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ORIGINAL ARTICLE

Relationship between Pigments and Seed Fall Rate of Iranian Castor Genotypes and Genetic Diversity

Ghanbar Laei[1], Mohammad Reza Bihamta[*2], Reza Azizinezhed[1], Farokh Darvish Kojou[1]

[1]*Department of Plant Breeding, Science and Research Branch , Islamic Azad University, Tehran, Iran*

[2] *Department of Agronomy, Tehran University, Tehran, Iran*

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KEYWORDS

Castor;

Genotypic Diversity;

Grain Fall;

Color Combinations

ABSTRACT: This study aimed to examine the relationship between pigments and seed fall rate of Iranian castor genotypes and genetic diversity, specifically 28 castor genotypes (27 native and 1 modified), a randomized complete block design with three replications was conducted in 2014 and 2015 at the Research Farm of Islamic Azad University in Damghan, northern Iran. During the growth period, the following traits were sampled: seed length; seed width; weight of 1,000 seeds; color of seed coat; number of leaves in the bush; leaf, nervure, and stem color; seed fall rate; growth type; seed performance; oil percentage; and chlorophyll fluorescence rate. After data collection, variance analysis was conducted through SAS and mean comparison was performed through Duncan test at 5% probability level. Correlation coefficients were calculated to find correlations, and cluster analysis was used to group the genotypes. Finally, graphs were drawn with Excel. The results indicated diversity in the investigated traits. Differences were observed among the native castor genotypes so that they were divided into five groups in terms of grain fall rate. A significant negative correlation at 1% probability level between the grain fall rate and the leaf color (r= –0.71**), nervure color (r= –0.56**), and stem color (r= –0.57**) indicated that in all of these three traits, when the color changed to dark red, the rate of grain loss decreased. Thus, the color trait can be used as a reference in breeding programs so that grain fall in the castor plant can be prevented in the future.

INTRODUCTION

Castor plant (*Ricinus communis l.*) is a member of the Euphorbiaceae family [1]. “This plant is also called castor oil plant and is sold under the trade name Neoloid. A hybrid and diploid plant with 20 chromosomes (2n=20), castor grows in temperate regions. The plant originated from Ethiopia” [2] and is now founding different regions of Iran, including Yazd, Khuzastan, Khorasan, and the North. Castor also grows wildly in the central and southern parts of the country [3].

Biodiversity is a subject investigated from the aspects of gene, breed, and ecosystem [4]. According to a study [5], four levels of biological diversity have been defined, namely, molecular, breed, ecosystem, and genetic diversity. Genetic di-

* Corresponding author: pomato1960@yahoo.com (M.R. Bihamta)
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versity refers to gene diversity in the breeds. Developing new types with special traits compatible with a special climate is possible only if ample information is available regarding the genetic diversity of that type [6]. The first step in identifying native genotypes is morphological identification because these traits are easily measurable and have wide-ranging scientific applications [7]. Significant diversity in the growth traits of castor has been reported, including diversity in leaf, stem color, number and size of leaf lobes, and polished mode of stems [8]. Furthermore, dependent on environmental conditions; diversities exist in the growth habit and bush form of castor [9]. However, the greatest diversity has been reported in fertility rate, shape, seed color and size, number of flowers in each cluster, length of pedicle, and capsule opening [8]. Despite the worldwide reproduction of the plant, insufficient information is available regarding the genetic diversity of this plant [10]. Foster et al investigated the genetic diversity of castor in the world, but they reported a low genetic–geographical diversity in the germplasm of this plant [11].

Allen *et al* studied the genetic diversity in the wild castor genotypes and reported a low genetic diversity of the plant worldwide [12]. Moreover, the phenotypic diversity observed in castor cannot reflect its high genetic diversity [13]. Foster *et al* examined the genotypic diversity of castor in 45 countries; they found that the largest diversity was in India with 79 polymorphisms and in Iran with 25 polymorphisms, while the smallest diversity was observed in Yugoslavia with only one polymorphism [11]. Goodarzi *et al* reported variety in investigating the genetic diversity of 12 native masses of castor for traits such as bush height, number of primary side stems, female flowers, male flowers, fresh weight of main stem, secondary cluster weight, primary side stem, length of main stem, secondary side cluster length, dry weight of main stem, and diameter of main stem [7]. In investigating two genotypes of the purple morph type of castor, these two genotypes differ significantly from each other in the investigated traits and the genotypes should be classified into two separate groups [14]. Shaheen, focusing on the genetic diversity of castor plants collected from different regions of Egypt, studied 20 morphological traits and reported two morphological patterns in these native genotypes for leaf, pollen, capsule, and seed traits [15]. In a genetic investigation of 27 castor genotypes, Thatikunta *et al* reported diversity in 15 traits of root and stem [16]. Shidfar *et al* in investigating the agronomic traits of 12 castor genotypes found that the effect of genotype is significant on all of the investigated traits [17]. Sayadi Dizaj *et al* observed diversity in the performance and the performance components of 12 castor genotypes [18]. The ratio of the number of seeds to the number of capsules in the bush is a good criterion in evaluating the seed performance of castor [19]. The number of seeds and the number of capsules in the bush have correlations of 99%, respectively, with the performance. Therefore, various factors such as climate conditions, plant population, and growth habit influencing the castor plant lead to performance diversity [15]. Seed performance in the castor plant is a complex and important trait that results from the interplay of many traits influenced by various factors such as genotype [20].

