factor for achieving a profitable balance between labour costs and crop yield without loss of quality. Pruning is also one of these systems that consist of completely or partially cut off branches, stems and roots, considering the growing variety characteristics. Pruning off is one of the important horticultural operations that has been known and used about three thousand years ago. By means of shoot pruning, light penetration and distribution within the canopy are improved and older leaves are exposed more to incident irradiation. Older leaves may have different responses to irradiation than younger leaves, as it occurs in soybean (Beuerlein and Pendlenton, 1971), alfalfa (Hodgkinson, 1974). The method of pruning is determined by the variety, plant spacing, time and conditions of growing (Cebula, 1996). Ambroszczyk et al., 2008) determined that intensive pruning had a positive effect on irradiation on PAR range in plant profile. Isaac

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et al. (2004) found that 3 pruning per maize crop gave higher yields than 2 pruning. Diniz et al. (2009) with the manipulation of the castor bean growth through the pruning at different planting densities concluded that the nipping of the apical shoot at the 6th, 10th and 14th node of the main stem reduced the plant height, but it did not affect seed yield. In India picking all subsidiary buds increase average yield castor bean nearly 30% and also because growth was accelerated (Patel, 1976). Picking the top branches at a height of 60 to 30 cm plant height can be reduced and increase the branches, but usually reduces product (Khan, 1973). Many investigators have emphasized the importance of the foliage that remains after pruning the flower shoots and its effect on the subsequent crop growth (Zieslin et al., 1975). Also is probable that photosynthetic rate increased as a result of pruning (Helms, 1964; Heichel and Turner, 1983; Hoogesteger and Karlsson, 1992) and that there were changes in biomass partitioning to favor shoot growth and leaf development (Cannell, 1985; Pinkard and Beadle, 1999). These sorts of responses can moderate the effects of pruning.

The objective of this paper was to study the effect of pruning lateral branches on four varieties of castor bean and to evaluate yield, growth and development.

MATERIALS AND METHODS

This experiment was conducted at the Agricultural Research Station of Saatlo in Urmia, Iran, (37°44'18"N latitude and 45°10'53"E longitude), at an elevation of 1338 m above mean sea level during the 2010 growing season. Average rain fall in this growing season was 2.32 mm and average temperature was nearly 61.18°C. The soil type was clayloam with pH 7.9 and a 1.1 average organic matter concentration. The 0 to 40 cm soil layers contained 0.011% nitrogen, 4.8 $mgkg^{-1}$ phosphorus rate and 335 $mgkg^{-1}$ potassium exchange.

Experimental design was a split plot, completely randomized block design with three replications. The main plots were varieties of castor bean (that is, 80-23, 80-29, 80-12-1 and 80-17), and sub plots included three types of pruning (that is, no pruning, pruning of two lateral branches, and pruning of four lateral branches). Planting was done in rows and each plot consisted of 4 rows, 6 min length, inter row spacing was 100 cm and inter plant spacing was 60 cm. To determine the effect of the treatments, 2 border rows in each plot were considered as sidelines, and the plants of middle 2 rows were harvested after drying plants, panicles of plants were separated and sifter. Then grain yield with 9% moisture content was measured. The straw remaining were dried in a dry oven at 75°C for 62 h, and then biological yield of the total weight of stems, leaves and panicles was calculated. Soxhlet method was used for extracting oil and the amount of oil percent was calculated with the following process. At first, we grounded some seeds sample and then weighted (W_1). Grounded samples immediately dried in drier at 85°C for 1.5 (W_2) and then transfer to desiccator for 35 min (W_3). After this process we used the following formula for measurement of oil percent:

Seed oil percent = $(W_2\text{-}W_3) / (W_2\text{-}W_3)$

Then oil yield was obtained, multiplied by grain yield and oil percent.

The data were processed by analysis of the variance (ANOVA) and analyzed with SAS program and we used Excel software for drawing of the charts. The means were compared using the Duncan test.

RESULTS AND DISCUSSION

Main panicle length

Main panicle length showed significant difference between varieties ($p<0.01$). The main effect of pruning and interaction (variety and pruning) had no significant effect on this trait in castor bean (Table 1). The mean comparison showed that, maximum length of the main panicle (44.05 cm) was observed in 80-12-1 variety because of genetic superiority, and minimum length (22.55 cm) was observed in 80-17 variety (Table 2). Main panicle length had significant and positive correlation with all the traits, but its correlation with harvest index was negative and significant (r = -0.41) only in the 5% level (Table 3). Main panicle length in this plant is the most important trait for mechanized harvesting. According to the theory of Laureti et al. (1998) there was mechanized harvesting problem in some varieties with short panicle length (less than 30 cm). Generally, the main panicle length, which caused non-uniformity in seed handling, can be increased to 100 cm (Koutroubas et al., 1999).

