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Inheritance of Plant Height in two Ethiopian Castor Varieties

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አሕፅሮተ-ጥናት

የጉሎ ዕፅዋት ቁመታቸው ረዣዥም የሆነ በቀላሉ ወድቀው የሚሰበሩ በመሆናቸው ምርት ለመሰብሰብ አስቸጋሪ የሆኑ እንዲሁም የምርት መቀነስ የሚያስከትሉ ናቸው:: በሌላ መልኩ አጫጭር ዕፅዋት ለማዳበሪያ ምላሽ እንደሚሰጡና በዛ ባለ የዘር መጠን መዝራት ስለሚቻል የተሻለ ምርት እንደሚሰጡ ታውቋል:: በዚህም የተነሳ የአባሮና ህሩይ የጉሎ ዝርያዎች የቁመት ስራተ-ውራሴ MD-1 ከተባለ አጭር ዝርያ ጋር በማዳቀል በ2005 እና በ2006 ዓም መልካሳ ላይ ተጠንቷል:: በውጤቱም የመጀመሪያው ትውልድ በሙሉ ረዣዥሞች ነበሩ:: ሁለተኛው ትውልድ (F_2) ከጠቅላላ ዕፅዋቶች ውስጥ አንድ እጅ አጭር ሁለት እጅ ረዥም ነበሩ:: የመጀመሪያው ትውልድ ከረዣዥም ወላጆቹ ጋር ተመልሶ ሲዳቀል ሁሉም ዕፅዋት ረዣዥሞች ሲሆኑ ከአጭር ወላጁ ጋር ተመልሶ ሲዳቀል ግን ከጠቅላላ ዕፅዋት ውስጥ አንድ እጅ አጭርና አንድ እጅ ረዣዥም ሆኑ:: ይህ ውጤት የሚያሳየው የአባሮና ህሩይ ቁመት በአንድ ዘረመል ብቻ እንደሚወሰን ነው:: በጣም አጭር የዕፅዋት ቁመት የሚገኘው ዘረመሎች አንድ ዓይነትና አቅመ-ቢስ (recessive) ሲሆኑ ነው:: የዚህ ጥናት ውጤት አጫጭር የጉሎ ዝርዎችን ለማዳቀል መሰረታዊ መረጃ ነው::

Abstract

Castor varieties are tall in plant height which makes them difficult for harvesting. A study was carried out to investigate the inheritance of plant height among two tall Castor varieties Hiruy and Abaro and one dwarf experimental line MD-1 during 2012 to 2014 at Melkassa. The F_1 from reciprocal crosses of Abaro and Hiruy with MD 1 were all tall. The F_2 plants segregated in to 1 dwarf to 3 tall plants and the backcross plants to the tall parents were all tall while plants from the backcross to the dwarf parent segregated into 1 tall to 1 dwarf. The data in this study shows that plant height in castor varieties Abaro and Hiruy is controlled by a single gene at one locus. Dwarf plants appeared at a homozygous recessive condition (ht1ht1) while tall plants can be either homozygous (ht1Ht1) or heterozygous (Ht1Ht1). The results of this study will assist in the breeding for semi-dwarf genotypes of castor varieties in the future.

Introduction

The introduction of dwarfing and semi dwarfing genes in to small cereal crop varieties was one of the most important factors affecting the increases in harvest index and yield (Makela 2008, (Bachir and Hu 2014).). There are 20 dwarfing genes in wheat, out of which *Rht*1 and *Rht*2 are most widely used around the world. Dwarf and semi dwarf wheat varieties have reduced stature, lodging resistant and superior in yield stability than their tall parental lines.

The green revolution in Asia was led by the semi dwarf varieties of wheat and rice during the 1960s. Nowadays wheat varieties possess one or two dwarfing genes or semi dwarfing genes that originated from various sources. The semi dwarfing gene in rice has been one of the most important genes deployed in modern rice breeding. Its recessive character resulted in shortened culm with improved lodging resistance, greater response to nitrogen fertilizer and improved harvest index (Wolfgang et al. 2002**).**

In sunflower dwarf varieties were developed following the success story of cereals. Dwarf sunflower varieties were resistant to lodging, early to mature, responsive to nitrogen fertilizer, suitable for harvesting with improved harvest index (Angadi and Entz 2002). An added advantage of semi dwarf varieties was that they can be planted in higher plant density than standard varieties. However, standard sunflower varieties have deeper root system and depletes soil moisture to a depth of up to 1.9 meters than dwarf varieties.