We aimed to determine the relationship between pigments and seed fall rate of Iranian castor genotypes and genetic diversity

MATERIALS AND METHODS

In order to relationship between pigments and seed fall rate of Iranian castor genotypes and genetic diversity, specifically 28 castor genotypes (27 native and 1 modified) were investigated in a randomized complete block design with three replications and with fixed density of five bushes in square meters.

The study was conducted in 2014 and 2015 at the Research Farm of Islamic Azad University, Damghan branch (34° 12′ latitude; 53° and 42′ longitude; 1155.4 m above sea level) and sandy soil texture. Table 1 presents the climatic features of the region in which the native genotype was collected. Crop care, including seedbed preparation and proper use of fertilizer based on soil test, was identical for all treatments. During the growth period, sampling and note taking of the traits such as seed length; seed width; weight of 1,000 seeds; seed coat color; number of leaves in the bush; leaf, color, and stem color; seed fall rate; bush growth type; seed performance; oil percentage; and physio-morphological features of chlorophyll fluorescence rate on the leaf surface were measured by a chlorophyll fluorescence set (Opti-Sciences Inc.). Thus, the plant leaves were protected from light by special clips so that they could get used to darkness. Then, the fluorescence parameters, such as fluorescence rate, minimum (F_O) fluorescence, maximum (Fm) variable fluorescence (Fv), and ratio of Fv to maximum fluorescence (Fv/Fm), were measured. After data collection, variance analysis was conducted by SAS and mean comparison was performed through Duncan test at 5% probability level. Correlation coefficients were calculated to find correlations and cluster analysis was conducted to group the genotypes. Finally, graphs were drawn with Excel.

RESULTS AND DISCUSSION

The analysis of variance of the traits indicated a significant difference at the 1% probability level in the color of leaf, nervure, stem, and seed; seed fall rate; growth type of bush; width and length of seed; weight of 1,000 seeds; oil percentage; and seed performance. Moreover, significant difference was observed at the 1% probability level in Fm and Fv/Fm. However, no significant difference was observed in F_O and F_v.

Leaf color

Differences were observed in the leaf color of the native castor genotypes so that they were classified into four genotypic groups. The first group, with dark green leaf color, included eight genotypes (Ricindozho, Kashan, Shahrood, Darab, Damghan, Ardebil, 14283, and Tabriz). The second group, with green leaf color, included 14 genotypes (Mobarakht, Arak, Semnan, Birjand, Zabol, Urmia, Karaj, 1574, 1083, 1084, Mashhad, Fasa, Yazd, and Ahwaz). Three genotypes (Dezful, Maragheh, and 1573) were included in the third group with pink leaf color. Three genotypes (Gachsaran, Jiroft, and Sirjan) were includedin the fourth group with red leaf color (Figure 1).

Popova and Moshkin reported varieties in the growth traits of the castor plant, such as leaf, size and number of leaf lobes, and polished mode of the stems. However, the most evident variety was observed in the seed shape, color, and size; number of flowers in each cluster; pedicle length; and capsule opening [8].

The existence of significant positive correlation between the leaf color and F_M(r= 0.56**) and the F_v(r= 0.48**) indicated that the fluorescence rate increased with the color change from dark green to dark red. Moreover, the correlation with the stem color (r= 0.56**) was significant at the 1% probability level. However, it was negatively correlated with the seed fall rate (r= –0.71**), thereby indicating that the seed fall rate decreases with the color change from dark green to dark red. The reason is that the red color has a larger amount of pigments; thus, the chance of electron and light trapping increases, that can be closed capsules are effective in preventing grain fall (Table2).

