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COMPARATIVE MORPHO-AGRONOMIC STUDY OF ROSELLE GENOTYPES BASED ON THEIR GROWTH AND YIELD TRAITS

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A B S T R A C T

Roselle (*Hibiscus sabdariffa* var. sabdariffa) is an annual subshrub, and its leaves, seeds, and especially calyces are valued for their nutritional and medicinal uses. The objectives of the study were to evaluate the best one among three morphotypes of Roselle. The morphotypes of Roselle were green plant with green calyx (WC); light red plant with light red calyx (LRC); and deep red plant with deep red calyx (DRC). The field experiment was laid out in Randomized Complete Block Design (RBCD) with three replications. Several morphological characteristics include plant height, stem base diameter, number of branches per plant, total fresh and dry biomass yield, number of capsules per plant, the weight of capsule per plant, weight of fresh calyx per plant, weight of dry calyx per plant, shelling ratio (%), etc. were evaluated. Significant differences were observed in morpho-agronomic characters in these three morphotypes. The DRC demonstrated the greatest performance across morphotypes for the number of capsules per plant (343.33), the weight of fresh capsules per plant (2227.77g), and shelling ratio (% calyx to capsule) (43.03 %). And LRC morphotype had the best performance in plant height (114.00 cm) and stem base diameter (4.30 cm). In general, the DRC morphotype outperformed the WC and LRC morphotypes.

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INTRODUCTION

Many tropical and subtropical regions, including Bangladesh, grow 'Chukur' (in Bangla)/Sorrel/Roselle (*Hibiscus sabdariffa* var. *sabdariffa*), a functional food with high nutritional and medicinal values. (Halimatul et al., 2007; Rao, 2008, Akanbi et al., 2009; Fakir et al., 2012). It's a malvaceous family annual subshrub. The leaves range in color from dark green to red. Short-peduncled bisexual flowers range in color from red to yellow. The persistent, fleshy sepals grow and become succulent. The capsules are ovoid, hairy, and beaked. The plant is typically grown for its stems, leaves, seeds, and calyces, which are used as vegetables, refreshing drinks, oil sources, and food preserves (Wong, 2000), as well as for medicinal and health purposes (D'Heureux and Badrie, 2004). The stems are generally utilized to produce fiber, which can be used to make burlap as a substitute for jute (Riaz and Chopra, 2018). Tender leaves and stalks are used in salads and curries as seasonings. Micronutrients such as iron, manganese, copper, and zinc were found in the leaves. (Sena et al., 1998). Protein, fat, carbohydrate, fiber, ash, calcium, phosphorus, iron, thiamine, carotene, riboflavin, niacin, and ascorbic acid are all said to be present in the leaf. (Duke et al., 1984). Roselle seeds were high in protein as well as important micronutrients, dietary fiber, and minerals like phosphorus, magnesium, and calcium. (Hainida et al., 2008; Akanbi et al., 2009; Chowdhury, 2012). The calyces of the Roselle plant, which can be green, deep red, or light red, are the most useful component of the plant. (Islam et al., 2008). Vegetable stew is made using green calyces. (Babalola, 2000); While roselle calyces are commonly employed in the creation of beverages such as herbal tea, wine, and preserves such as syrup, jams, jellies, and sauces (Mahadevan et al., 2009; Clydescale, 1979, Tsai et al., 2002; Fakir et al., 2012, Ansari and Eslaminejad, 2013). They are utilized in ice cream, cake, pudding, and rum as a natural colorant and flavoring agent. (Ismail et al., 2008; Biswa and Singo, 2019). It is a cherished food product because of its beautiful red color and unusual flavor. The juice extracted from the calyces of roselle is said to be a health-promoting beverage and is commonly consumed as a dietary item in some regions of the world. The dried calyces, which may be a good source of carbohydrate, dietary fiber, vitamins, minerals, and bioactive substances such as organic acids, phytosterols, and polyphenols, are a source of economic importance in roselle. (Riaz and Chopra, 2018; Hannan et al., 2020). Roselle, a great source of natural antioxidants (Mourtzinos et al., 2008), and the therapeutic characteristics of its sepal extract include anti-hepatotoxicity anthocyanins. (Liu et al., 2002, Herrera-Arellano et al., 2004) and antibacterial, antifungal, anticarcinogenic, and anti-hypertensive properties (Heureux-Calix and Badrie, 2004; Chen et al., 2003; Hou et al., 2005).