Number of seeds per plant

Number of seeds per plant showed significant difference between varieties in 5% probability level. In contrast, pruning factor and interaction between factors (variety and pruning) had no significant effect on this trait in castor bean (Table 1). The mean comparison showed that, maximum number of seeds per plant (327 seed) was in 80-12-1 variety, and minimum number of seeds (190.22 seed) was in 80-29 variety (Table 2). Number of seeds per plant had significant and positive correlation with the seed weight per main panicle (r = 0.8), weight of main panicle (r = 0.76), grain yield (r = 0.89), biological yield (r = 0.58), days from planting to maturity (r = 0.57), and oil yield (r = 0.85) (Table 3). Castor bean is an unlimited growth plant and continues to grow until the beginning of cold season and produces many side branches. Castor bean panicles other than the main stem, appear in the side branches, if these branches are not remove, more panicles appeared in per plant and finally, lead to production more seeds in castor bean.

100 seed weight

100 seed weight showed significant difference between varieties in 5% probability level, but pruning factor and interaction between factors had no significant effect on

Table 1. Results of analysis of variance (mean squares) treatments in castor bean.

Source of variation	d.f.	Main panicle length (cm)	Number of seeds per plant	100 seed weight (g)	Seed weight per main panicle (g)	Weight of main panicle (g)	Grain yield ($kg.ha^{-1}$)	Biological yield ($kg.ha^{-1}$)	Harvest index (%)	Days from planting to maturity	Oil yield ($kg.ha^{-1}$)
Rep	2	119.04^{ns}	15000.08^{ns}	10.38^{ns}	7886.43^{ns}	2493.366^{ns}	1167889.06^{ns}	9982433.3^{ns}	0.63^{ns}	0.44^{ns}	54064.91^{ns}
Varieties	3	698.41**	40122.11*	100.53*	26023.41**	8959.19**	640542.3**	56848088.9*	38.41*	211.95**	*97.190784
Error (a)	6	36.35	6103.19	19.33	2398.10	618.47	62396.47	9879455.6	4.67	0.14	08.24394
Pruning	2	17.13^{ns}	50.33^{ns}	8.59^{ns}	1938.56*	1679.36*	17463.02^{ns}	113233.3^{ns}	4.42^{ns}	48.11**	89.9699^{ns}
V×P	6	21.07^{ns}	1457.11^{ns}	6.26^{ns}	1940.47*	1253.80**	27949.59^{ns}	7518388.9ns	4.44^{ns}	0.70*	43.7213^{ns}
Error (b)	16	17.90	1444.87	7.14	507.68	297.12	20389.67	7646183.3	4.84	0.22	01.9638
CV (%)		12.89	14.01	9.74	17.98	23.35	13.91	29.81	18.76	0.36	18.28

*, **, ns, Significant at P = 0.05, P = 0.01 and non-significant, respectively. d.f. degree of freedom.

Table 2. Mean comparison of varieties of castor bean and pruning on traits.

Studied factors	Main panicle length (cm)	Number of seeds per plant	100 seed weight (g)	Seed weight per main panicle (g)	Weight of main panicle (g)	Grain yield ($kg.ha^{-1}$)	Biological yield ($kg.ha^{-1}$)	Harvest index (%)	Days from planting to maturity	Oil yield ($kg.ha^{-1}$)
Varieties										
80-23	32.88^{b}	324.89^{a}	27.05^{b}	147.00^{b}	86.00^{b}	1198.06^{a}	9476^{a}	13.05^{ab}	130.11^{b}	624.11^{a}
80-29	31.72^{b}	190.22^{c}	30.77^{a}	75.00^{c}	45.33^{c}	827.50b	9602^{a}	9.09^{c}	125.33^{c}	409.88^{b}
80-12-1	44.05^{a}	327.00^{a}	28.94^{ab}	190.83^{a}	112.72^{a}	1307.78^{a}	12062^{a}	$11.10b^{c}$	135.11^{a}	696.56^{a}
80-17	22.55^{c}	242.56^{b}	22.97^{c}	88.17^{c}	51.16^{c}	770.83^{b}	5953^{b}	13.66^{a}	124.66^{d}	417.06^{b}
Pruning types										
No pruning	31.54^{a}	273.50^{a}	26.72^{a}	115.50^{b}	66.00^{b}	991.67^{a}	9320^{a}	11.05^{a}	126.75^{c}	507.72^{a}
Pruning of 2 lateral branches	32.95^{a}	269.67^{a}	27.20^{a}	120.62^{ab}	68.00^{b}	1067.08^{a}	9162^{a}	12.22^{a}	128.91^{b}	564.51^{a}
Pruning of 4 lateral branches	33.91^{a}	270.33^{a}	28.37^{a}	139.62^{a}	87.41^{a}	1019.38^{a}	9338^{a}	11.91^{a}	130.75^{a}	538.48^{a}