Nervure Color

Differences were found in the nervure color of the native castor genotypes so that they were classified into four genotypic groups. The first group, with white nervure, included four genotypes (Sirjan, Ahwaz, Dezful, and Kashan); the second group, with green nervure, included 11 genotypes (Arak, 1048, Mobarakeh, Maragheh, Zabol, Urmia, Tabriz, Jiroft, Yazd, Mashahd, and 14283); the third group, with pink nervure, included seven genotypes (Karaj, 1274, Fasa, Damghan, Semnan, Birjand, and 1083); and the fourth group, with red nervure, included six genotypes (Ardebil, Gachsaran, 1573, RicinDonzho, Shahrood, and Darab) (Figure 2). The positive and significant correlation between the nervure and stem color (r= 0.62**) and the leaf color (r= 0.35**) indicates that with the change in the nervure color from white to dark red, the stem and leaf color also turns to dark red. However, the negative significant correlation between the nervure color and the seed fall (r= –0.56**) indicates that the seed fall decreases when the nervure color changes from white to red (Table 2).

Number of Leaves

Differences were observed in the number of leaves of various native genotypes of castor. The effect of genotypes indicated that the largest number of leaves belonged to the 1574 genotype with 39.89 leaves in a bush and the smallest number were in the Damghan genotype with 14.50 leaves in a bush (Table 3). Other researchers, found diversity in the number of leaves depending on environmental conditions, growth habit, and bush form [8,9]. In a study on genetic diversity of the castor plants selected from different regions in Egypt, Shaheen investigated 20 morphological features and reported two morphological patterns in these native genotypes for the features of leaf, pollen, capsule, and seed [15]. The positive and significant correlation between the number of leaves and the seed performance (r= 0.75**) and growth type (r= 0.32**) indicates that with the increase in the number of leaves, the photosynthesis increases and consequently, the performance improves (Table 2).

In a correlation study on eight traits, such as height of plant to the first cluster, ripping time, cluster length, weight of 100 seeds, number of leaves, and seed performance in 64 cross castors, the cluster height and length are strongly correlated with the seed performance [21].

Stem Color

Differences were observed in the stem color of the native castor genotypes so that they were classified into five genotypic groups. The first group, with dark green stem color, included three genotypes (Kashan, RicinDonzho, and Ahwaz); the second group, with green stem color, included six genotypes (Urmia, Karaj, 1573, Jiroft, Farab, and Dezful); the third group, with pink stem color, included 13 genotypes (Gachsaran, Mashahd, 1083, Ardebil, Damghan, Tabriz, Zabol, Semnan, Yazd, Birjan, 1048, Arak, and Mobarakeh); the fourth group, with red stem color, included five genotypes (Fasa, 14283, 1574, Shahrood, and Sirjan); and the fifth group, with dark red stem color, included one genotype (Maragheh) (Figure 3).

A wide diversity was observed especially in the growth traits such as stem color of the castor plant [8, 9]

In the present study, the positive and significant correlation at the 1% probability level between the stem color and the F_V rate (r= 0.63**) with the ratio of the maximum fluorescence to the variable and the Fv (r= 0.54**), with the leaf color (r= 0.56**), and with the nervure color (r= 0.62**), indicated that with the change of stem color from dark green to dark red, the leaf and nervure color turned to dark red, and the fluorescence rate also increased. However, negative significant correlation at the 1% level was observed in the seed fall rate (r= –0.57**), which indicated that the rate of seed fall decreased with the change of the stem color from dark green to red (Table 2).

Seed Color

Differences were observed in the seed color of the native castor genotypes so that they were classified into five genotypic groups. The first group, with white seed color, included three genotypes (Kashan, Arak, and RicinDonzho); the second group, with black seed color, included 10 genotypes (Mobarakeh, Semnan, Birjand, 1573, 1083, 1084, Fasa, Darab, Damghan, and Sirjan); the third group, with pink seed coat color, included 11 genotypes (Ahwaz, Mashhad, 14283, Gachsaran, 1574, Karaj, Ardebil, Tabriz, Zabol, Jiroft, and Dezful); the fourth group, with dark red seed, included two genotypes (Yazd and Shahrood); and the fifth group, with black seed color, included two genotypes (Urmia and Maragheh) (Figure 4). Popova and Moshkin (1986) reported variety in the fertility rate, shape, color, seed size, number of flowers in a cluster, pedicle length, and capsule opening [8].