Castor (*Racinnus communis* L.) is an industrial non edible oil seed that originated in East Africa probably Ethiopia (Weiss 2000). Evaluation of the indigenous germplasm at Melkassa and Arsi Negelle in the Central Rift Valley of Ethiopia showed that height of castor plants exceeds mostly two and half meters and in some cases up to four meters. Hence reduction of plant height to improve harvest index and ease of management is required. Semi dwarfing genes were introduced into hybrid varieties of castor first in USA followed in Brazil, India and China.

Ethiopia has not benefited from the available genetic resources of castor due to lack of modern varieties and cultivation techniques. The Biodiversity Institute in Addis Abeba is the repository for the local germplasm while castor research in breeding and agronomy is being conducted at Melkassa Agricultural Research Center. The major objective of castor breeding is to develop semi dwarf, high yielding varieties containing high oil in their seed along with cultivation techniques. So far two varieties namely Abaro and Hiruy are released and elite lines containing oil contents of well over 49% are identified. However, both varieties and elite lies are tall with a height exceeding 2.5 meters. Therefore the objective of this experiment was to study the genetics of tall plant height in the released varieties of Hiruy and Abaro.

Materials and Methods

This study was conducted using two released castor varieties Hiruy and Abaro and an elite semi dwarf or short internode MD-1. Hiruy is upper branching with single large main raceme and unique purple color variety released in 2012 (Getinet et al 2013). The plant height of Hiruy is about 260 cm with internodes length of 15 cm under normal condition. Abaro is lower branching bold seeded with chocolate seed color released in 2011 (Getinet et al 2011). The plant height of Abaro is about 240 cm with internodes length of 14 cm. MD-1 is an elite selection from a Brazilian Variety Gurani for its short plant height and internode length. The plant height of MD-1 is about 100 cm with internodes length of 3 cm under Melkassa condition. Single plants from each genotypes were selfed for three generations to make sure that the genotypes used in this study were true breeding. At the fourth generation single plants from each inbred line were reciprocally crossed to produce F_1 seeds. F_1 plants were grown and selfed to produce F_2 seeds. At the same time F_1 plants were backcrossed reciprocally with their parents to produce BC_1F_1 seeds.

In 2014 main season, parents, F_1, F_2 and BC_1 seeds were planted in the field. Plant height was measured from the ground to the tip of the main raceme. The data from each plot was classified in to two types of < 150 cm and > 250 cm. This was because the plants showed clear classification. The crosses Hiruy and Abaro were summarized and tested using chi square, Finally the data from cross of Abaro x MD-1 and Hiruy x MD-1 was combined following test of heterogeneity.

Results and Discussion

All plants from Abaro and Hiruy were all taller than 250 cm and MD-1 less than 150 cm indicating that the parents were true breeding for plant height or short inter node. Hiruy and Abaro are tall type with long internodes as internodes length adds up to plant height. The tall parents have too many leaves and are inefficient in utilizing resources.

The F_1 plants from the reciprocal crosses of Abaro and Hiruy with MD-1 were all tall indicating that tall is dominant over short or semi dwarf (Tables 1, 2 and 3). In all similar studies, tall plants were dominant over dwarf (Severino *et al*. 2012). In this study the F_1 plants from the two crosses showed similar plant height indicating that the factors responsible for plant height in Abaro and Hiruy are not different from each other. The F_2 plants from the reciprocal crosses of Abaro and Hiruy with MD-1 segregated in to 1 dwarf to 3 tall. The combined data from both crosses segregated in to similar class ratios. The F_2 data was supported by 1:1 segregation ratio of backcross to the dwarf parent and those pants of backcross to the tall parents of Hiruy and Abaro were all tall. The 1 dwarf : 3 tall segregation ratio at F_2 and 1 dwarf : 1 tall in back cross to the dwarf parent as well as all plant in the back cross to the tall parents shows that plant height is controlled by a single dominant gene at one locus. The fact that dwarf is controlled by recessive genes is an added advantage in castor breeding because dwarf plants can only be obtained at a homozygous level. In castor dwarf plants are preferred for ease harvesting and management. In this study we propose plant height to be controlled by a single gene ht1 at one locus. Semi dwarf plants appear at homozygous recessive condition ht1ht1 while tall plants can be genotypically heterozygous (ht1Ht1) or homozygous (Ht1Ht1). The results of this study were utilized to transfer the dwarfing locus from MD-1 to the released varieties of Hiruy and Abaro. Crossing and backcrossing followed by selection at F_2 and BC_1F_2 generation resulted in semi dwarf lines that are now being tested at several locations.