In each section, means followed by the same letter within columns are not significantly different (p≤0.05) according Duncan test.

this trait (Table 1). The mean comparison showed that the maximum 100 seed weight (30.77 g) was in 80-29 variety, because genetic superiority can be better used with environmental facilities increased seed weight, and minimum weight (22.97 g) was in 80-17 variety (Table 2). Also, 100 seed weight had significant and positive and longer period of development can transport more photo-assimilate to seed storage and correlation

Table 3. Correlation coefficients of traits in the castor bean.

Treatments	Main panicle length (cm)	Number of seeds per plant	100 seed weight (g)	Seed weight per main panicle (g)	Weight of main panicle (g)	Grain yield (kg.ha)	Biological yield (kg.ha)	Harvest index (%)	Days from planting to maturity	Oil yield (kg.ha)
Main panicle length	1									
Number of seeds per plant	0.58**	1								
100 seed weight	0.49**	0.11	1							
Seed weight per main panicle	0.8**	0.8**	0.36*	1						
Weight of main panicle	0.79**	0.76**	0.37*	0.97**	1					
Grain yield	0.78**	0.89**	0.44**	0.93**	0.89**	1				
Biological yield	0.78**	0.58**	0.64**	0.67**	0.67**	0.75**	1			
Harvest index	-0.41*	0.07ns	-0.51**	-0.02ns	-0.06ns	-0.09ns	-0.67**	1		
Days from planting to maturity	0.72**	0.57**	0.24ns	0.71**	0.67**	0.70**	0.49ns	0.01ns	1	
Oil yield	0.74**	0.85**	0.40*	0.91**	0.88**	0.96**	0.71**	-0.03ns	0.69**	1

*, **, ns, Significant at P = 0.05.

(1% probability level) with grain yield (r = 0.44) and biological yield (r = 0.64), and this trait had significant and positive correlation (5% probability level) with seed weight per main panicle (r = 0.64), weight of main panicle (r = 0.37), and oil yield (r = 0.4). 100 seed weight had negative and significant correlation with harvest index (Table 3).

Seed weight per main panicle

The main effect of variety for seed weight per main panicle showed significant difference ($p<0.01$), but pruning factor and interaction (variety and pruning) were significant only at 5% level (Table 1). Mean comparison effect of variety on this trait indicated that the maximum seed weight per main panicle (190.83 g) was in 80-12-1 variety, because the genetic superiority produced stronger main panicle, and minimum weight (75 g) was in 80-29 variety (Table 2). Mean comparison effect of pruning on this trait indicated that, maximum seed weight per main panicle (139.62 g) was of pruning of 4 lateral branches and minimum weight (115.50 g) was in no pruning (Table 2). Also, Mean comparison of the interaction of two factors (variety and pruning) indicated that, maximum seed weight per main panicle was observed in 80-12-1 variety with pruning of 4 lateral branches and minimum weight was observed in 80-29 variety with no pruning (Figure 1). Pruning of 4 lateral branches in 80-12-1 variety had most effective on the main panicle in this plant and the length and weight of this panicle increased. This trait had significant and positive correlation with weight of main panicle (r = 0.97), grain yield (r = 0.93), biological yield (r = 0.67), days from planting to maturity (r = 0.71), and oil yield (r = 0.91) (Table 3).