Seed Fall

Differences were observed in the seed fall of the native genotypes of castor so that they were classified into five genotypic groups. The first group, with no seed fall, included three genotypes (Ardebil, Gachsaran, and Sirjan); the second group with low seed fall, included 11 genotypes (Mobarakeh, Jiroft, Damghan, Yazd, Fasa, Mashhad, 14283, 1084, 1574, Karaj, and Arak); the third group, with medium seed fall, included seven genotypes (Semnan, Birjand, Tabriz, Urmia, 1083, Ahwaz, and Dezful); the fourth group, with high seed fall, included six genotypes (Kashan, Zabol, 1573, RicinDonzho, Maragheh and Shahrood); and the fifth group, with very high seed fall, included one genotype (Darab), (Figure 5).

The negative significant correlation at the 1% probability level between the seed fall rate and the stem color (r= –0.57**) with the leaf color (r= –0. 71**) and the nervure color (r= –0.56**) indicates that the seed fall rate decreases with the change in the color of stem, leaf, and nervure to red (Table2). Therefore, the influential gene in the color of these traits can help reduce the seed fall rate.

Plant growth type

Differences were observed in the plant growth type of the native genotypes of castor so that they were classified into three genotypic groups. The first group, with limited growth type, included three genotypes (Tabriz, Darab, and Birjand). The second group, with medium growth type, included 22 genotypes (Zabol, Sirjan, Damghan, Fasa, 1084, 1083, Semnan, Mobarakeh, RicinDonzho, Kashan, Arak, Maragheh, Urmia, Shahrood, Yazd, Jiroft, Dezful, Ahwaz, Mashhad, 14283, 1574, and Ardebil). Three genotypes were included in the third group with unlimited growth (Karaj, 1573, and Gachsaran), (Figure 6).

Seed performance

Differences were observed in the seed performance of the native castor genotypes so that they were classified into six genotypic groups. The first group, with very low performance, included three genotypes (Damghan, Birjand, and Mobarakeh); the second group, with low performance, included seven genotypes (Karaj, Kashan, Arak, Zabol, RicinDonzho, Maragheh, and Dezful); the third group, with medium performance, included eight genotypes (Gachsaran, Darab, Jiroft, 1084, Urmia, Semnan, Ardebil, and 1573); the fourth group, with high performance, included six genotypes (Shahrood, 1083, Ahwaz, Mashahd, Yazd, and Sirjan); and the fifth group, with very high performance, included two genotypes (14283 and 1754) (Figure 7).

The highest seed performance was in the native genotype of 14283 with 2,134 kg per hectare and the lowest seed performance was in the native genotype of Mobarakeh with 1,183 kg per hectare. Although other genotypes were classified among the highest or lowest seed performance groups, the lowest and highest performances were observed in the two aforementioned genotypes (Table 3). The less and most productive native genotypes were compared by considering traits such as weight of 1,000 seeds; seed length and width; number of leaves; and so on. Thus, differences were observed in the seed performance of the genotypes investigated in this experiment. These results were in accordance with the findings of [18, 19, 22] .

Genotype 14283 was found to exhibit higher seed performance and thousand-seed weight [23], and seed performance in the castor plant depended on environmental conditions. The positive significant correlation at the 1% probability level between the seed performance and the number of leaves (r= 0.75**) indicated that with the increase in the number of leaves, the photosynthesis also increased and consequently, the performance improved. However, significant negative correlation at the 1% probability level between the seed performance and the leaf color (r= –0.56**) indicated that the seed performance decreased with the change of leaf color from dark green to dark red. Nevertheless, no significant relationship was observed between the thousand-seed weight and the seed performance, which was in accordance with the findings of (Table 2) [18].

Sarwar and Chaudhry investigated traits, such as the ripping time, plant height, number of clusters, and length of main cluster, number of capsules in the main cluster, capsule weight, and weight of 100 seeds, in the performance of 16 castor genotype mutants with gamma radiation to find the proper criterion for the ideal types with high performance [24]. They found a significant positive relationship between the capsule weight and performance and the number of clusters, capsule weight, and weight of 100 seeds, which has a strong and positive effect on the seed performance.

Weight of 1,000 seeds

Differences were observed in the weight of 1,000 seeds of the native castor genotypes so that the highest weight of 1,000 seeds was 412.16 g for the 14283 genotype, and the lowest weight of 1,000 seeds was 146.44 g for the Birjand genotype. Diversity was observed in the weight of 1,000 seeds, and the 14283 genotype had a higher weight of 1,000 seeds compared with the genotypes of the same group; this finding can be a useful reference to achieve future breeding objectives (Table 3). Several researchers have related the diversity in the weight of 1,000 seeds to the genotype and the environmental conditions [22, 23, 25], while others related the diversity only to the genotype [18, 19].