Roselle is available in a variety of forms all over the world. Even though a significant study is being done on different types of Roselle all over the world, there isn't much being done in Bangladesh. As a result, this research focused on three Bangladeshi cultivars. Although the growing process and proximate composition of Roselle plant parts have been carried out (Chowdhury, 2012) However, there has never been a study in Bangladesh that compares canopy structure and calyx yield among different roselle morphotypes. Different parameters of each variety are noted here, including plant height, base perimeter, number of branches, node number, biomass yield, selling ratio, and other metrics.

MATERIALS AND METHODS

Location of the study

The experiment was conducted at the experimental field; Physiology, and Ecology Laboratories; Department of Crop Botany, Bangladesh Agricultural University, Mymensingh (24°75′ N and 90°50 ′ E), at the elevation of 18m above the sea level between March 2017-December 2018

Materials of the experiments

Three morphotypes of *Hibiscus sabdariffa* var. sabdariffa were green plant with green calyx characterized by WC, light red plant with light red calyx by LRC; and deep red plant with deep red calyx by DRC. Leaves and capsules were harvested during November-January when the temperature (18-27°C) is conducive to the maturation of leaf and calyx and the physiological maturation of the capsule. Fresh and oven-dried leaves and calyces of Roselle were taken for the experiment.

Establishment of crops

Seeds of the three morphotypes were collected from the previous experiment in the field laboratory of the Crop Botany Department. Seeds were hand sown in April 2017 maintaining spacing of 1m × 1m in plots of each 4m × 4m size following Randomized Complete Block Design with three replications. Standard cultural practices were carried out (Chowdhury, 2012)

Experimental data collection

Morphological traits and biomass yield at five months after planting

Three plants of each of the three morphotypes were selected randomly for morphological study. Plant height, stem base perimeter (perimeter was measured at 12 cm above the ground level of the stem), number of branches plant^{-1}, fresh weight of leaf and stem plus branch; the fresh and oven-dry weight of leaf and other plant parts of three plants in three morphotypes were recorded.

Morphological traits and capsule yield at seven months after planting

Five plants of each of the three morphotypes were randomly selected for morphological traits and capsule yield. Plant height, stem base perimeter, number of effective and ineffective branch plants (effective branch: contained at least one capsule; ineffective branch contained no capsule), total nodes plant^{-1}, number of capsule plant^{-1}in the main stem and primary branch, capsule weight plant^{-1}, calyx plus epicalyx fresh and sundry weight, average height and perimeter of the capsule, mean fresh and sundry weight of capsule of three plants in three morphotypes were recorded.

Categorization of capsules on basis of their calyx quality

Capsules were harvested at physiological maturity following Choudhury (2012) from three morphotypes of Roselle. Capsules of each morphotype were classified into three categories (Primier, Standard, and Good) on basis of their calyx quality.

Calyx shelling ratio and dry matter determination

Calyces of the three morphotypes were processed like above. One kg capsule of each of the morphotypes was separated into calyx and ovary and weighed out.

The shelling ratio (SR) was calculated as follows:

% SR= (Fresh wt. of calyx from 1 kg capsule / Fresh wt. of 1 kg capsule) × 100. Dry matter (DM) of leaf and calyces (at PM) were determined from fresh samples in quadruplets in three morphotypes.

RESULTS

Morphological characteristics at three months after planting

Various types of morphological traits like plant height, root length, stem base perimeter, number of effective branches, capsule number, and fresh and dry weight of plant parts (root, capsule, and leaves) varied significantly in the three Roselle morphotypes at three months (Table 1). Plant height in WC, LRC, and DRC was similar (av. 60.93 cm) and not significant. Root length and stem base perimeter were found higher in WC (13.80 cm and 3.28 cm, respectively) and lower in LRC (9.20 cm and 2.38 cm, respectively) than in DRC (11.14 cm 2.82 cm, respectively). But DRC produced a maximum number of the effective branch (7.20 plant^{-1}) than in WC and LRC (av. 5.70 plant^{-1}) where the ineffective branch number is more or less similar in three morphotypes (av. 2.78 plant^{-1}). However, a maximum number of nodes and mature capsules in the primary branch were found higher in WC (43.20 plant^{-1} and 3.60 plant^{-1}, respectively) than in WC and LRC (av. 24.10 plant^{-1} and av. 0.7 plant^{-1}, respectively). But DRC carried a maximum number of immature capsules both in the primary branch and main stem (av. 2.20 plant^{-1}).