Weight of main panicle

The effect of variety factor and interaction of factors (variety and pruning) were significant ($p<0.01$), but pruning factor on the weight of main panicle was significant at 5% level (Table 1). Mean comparison effect of variety on this trait indicated that the maximum weight of main panicle (112.72 g) was in 80-12-1 variety, because the genetics superiority produced stronger main panicle, and minimum weight (45.33 g) was in 80-29 variety (Table 2). Mean comparison effect of pruning on this trait indicated that, pruning of 4 lateral branches (87.41 g) showed maximum weight of main panicle and no pruning (66 g) showed minimum weight of main panicle (Table 2). Also, mean comparison for interaction of factors (variety and pruning) indicated that, maximum weight of main panicle was obtained for 80-12-1 variety with pruning of 4 lateral branches and minimum weight was obtained for 80-29 variety with no pruning (Figure 2). Pruning of 4 lateral branches of 80-12-1 variety had most effective on the main panicle and increased the length and weight of this panicle.

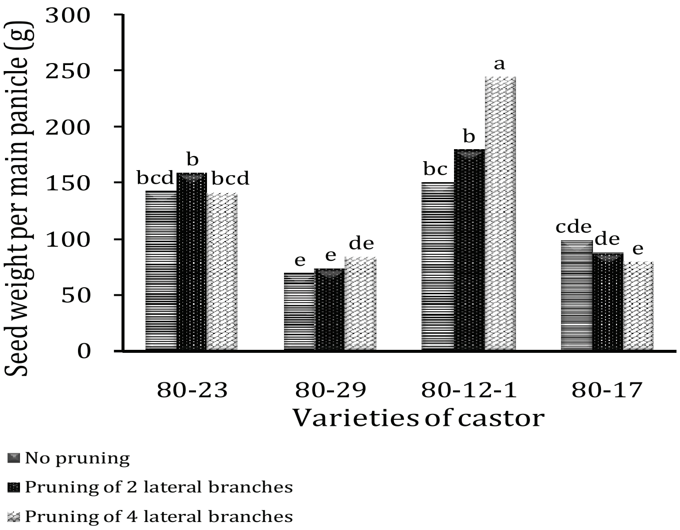

Figure 1. Comparison of interaction of castor bean varieties and pruning on seed weight per main panicle.

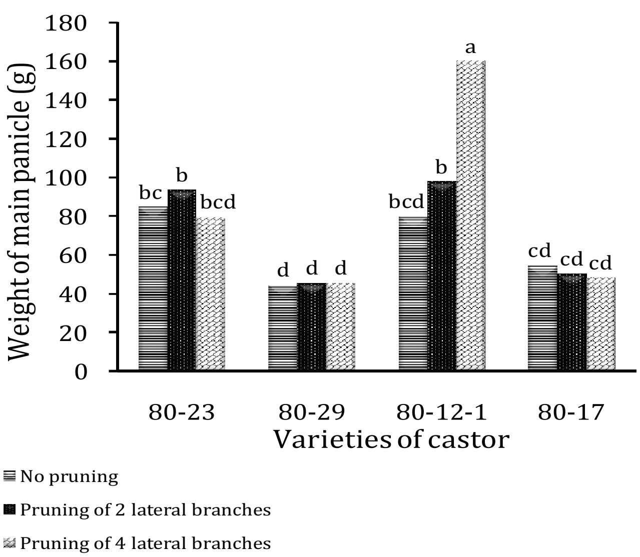

Figure 2. Comparison of interaction of castor bean varieties and pruning on weight of main panicle.

Weight of main panicle had significant and positive correlation with grain yield (r = 0.89), biological yield (r = 0.67), days from planting to maturity (r = 0.67), and oil yield (r = 0.88) (Table 3).

Grain yield

Variety factor showed significant difference for grain yield ($p<0.01$). In contrast, pruning factor and interactions of variety and pruning had no significant effect on grain yield in castor bean (Table 1). The mean comparison showed that, maximum grain yield (1307.78 kg ha^{-1}) was in 80-12-1 variety, and minimum yield (770.83 kg ha^{-1}) observed in 80-17 variety (Table 2). Grain yield had positive and significant correlation with biological yield, days from planting to maturity, and oil yield (Table 3). Grain yield is an important trait that is influenced by many factors such as genotype (Jabbariet al., 2007). Lopez et al. (2000) reported that, the number of seed sand and seed weight are the most effective factors on grain yield in sun flower.

Biological yield

Biological yield for castor bean varieties showed significant difference ($p<0.05$), but pruning factor and interaction between variety and pruning had no significant effect on biological yield (Table 1). The mean comparison showed that, maximum biological yield (12062 kg ha^{-1}) was in 80-12-1 variety, because of genetic superiority, and minimum yield (5953 kg ha^{-1}) was in 80-17 variety (Table 2). Biological yield had significant and positive correlation with oil yield (r = 0.71), but its correlation with harvest index was significant and negative in the 1% level (r = - 0.67) (Table 3).