Width and length of seed

Differences were observed in the seed width and length of the native castor genotypes. The maximum seed length was 14.52 mm for the Yazd genotype and the maximum width was 9.52 mm for the Karaj genotype; the minimum seed length was 8.71mm and the minimum width was 6.55mm for the Birjand genotype (Table 3).The positive significant correlation at the 1% probability level between the weight of 1,000 seeds and the seed length (r= 0.87^{**}) and seed width (r= 0.86^{**}) indicates that with the increase in each of these two traits, the weight of 1,000 seeds increases, thereby resulting in improved performance (Table 2).

Seed oil percentage

Differences were observed in the seed oil percentage of the native castor genotypes so that they were classified into four genotypic groups. The first group, with low seed oil percentage, included 17 genotypes (Ardebil, Mobarakeh, Urmia, Tabriz, Yazd, 14283, 1084, Arak, Sirjan, Darab, Shahrood, RicinDonzho, 1573, 1083, Semnan, Damghan, Fasa, and Karaj). The second group, with medium oil percentage, included eight genotypes (Dezful, Ahwaz, Mashhad, Zabol, Kashan, 1574, Jiroft, and Maragheh). Two genotypes were included in the third group with high percentage of oil (Gachsaran and Birjand). One genotype (1084) was found in the fourth group with very high oil percentage (Figure 8). Furthermore, the highest oil percentage at 55% was observed in the 1084 genotype and the lowest was 38% in the Maragheh genotype.

The negative significant correlation at the 1% probability level between the oil percentage and the seed length (r= –0.55**) and seed width (r= –0.53**) with thousand-seed weight (r= –0.60**) indicates that with the increase in each of the three mentioned traits, the oil percentage decreases (Table 2). Kittock et al reported a positive relationship between the seed weight and the oil percentage, which was contrary to the findings of the present study [23]. However, Sayadi Dizaj et al reported a negative relationship between the seed weight and the oil percentage (r= –0.65**) which was in accordance with the findings of the present study [18]. The oil percentage in the castor seed is a genetic trait that is influenced by the genotype, environmental conditions, agricultural operations, harvest time, and so on [25]. The amount and ingredients of castor oil are related to the climate, cultivar, and cultivation and processing methods [26]. The oil percentage in the trade varieties normally varies between 40%and 60%. The oil performance is a combination of seed performance and amount of oil [27]. Therefore, a reduction in the seed performance reduces the oil performance [28].

Fluorescence parameters

Differences were observed in the maximum fluorescence rate and the ratio of the variable fluorescence to maximum fluorescence (F_v/F_M) of the native castor genotypes; however, no differences were observed in the parameters of the F_v and F_O. The positive significant correlation at the 1% probability level between the Fmand the Fv (r= 0. 99**), between the ratio of the variable fluorescence to maximum fluorescence (Fv/F_m) and the variable fluorescence (r= 0. 51**), and the F_m and ratio of the variable fluorescence to maximum fluorescence (Fv/F_m) (r= 0. 47**) indicates that with the change in every fluorescence variable, the other fluorescence (F_O, F_V, F_m and ratio Fv/F_m) changes accordingly.

The positive significant correlation between the leaf color and the Fv (r= 0.56**), between the leaf color and the maximum fluorescence (r= 0. 48**), between the stem color and the Fv (r= 0.63**), and between the stem color and the ratio of the maximum fluorescence to the variable (r= 0.54**) indicates that the fluorescence rate increases with the change in the leaf and stem colors.

CONCLUSIONS

The color trait in the leaf, nervure, and stem can decrease the seed fall in castor. Moreover, the 14283 genotype exhibited the highest seed performance; the 1084 genotype exhibited the highest oil percentage; and the Ardebil, Gachsaran, and Sirjan genotypes exhibited the lowest seed fall rate. These findings can be used as a reference in future breeding programs.