Biomass yield at three months after planting

The fresh and dry weights of plant parts (root, capsule, and leaf) varied significantly in the three Roselle morphotypes at three months. DRC had higher performance both for root fresh and dry weight (20.34 g and 6.90 g, respectively) than WC and LRC (16.06 g and 4.69 g, respectively). Capsule fresh weight and calyx dry weight were also found higher in DRC (152.10g and 6.35g, respectively) than in WC and LRC (117.08g and 4.78g, respectively). However, leaf fresh weight was more or less similar and high in DRC and LRC (65.54g and 70.55g, respectively) than in WC (40.30g). Leaf dry weight (av. 6.77g) was found similar in three morphotypes and it was non-significant. Among these three morphotypes, DRC showed the best performance for biomass yield five months after planting.

Morphological characteristics and biomass yield at five months after planting

Morphological traits (plant height, stem base perimeter, number of effective branches), fresh and dry weight of plant parts (leaf, stem, and branches) varied significantly in the three Roselle morphotypes (Table 3). The plant was taller in LRC (114.00 cm) but produced fewer branches (3.0 plant^{-1}) than in DRC and LRC (plant height 92.67 cm and 76.33 cm and several branches plant^{-1} 6.0 and 4.0, respectively). The stem base perimeter (4.30 cm) is also higher in LRC. However, fresh total biomass yield was higher in DRC and LRC (201.30 g and 189.59 g per plant, respectively) while dry biomass yield was higher in DRC (37.60 g plant^{-1}) than LRC and WC (34.98 and 27.41 g plant^{-1}, respectively).

Capsule and calyx yield in main stem and branch

Capsule yield and calyx yield were significant in three Roselle morphotypes (Table 4). In the main stem, capsule and calyx fresh weight was found higher in DRC (av. 45.29 g plant^{-1}) than in LRC (av. 29.44 g plant^{-1}) and WC (av. 26.83 g plant^{-1}). Calyx dry weight was noticed maximum in DRC (2.76 g plant^{-1}) than in LRC & WC which showed more or less similar results (av. 154 g plant^{-1}). Similar results were found in the primary branch. DRC showed better performance for capsule & calyx fresh and (1292.09 g plant^{-1} and 581.44 g plant^{-1}, respectively). Dry matter content of calyx (%) in WC, LRC, and DRC was similar (av. 10.15%) and not significant. This indicated higher capsule and calyx fresh weight were found in DRC.

Total capsule and calyx yield of a single plant of three roselle morphotype

On average, 343.33 capsules were obtained from a single plant of DRC and which was greater than LRC (170.66) and WC (133.66). DRC produced a greater capsule weight (2227.77 g plant^{-1}) than the other two (av. 907.28 g plant^{-1}). And shelling ratio was also found higher in DRC (43.03 %) than in WRC (39.36 %) and LRCD (34.68 %). This indicated higher capsules number and weight were found in DRC.

Capsule yield and shelling ratio on basis of the quality of three morphotypes of roselle

Capsule yield and shelling ratio were significant in all types of capsule quality in three morphotypes of Roselle (Table 6). Calyx dry weight and shelling ratio (%) was higher in premier type capsules (av. 39.43%) than standard and good in all morphotypes (av. 37.56 % and av. 35.31 %, respectively). Among these three morphotypes, DRC showed the best performance for dry weight and shelling ratio (%) (av. 20.25 g and av. 41.05 %, respectively) where LRC produced a lower amount (av. 17.13 g and av. 33.85 %, respectively). However, calyx yield and shelling ratio was the best in premier than in standard and good quality capsules in all three morphotypes.