The reduction of plant height in castor plants was as result of reduction inter node length. The mean inter node length in Hiruy was 15.0 cm and 14.7 cm for Abaro as compared to 3.0 cm for MD-1. As a result the mean plant height for Hiruy was 2.6 meters and 2.4 meters for Abaro as compared to 1.2 meters for the MD-1. In sunflower, the inheritance of reduced plant height was studied using sunflower line DW-89 containing plant height of 47 cm and standard cultivars having plant height of 120 cm. The F_1 plant height averaged 120 cm indicating dominance of tall over reduced plant height. The F_2 plants segregated in to 1:15 indicating reduced plant height was controlled by alleles at two loci. This was confirmed by 1:3 ration of back to the DW-89.

Semi dwarf and dwarf genotypes of castor can be planted at a higher plant density than standard tall varieties. In addition semi dwarf genotypes tends to bear less branches and larger and main inflorescence. In castor the main inflorescence bear more seeds as compared to inflorescences secondary and thirtiary branches. In addition seeds born on the main raceme are larger and contains more oil than seeds born on secondary branches. hence maximizing the size of the and number of female flowers on main raceme has been a major objective in castor crop management and breeding. Therefore, semi dwarf genotypes have significant contribution for higher yield.

Castor is a dry land crop because it tolerates moisture stress by depleting moisture from deeper soil layers. However, weather reducing the plant height through reduction of inter node length would also reduce root depth or not remains to be seen. In sunflower standard varieties tolerates moisture stress by depleting moisture as deep as 1.9 meters compared to semi dwarf varieties. Hence the stability and response of semi dwarf castor genotypes to moisture stress requires a careful study.

Table 1. Number of plants from the cross of the tall castor variety Abaro and dwarf MD-1, Melkassa 2014.

	Number of plants with plant height (cm)				
Parent or Cross	< 150	>250	Ratio	Chi square	Probability
Abaro MD-1	33	20			
Abaro x MD-1 F_1		18			
MD1 x Abaro F_1		41			
Abaro x MD-1 F_2	11	28	1:3	0.2788	0.75-0.50
MD1 x Abaro F_2	13	36	1:3	0.2500	0.50-0.25
Backcross to Abaro		184			
Back Cross to MD-1	108	112	1:1	0.0727	0.90-0.75

Table 2. Number of plants from the cross of the tall castor variety Abaro and dwarf MD-1, Melkassa 2014.

	Number of plants with plant height (cm)		Ratio	Chi square	Probability
Parent or Cross	< 150	>250			
Hiruy		55			
MD-1	33				
Hiruy x MD-1 F_1		57			
MD1 x Hiruy F_1		49			
Hiruy x MD-1 F_2	12	34	1:3	0.0217	0.90-0.75
MD1 x Hiruy F_2	13	37	1:3	0.0283	0.90-0.75
Backcross to Hiruy		201			
Back Cross to MD-1	56	61	1:1	0.2186	0.75-0.50

Table 3. Number of plants from the cross of the tall castor varieties Abaro and Hiruy with dwarf MD-1, Melkassa 2014.

	Number of plants with plant height		Ratio	Chi square	Probability
Parent or Cross	< 150	>250			
Tall		75			
MD-1	33				
F_1		165			
F_2	49	135	1:3	0.2608	0.75-0.50
Back cross to the tall		385			
Back cross to the MD-1	164	173	1:1	0.1216	0.75-0.50

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