Table 1. Name, origin and geographical location of different Iranian castor genotypes

Genotype number	Genotype	(Altitude) Meter	Geographical coordinates (Longitude) Degree	(Longitude) Minute	(Latitude) Degree	(Latitude) Minute
1	Mobarakeh	1900	51	30	32	21
2	Arak	1755	49	41	34	5
3	Kashan	950	51	27	33	59
4	Semnan	1130	53	23	35	34
5	Birjand	1480	59	13	32	53
6	Zabol	475	61	29	31	1
7	Tabriz	1366	46	18	38	4
8	Ardebil	1500	48	18	38	15
9	Urmia	1340	45	4	37	33
10	Karaj	1360	51	0	35	48
11	1574	-	-	-	-	-
12	Gachsaran	357.5	50	45	30	15
13	1573	-	-	-	-	-
14	1083	-	-	-	-	
15	1084	-	-	-	-	-
16	14283	-	-	-	-	-
17	Mashhad	1050	59	34	36	16
18	Fasa	1750	53	41	32	11
19	Yazd	1230	55	0	32	0
20	Darab	1180	54	30	28	53
21	Damghan	1170	34	15	53	42
22	Ricin donzho	-	-	-	-	-
23	Shahrood	1380	54	58	36	25
24	Jiroft	685	57	44	28	40
25	Dezful	143	48	30	32	20
26	Sirjan	1735	55	40	29	27
27	Ahwaz	18	48	40	21	20
28	Maragheh	1477	46	12	37	30