Harvest index

Analysis of variance showed that, varieties had significant difference on harvest index in 5% probability level. On the other hand, pruning factor and interactions between factors (variety and pruning) had no significant effect on harvest index in castor bean (Table 1). The mean comparison showed that, maximum harvest index (13.66%) was in 80-17 variety, and minimum harvest index (9.09%) was in 80-29 variety (Table 2). Harvest index represents the ratio photosynthetic material distribution between the grain yield and biological yield is influenced by genotype and environment.

Days from planting to maturity

Analysis of variance showed that, the variety and pruning factors had significant difference on days from planting to maturity ($p<0.01$), but interaction of variety and pruning on this trait was significant at 5% level (Table 1). The mean comparison showed that, maximum growth period (135.11 days) was in 80-12-1 variety, and minimum growth period (124.66 days) was in 80-17 variety (Table 2). Mean comparison effect of pruning on this trait indicated that, maximum growth period (130.75 days) obtained for pruning of 4 lateral branches, and minimum growth period (126.75 days) obtained for no pruning

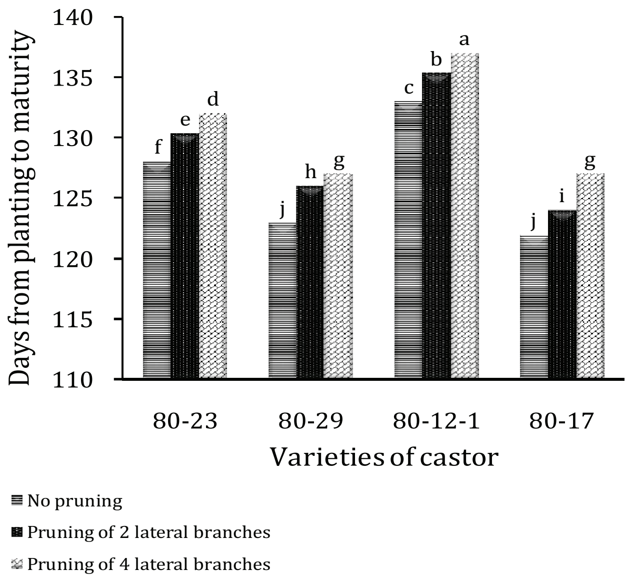

Figure 3. Comparison of interaction of castor bean varieties and pruning on days from planting to maturity.

(Table 2). Also, mean comparison of the interaction between factors (variety and pruning) indicated that, maximum growth period obtained for 80-12-1 variety with pruning of 4 lateral branches and minimum growth period obtained for 80-17 variety with no pruning (Figure 3). Days from planting to maturity had positive and significant correlation with oil yield (Table 3). Alyary and Shekary (2000) stated that, usually the yield of early varieties is less than the late varieties.

Oil yield

Variety factor showed significant difference on oil yield ($p<0.05$). In contrast, pruning factor and interactions of variety and pruning had no significant effect on oil yield in castor bean. The mean comparison showed that, maximum oil yield (696.56 kg ha^{-1}) obtained in 80-12-1 variety, and minimum oil yield (409.88 kg ha^{-1}) obtained in 80-29 variety (Table 2). Oil yield is the combination of seed yield and oil content. Koutroubas et al. (1999) reported that, the rate of oil yield like the grain yield depends on variety, climate, and interaction of climate and variety. Castor bean is an oil seed plant with oil content between 40 and 60% in commercial varieties (Weiss, 1983). Oil content in castor bean is a genetic trait but is affected by environmental conditions, agricultural operations and harvesting time (David and Beevers, 1961). Difference latitude is one of the influencing climatic factors on oil yield (Morison and Morecroft, 2006). Grain yield reduction can reduce oil yield (Kittock et al., 1967). Thus, the aim of the growers should be to increase the seed yield.

Conclusion

In general, the highest grain yield (1307.78 kg ha^{-1}) and oil yield (696.56 kg ha^{-1}) obtained for 80-12-1 variety and according to the results, the 80-12-1 variety and pruning of four lateral branches can be recommended in the similar areas for cultivation, and more research is needed to assess the effects of pruning on high yield in castor bean and other crops.

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