Table 1. Morphological traits and biomass yield of three morphotypes (White calyx, WC; Light red calyx, LRC and Deep red calyx, DRC) in Roselle (*Hibiscus sabdariffa* var. sabdariffa) at three months after planting

Morphotype	Plant Height (cm)	Root Length (cm)	Stem Base Diameter (cm)	Primary Branch			Main Stem			
				Effective Branch	Ineffective Branch	Nodes	Capsule		Capsule	
							Mature	Immature	Mature	Immature
WC	60.40	13.80a	3.28a	5.60b	3.20	43.20a	3.60a	1.00b	2.20b	1.00b
LRC	60.20	9.20c	2.38b	5.80b	2.40	21.20b	0.00b	0.60b	4.20a	0.80b
DRC	62.20	11.14b	2.82ab	7.20a	2.74	27.00b	1.40b	2.20a	2.60b	2.20a
Level of significance	NS	**	**	*	NS	**	**	*	*	*
$LSD_{0.05}$	6.61	1.806	0.478	1.30	0.773	6.60	1.66	1.08	1.41	1.07
CV (%)	7.44	10.88	11.61	14.43	19.07	14.86	68.41	58.55	32.20	54.77

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant

Table 2. Morphological traits and biomass yield of three morphotypes (White calyx, WC; Light red calyx, LRC and Deep red calyx, DRC) in Roselle (*Hibiscus sabdariffa* var. sabdariffa) at three months after planting

Morphotype	Root Fresh wt.(g)	Root Dry wt. (g)	Cap. fresh wt. (g)	Calyx fresh wt. (g)	Calyx Dry wt. (g)	Leaf fresh wt. (g)	Leaf Dry wt.(g)
WC	14.01c	3.80c	99.98c	41.21b	3.81c	40.30b	6.27
LRC	18.10b	5.58b	134.18b	60.26a	5.74b	70.55a	7.41
DRC	20.34a	6.90a	152.10a	65.95a	6.35a	65.54a	6.62
$LSD_{0.05}$	2.23	1.01	13.54	6.35		15.03	1.60
Level of significance	**	**	**	**	**	**	NS
CV (%)	8.75	12.72	7.21	7.80	6.67	17.52	16.22

** = Significant at 1% level of probability, NS = Not significant

DISCUSSION

Roselle (*Hibiscus sabdariffa* var. sabdariffa) is a subshrub of tropical and sub-tropical regions. The leaf, calyces, and seeds of Roselle have many important uses *viz*. vegetables, oils, refreshing drinks, and food preserves (Pen-kong et al., 2002) and for medicinal and health purposes (Islam, 2019, Delgado-vargas et al*.,* 2000). The tender stems, leaves, and calyces are used as a vegetable in the preparation of soups and sauces. The brilliant red color of flower calyces and their unique flavor makes valuable food products (Tsai et al., 2002). The calyces, stems, and leaves are acidic in taste. The leaves are emollient and are much used as a diuretic, refrigerant, and sedative (Anhwange et al., 2006). The calyces, boiled in water are used as a drink in bilious attacks. They are also used to reduce hypertension (Onyenekwe et al., 1999). The juice from the calyces is claimed to be a health-enhancing drink due to its high content of vitamin C, anthocyanins, and other antioxidants (Mohamad et al., 2002). In China, it is used to treat hypertension, pyrexia, and liver damage, and in ayurvedic medicine (Odigie et al., 2003; Tseng et al., 2000). The seeds contain 17.8–21% non-edible oil (Ahmed, 1980) and are sometimes used for animal feed (Ahmed and Nour, 1981). Roselle is a good source of lipid-soluble antioxidants, particularly γ-tocopherol (Mohamed et al., 2007).

Plant morphological characteristics (plant height, stem base perimeter, number of effective branches), fresh and dry weight of plant parts (leaf, stem, and branches) are very much important for calyx production in Roselle. Capsule yield varies from morphotype to morphotype. These three morphotypes did not show a significant difference in plant height at three months. But LRC showed a maximum height (114.00 cm) five months after planting (Table 1). Generally, growth was very slow at the earlier stage, rapid and linear at the intermediate, and reached a plateau at maturity (Fakir et al, 2012). Stem base perimeter was found high in WC at three months but became high in LRC at five months. However, DRC showed better performance for a maximum number of effective branches both at three months and five months (7.20 $plant^{-1}$ and 6.0 $plant^{-1}$, respectively) (Table 1 and Table 3) than WC and LRC. Similar results were obtained from the UKMR-2 variety (like with DRC) of Roselle (Osman et al., 2011). But maximum nodes number was found in WC where DRC carried a maximum number of immature capsules both in the primary branch and main stem (av. 2.20 $plant^{-1}$) (Table 1). These all indicated the better performance of DRC. DRC had higher performance both for root fresh and dry weight (20.34 g and 6.90 g, respectively) than WC and LRC (Table 2).