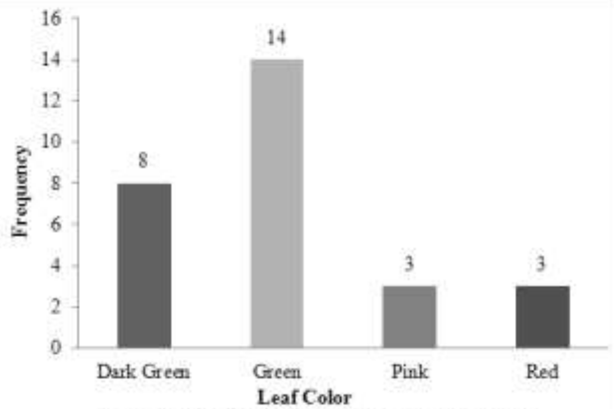

Figure 1. Distribution Frequency leaf color in Iranian Genotypes Castor

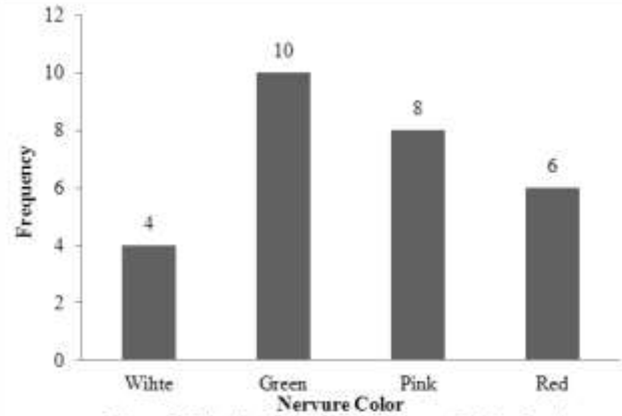

Figure 2. Distribution Frequency Nervure Colorin Iranian Genotypes Castor

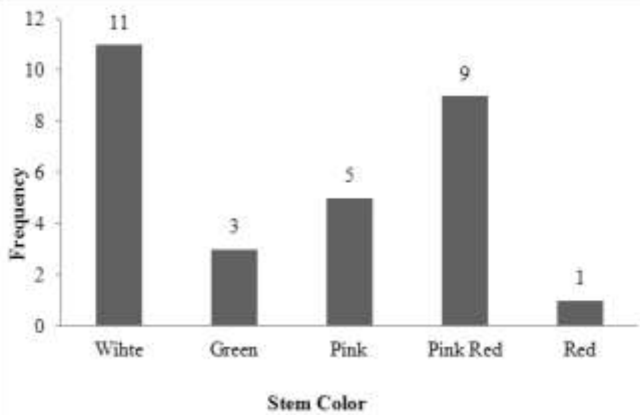

Figure 3. Distribution Frequency Stem Color in Iranian Genotypes Castor

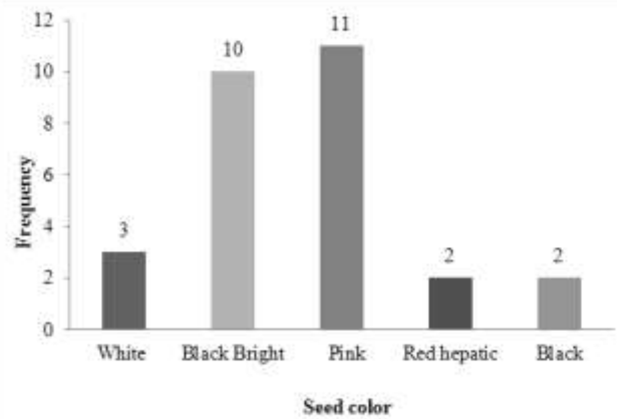

Figure 4.Distribution Frequency Seed color in Iranian Genotypes Castor

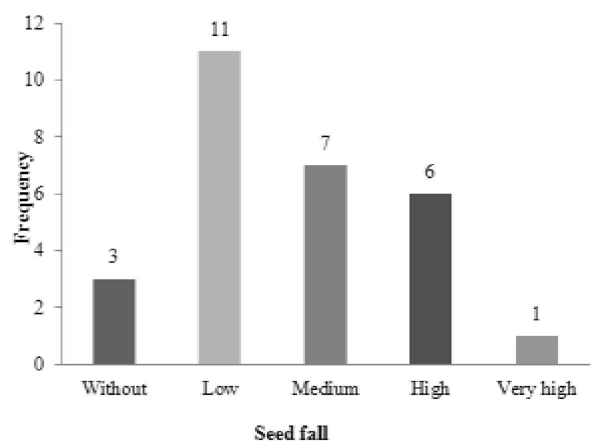

Figure 5. Distribution Frequency Seed fall in Iranian Genotypes Castor

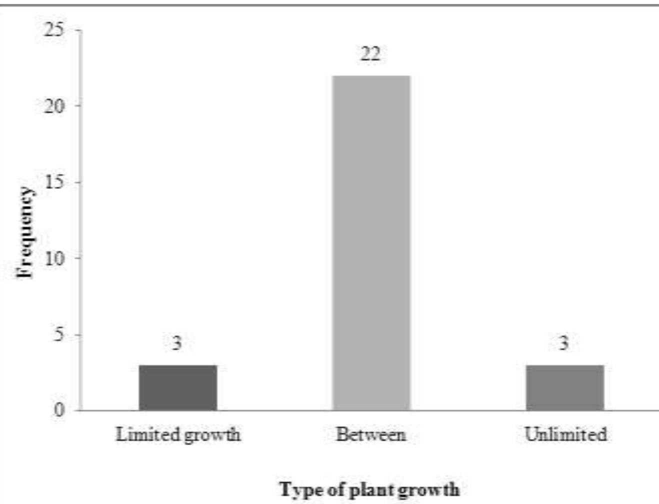

Figure 6. Distribution Frequency Type of plant growth in Iranian Genotypes Castor

Table 2. Correlation Coefficients among traits 16 of Iranian Castor Genotypes.

Traits	Fo	F_M	Fv	Fv/ F_M	seed performance	Leaf color	Nervure Color	Stem color	Seed fall	Seed color	Type of plant growth	Num of leaves	Grain Length	Grain width	Weight of 1000 Grains	Oil percentage
Fo	1.00															
F_M	0.20	1.00														
Fv	0.08	0.99**	1.00													
Fv/ F_M	-0.21	0.47*	0.51**	1.00												
seed performance	-0.09	0.06	0.08	-0.03	1.00											
Leaf color	-0.03	0.48*	0.56**	0.19	-0.65**	1.00										
Nervure Color	0.04	0.10	0.10	0.14	-0.06	0.35*	1.00									
Stem color	-0.09	0.21	0.63**	0.54**	-0.05	0.56**	0.62**	1.00								
Seed fall	-0.04	0.01	0.01	0.06	-0.01	-0.71**	-0.56**	-0.57**	1.00							
Seed color	-0.02	0.09	0.10	0.01	0.12	-0.03	0.12	0.09	0.00	1.00						
Type of plant growth	-0.11	-0.18	-0.17	-0.08	0.16	-0.18	0.01	-0.01	-0.13	0.45*	1.00					
Number of leaves	-0.24	-0.08	-0.06	0.01	0.75**	-0.12	0.01	0.03	-0.07	0.03	0.32*	1.00				
Grain Length	-0.15	0.03	0.05	-0.02	0.14	0.12	0.19	0.21	-0.20	0.24	0.15	0.11	1.00			
Grain width	-0.07	0.05	0.06	-0.07	0.18	0.10	0.16	0.19	-0.22	0.23	0.15	0.14	0.88**	1.00		
Weight of 1000 Grains	-0.11	0.13	0.14	0.03	0.17	0.16	0.10	0.15	-0.20	0.22	0.15	0.11	0.87**	0.86**	1.00	
Oil percentage	0.08	-0.24*	-0.25*	-0.10	-0.11	-0.14	-0.09	-0.14	-0.07	-0.49*	0.02	-0.05	-0.55**	-0.53**	-0.60**	1.00

ns,* and**: Non Significant, Significant at 5% and 1% Levels Respectively.