Table 3. Morphological traits and biomass yield at five months after planting of three morphotypes (White calyx, WC; Light red calyx, LRC and Deep red calyx, DRC) in Roselle (*Hibiscus sabdariffa* var. sabdariffa)

Morphotype	Plant height (cm)	Stem base diameter (cm)	Branch Per plant (No.)	Fresh Biomass yield (g/plant)				Dry Biomass Yield (g/plant)			
				Stem & branches	Young leaf	All other leaves	Total	Stem & branches	Young leaf	All other leaves	Total
WC	76.33 c	3.80 b	4.00 b	65.55 b	15.62 b	59.60 b	140.77 b	16.27 b	2.16 b	8.98 c	27.41c
LRC	114.00 a	4.30 a	3.00 c	102.24 a	16.79 b	70.56 ab	189.59 a	20.29 a	2.38 b	12.31b	34.98 b
DRC	92.67 b	3.83 b	6.00 a	93.20 a	21.85 a	86.25 a	201.30 a	20.43 a	3.07 a	14.10 a	37.60 a
$LSD_{0.05}$	10.791	0.386	0.802	13.612	3.294	16.952	18.081	2.462	0.336	1.235	2.011
Level of significance	**	*	**	**	**	*	**	**	**	**	**
CV (%)	5.05	4.31	8.16	6.90	8.02	10.36	4.50	5.71	5.86	4.61	2.65

** = Significant at 1% level of probability, * = Significant at 5% level of probability

Table 4. Capsule and calyx yield and shelling ratio in main stem and branch of three morphotypes during harvesting time in Roselle (Hibiscus sabdariffa var. sabdariffa)

Morphotype	Capsule yield in the main stem			Capsule yield in primary branch		
	Capsule fresh wt. (g)	Calyx fresh wt. (g)	Calyx dry wt. (g)	Capsule fresh wt.(g)	Calyx fresh wt. (g)	Calyx dry wt. (g)
WC	37.13b	16.52b	1.49b	811.40b	313.31b	10.27c
LRC	43.53b	15.35b	1.58b	1003.44b	356.29b	10.15c
DRC	63.12a	27.45a	2.76a	1292.09a	581.44a	10.04c
$LSD_{0.05}$	6.63	3.63	0.468	251.00	94.15	0.444
Level of significance	**	**	**	**	**	NS
CV (%)	9.49	13.19	16.49	16.62	15.48	3.00

** = Significant at 1% level of probability, NS = Not significant

Table 5. Total capsule yield ofthree morphotypes in Roselle (*Hibiscus sabdariffa* var. sabdariffa) plant during harvesting time in three morphotypes of Roselle (*Hibiscus sabdariffa* var. sabdariffa)

Morphotype	Capsule/plant (No.)	Fresh Capsule wt./plant (g)	Shelling Ratio (%)
WC	133.66b	855.96b	39.36b
LRC	170.66b	958.59b	34.68c
DRC	343.33a	2227.77a	43.03a
$LSD_{0.05}$	76.94	244.70	2.88
Level of significance	**	**	**
CV (%)	15.72	8.01	3.26

** = Significant at 1% level of probability

Capsule fresh weight, calyx fresh, and dry weight were also found higher in DRC both in the early stage and mature stage of plants (Table 2 and Table 4). The same result was concluded by another scientist named Osman where the UKMR-2 variety (like DRC) showed the best performance for fresh calyx weight when compared to the other varieties (Osman et al., 2011). However, leaf fresh weight was more or less similar and high at three months in DRC and LRC but both leaf fresh and dry weights were found higher in DRC at five months after planting (Table 2 and Table 3). However, total fresh biomass yield was not significantly differed in DRC and LRC but dry biomass yield was found higher in DRC (37.60 g $plant^{-1}$) than in LRC and WC (Table 3). But scientist Mara concluded African Green Roselle yielded the highest dry weight of stem and branches (Mara et al., 2020). This variation may be attributed due to genetics as well as to environmental and cultural practices (Bety et al., 2021). There were some findings in our experiment that each plant had higher fruits number and weight in DRC (343.33 number $plant^{-1}$ and 2227.77 g $plant^{-1}$; respectively) than WC and LRC (av. 152.16 number $plant^{-1}$ and av. 907.28 g $plant^{-1}$; respectively) indicating a good genetic variation (Table 5). And also, the shelling ratio (% calyx to capsule) was found high in DRC (43.03%). A similar conclusion was reported by scientist Osman. He found that UKMR-2 (similar to DRC) showed better performance for the number of fruits per plant (173) and weight of fruits per plant (2170.7 g) than other varieties. (Osman et al., 2011).

Table 6. Capsule and calyx yield and shelling ratio in three roselle morphotypes (*Hibiscus sabdarifa* var. sabdarifa) based on their quality by Bulk analysis

Morphotype	**Primer**				**Standard**				**Good**			
	Capsule Fresh wt.(g)	Calyx Fresh wt.(g)	Calyx Dry wt.(g)	Shelling ratio (%)	Capsule Fresh wt.(g)	Calyx Fresh wt.(g)	Calyx Dry wt.(g)	Shelling ratio (%)	Capsule Fresh wt.(g)	Calyx Fresh wt.(g)	Calyx Dry wt.(g)	Shelling ratio (%)
WC	500	195.02b	19.29b	39.00b	500	188.19b	18.70b	37.63b	500	177.84b	17.58b	35.57b
LRC	500	178.88c	18.29c	35.74c	500	170.13c	17.12c	34.02c	500	158.95c	16.00c	31.79c
DRC	500	217.79a	21.27a	43.56a	500	205.15a	20.30a	41.03a	500	192.92a	19.19a	38.58a
$LSD_{0.05}$	-	10.79	0.798	2.36	-	13.95	1.24	2.80	-	8.39	0.706	1.68
Level of significance	-	**	**	**	-	**	**	**	-	**	**	**
CV (%)	-	2.41	1.80	2.64	-	3.28	2.93	3.29	-	2.10	1.77	2.10

** = Significant at 1% level of probabilit

Capsule quality depends on physiological maturity (PM) when the capsule accumulates a higher amount of dry matter contents. After or before this stage capsule quality becomes deteriorates. On basis of their calyx quality in this experiment, we categorized capsules into three types. Type 1 (Primier) indicates the best capsule quality at PM with higher dry matter content and with no spot, no fungus infestation. Type 2 (Standard) indicates spotted and infested capsule and relatively immature capsule after or before the PM and type 3 (Good) indicates small size capsule with a lower amount of dry matter before or after PM. A harvestable portion of the flower i.e. magnitude of calyces to fruit (shelling ratio) was also important. The shelling ratio (% calyx to capsule), was higher in primier type capsules (av. 39.43%) than standard and good in all morphotypes (av. 37.56 % and av. 35.31 %; respectively) (Table 6). Our result found that primier type capsule was better than standard and good for higher dry matter content and shelling ratio in all three morphotypes indicating PM was the best period for capsule harvesting. Among these three morphotypes, in our result, DRC showed better performance for shelling ratio in all types of capsule quality in primier, standard and good (43.56 %, 41.03%, and 38.58%; respectively) than others (Table 6). The observed difference among these results could be attributed due to genetics as well as to environmental factors, such as nutritional contents in soil, irrigations, temperatures, etc.

CONCLUSION

Morpho-agronomic traits and yield characteristics of three morphotypes of roselle (Hibiscus sabdariffa L.), namely WC (white calyx), LRC (light red calyx), and DRC (deep red calyx) were evaluated in our study to gather additional attribute about the best morphotypes. Morphotypes under this study exhibited significant differences in plant characteristics. The DRC showed better performance in all studied parameters compared to other morphotypes. DRC showed better performance than other morphotypes for some parameters of plant characteristics (number of branches per plant, number of capsules per plant, total biomass yield, the weight of fresh capsule and calyx per plant, shelling ratio%), whereas in plant height and stem base diameter it showed lower performance. DRC for several capsules per plant (343.33), the weight of fresh capsule per plant (2227.77g), and shelling ratio (% calyx to capsule) (43.03%) showed the best performance among morphotypes. LRC morphotype for plant height (114.00 cm) and stem base diameter (4.30 cm) showed the best performance. All the varieties also showed significant differences in yield characteristics. In general, the DRC morphotype performed inferior compared to WC and LRC morphotypes.

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CONFLICT OF INTEREST

The authors declared that there is no conflict of research interest.

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