Table 3. Means of traits of Iranian Castor genotypes (Duncan Multiple Range Test at The Level of 5%).

Genotype	FM	FV/FM	seed performance (kg/ha)	Number of Leaves	length seed (mm)	Width seed (mm)	Weight of 1,000 seeds(gr)	Oil percentage (%)
Mobarakeh	652a-c	0.65cd	1183.02g	18.33cd	11.25fg	7.95fg	225.25i	0.45fb-e
Arak	681.7a-c	0.69a-d	1768.96a-d	20.33cd	11.55ef	8.16f	265.18h	0.47a-d
Kashan	666.3a-c	0.68a-d	1711.71b-e	19.44cd	11.92de	7.98fg	264.88h	0.46a-e
Semnan	664a-c	0.68a-d	1898.81ab	21.22bcd	10.31h	7.28h	225.48i	0.41fde
Birjand	662.7a-c	0.69a-d	1202.15gf	20.89b-d	8.71j	6.55i	146.44k	0.44fb-e
Zabol	709.7a-c	0.72a-c	1413.62d-g	24a-d	14.03ab	9.13bc	330.39b-d	0.42fcde
Tabriz	754.7a-c	0.71a-c	1569.14eb-f	24.94a-d	12.06d-e	8.86c-e	330.92b-d	0.41fde
Ardebil	823.3ab	0.73a	1437.85ec-g	24.33a-d	12.26cd	8.72de	306.66c-g	0.39f
Urmia	582bc	0.63d	1319.97e-g	19.11cd	11.1fg	7.95fg	209.22ij	0.48a-d
Karaj	658a-c	0.68a-d	1427.57c-g	25.11a-d	14.15ab	9.52a	411.48a	0.43b-f
1574	516.7c	0.63d	1953.92ab	39.89a	12.87c	9.02cd	299.59d-h	0.43b-f
Gachsaran	626a-c	0.66b-d	1604.34b-e	33.67a-c	12.56cd	8.74de	288.95f-h	0.45 b-f
1573	608.7a-c	0.63d	1820.23a-c	30.22a-d	11.19fg	8.01fg	228.32i	0.43 b-f
1083	712a-c	0.73a	1898.38ab	39.56a	11.47ef	7.29h	227.43i	0.42d-f
1084	684.7a-c	0.7a-c	1585.44b-e	28.67a-d	10.42h	7.36h	188.55j	0.55a
14283	697.3a-c	0.69a-d	2134.59a	37.22ab	14.17ab	9.13bc	412.16a	0.38f
Mashhad	735a-c	0.71a-c	1936.69ab	27.67a-d	14.11ab	8.83c-e	325.37b-e	0.41 d-f
Fasa	730a-c	0.71a-c	1934.98ab	33.44a-c	11.13fg	8.05fg	285.61f-h	0.42 d-f
Yazd	769ab	0.73ab	1619.01b-e	22bcd	14.52a	8.76c-e	302.24d-g	0.49ab
Darab	790.3ab	0.73a	1601.44b-e	21.56b-d	11.13gf	8.05fg	306.71c-g	0.52a
Damghan	711.3a-c	0.69a-d	1595.93b-e	14.5d	9.47i	6.72i	197.59ij	0.4fe
Ricin Donzho	717a-c	0.73ab	1602.17b-e	24.11a-d	10.56gh	7.75g	214.54ij	0.41 d-f
Shahrood	646.3a-c	0.7a-c	1869.04ab	31.11a-d	10.56gh	7.39h	283gh	0.49a-c
Jiroft	838.7a	0.74a	1419.02d-g	24.56a-d	14.42a	9.46ab	319.26b-f	0.47a-e
Dezful	838.7a	0.73a	1706.63b-e	24.67a-d	13.89ab	8.8c-e	293.52e-h	0.43c-f
Sirjan	731.7a-c	0.73a	1676.43b-e	31.11a-d	10.65gh	7.32h	222.85i	0.41d-f
Ahwaz	778.3ab	0.68a-d	1901.37ab	24.67a-d	13.72b	8.89c-e	350.37b	0.43b-f
Maragheh	731.7a-c	0.73a	1568.26b-f	24.67a-d	12.25cd	8.58e	231.05i	0.38f

Mean Followed By Similar Letters In Each Column Are Not Significantly Different.

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