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Per se Performance and Variability in Dwarf Roselle Germplasm for Yield and Yield Attributing Traits

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Abstract

A research study was conducted with nine dwarf Roselle germplasm of *H. sabdariffa* var. *sabdariffa* at College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Hyderabad, Telangana State, India during first week, October, 2019 to 2nd week, January, 2020. The analysis of variance for yield and its contributing characters was found to be significant for all the characters. Based on mean performance, the Roselle accession SAS-14139-1 was the best performance for yield, number of fruits per plant and plant height. Seven accessions produced green calices with red tinging, which are having good demand in the market. Good amount of genetic variability was associated with the germplasm for majority of the characters. Significant differences ($p<0.05$) were observed for yield characters of the accessions. This is an indication that there is a store of genetic variability that can be exploited for the improvement of Roselle in India. There was also pronounced variation in yield and other morphological parameters, suggesting the possibility of evolving higher yield variants of Roselle through proper selection. High heritability was registered with plant height, number of branches per plant and fruit yield per plant. The present study identified agronomically better germplasm for yield exploitation coupled with high heritability characters for future varietal development and use as parents in further breeding programmes in Roselle, a future reliable vegetable crop.

Keywords: Dwarf Roselle, *sabdariffa*, genetic variability, yield, quality, *Per se* performance

1. Introduction

Hibiscus sabdariffa L., Roselle, an annual herbaceous shrub belongs to the family Malvaceae (Hutchinson and Dalziel, 1958). Roselle is an important annual crop which grows successfully in the tropics and sub-tropics (Cobley, 1975, El Naim et al., 2012). Their young succulent leaves contain nutrients such as phosphorus, calcium, magnesium, and potassium, anti- oxidants (El Naim et al., 2012, Balarabe et al., 2019, Mokhtari et al., 2018, Naeem et al., 2019.). The fleshy calyces of the plant are used in various countries in India, Africa and the Caribbean as food or food ingredient in jellies, syrups, beverages, puddings, cakes, and wines

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[Cobley,1975, Salami and Afolayan, 2021). The seeds of this species are known to be rich in fatty acids (Fifa et al., 2020), Roselle oil is used as bio-diesel blend on four stroke engines (Sahu et al., 2020).

It is highly self pollinated member of the family malvaceae. Two botanical types of roselle, namely *H. sabdariffa var. altissma* and *H. sabdariffa var. sabdariffa* (Wilson and Menzel, 1964). The first grown for its phloem fiber and the second for its fleshy, shiny-red calyxes which are usually extracted in hot or cold water and consumed as a beverage. Roselle in India is gaining importance in the manufacture of many small industries, e.g. cosmetics, sweets, sauces, jams, and jellies and a substitute for tea and also used as a coloring material for food (Schippers, 2000; Galaudu, 2006, Maria et al., 2017). It is also used in medicine, especially with problems related to the digestive tract (El Naim et al., 2012). On consumption of roselle, even reduce nutritional deficiency problems such as rickets, scurvy and night blindness (Salami and Afolayan, 2020a). The colour extract from the dry calyces has potential as a natural colourant to replace red synthetic colouring agents in foods, drinks and pharmaceutical preparations. This extract is rich in anthocyanin and is therefore also a potential source of natural colourant for the manufacture of jams, juices, wines, carbonated soft drinks (Salami and Afolayan, 2020b) and other acidic foods. The recent increased preference for food colouring materials of natural origin has led to substantial increases in its production. Seed contains a substantial amount of oil that resembles cotton seed oil and is found to have high antioxidant capacity and strong radical-scavenging activity (Gomez and Gomez, 1984). In India, the crop is extensively cultivated in many parts as a leafy vegetable and its fleshy fruits.

Estimating variability in a population is an effective tool for the breeder to design the selection procedures more accurately for identifying superior genotypes. Genotypic coefficient of variation would be a useful tool for the assessment of variability, since it depends upon the heritable portion of the total variability (Allard, 1960). Heritability estimates give a measure of transmission of characters from one generation to another. It is useful in selection of elite genotype from diverse genetic population. Johnson et al. (1955) reported that heritability along with genetic gain is more useful than the heritability alone, in predicting the resultant effect for selecting the best individuals.

Vegetable Roselle is largely underutilized and underexploited leafy vegetable crop. It has received no attention; not much research has been carried out on its genetic improvement, either. Little is known about its genetic potential, and variability, which are supposed to be large when considering its wide geographical distribution. Most breeding of Roselle has been for its fiber yield. Roselle is endowed with a rich reservoir of genetic variability for various yield components, adaptation and quality traits (El Tahir and El Gabri, 2013, Pidigam Saidaiah et al., 2021 in vegetable cowpea). Several studies were done on genetic potential (Ibrahim and Hussein, 2006; Ibrahim et al., 2013; Sabiel et al., 2014) and genetic variability of Roselle for calyx production as a seasonal crop (Sasmal and Chakraborty, 1977, Ibrahim and Hussein, 2006; Ahmed et al., 2009; Atta et al., 2011; Sabiel et al., 2014, Hari Satyanarayana et al., 2017, Hanafiah et al., 2019). Unfortunately, in India, there are very few commercial cultivars available for commercial cultivation to the farmers after assessing their stability (Saidaiah et al., 2021a, b). The main aim of this paper is to identify and assess accession(s) with superior agronomic performance suitable for adoption by Roselle farmers in India and accessions with unique features useful for the Roselle breeding programme.

2. Materials and Methods

The investigation was carried out at the Research Block, College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Hyderabad, Telengana State, India during first week, October, 2019 to 2nd week, January, 2020. The farm is situated geographically at latitude of 17.19° N, longitude of 79.23° E and a altitude of 542.3 m above mean sea level under Southern Telangana Agro Climatic Zone of Telangana. The experiment was laid out nine genotypes of tomato in Randomized Block Design (RBD) with three replications. Each germplasm line was grown in a plot of 1.8×3.15 m^2 with 21 plants $plot^{-1}$ $replication^{-1}$, three rows with 7 plants row^{-1} with spacing of 90×60 cm^2. All the recommended cultural practices were followed. Deep ploughing was before roselle seed is sown in the soil. One tonne of well decomposed farm yard manure was applied at the time of land preparation itself. Within 45 days after seeding, manual weeding was practiced. Acephate @ 1.5 g l^{-1} of water was sprayed to prevent damage to the crop by sucking pests. Five randomly selected equally competitive plants from each row in each replication were tagged for the purpose of recording the observations on seven characters viz. *viz*., plant height (cm), number of branches per plant, days to 50% flowering, number of fruits $plant^{-1}$, average fruit weight (g), 1000 seed weight (g) and fruit yield $plant^{-1}$ (g). The data were analyzed by the methods of Cochran and Cox (1957) using mean values of random plants in each replication from all genotypes to determine significance of genotypic effects. Genotypic and phenotypic coefficients of variation were calculated using the formulae of Burton (1953). Broad sense heritability was calculated as per Lush (1940) and genetic advance estimated by the method of Johnson et al. (1955). Categorization of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and genetic advance (GA) were done as per Sivasubramanyam and Menon (1973).

3. Results and Discussion

The analysis of variance for yield and its contributing characters understudy are presented in Table 1. The mean sum of squares for genotypes was found to be significant for

Table 1: RBD ANOVA of nine genotypes of Roselle for yield and yield attributes

Sl. No.	Character	Mean sum of squares		
		Replications (df=2)	Genotypes (df=8)	Error (df=16)
1.	Plant height (cm)	139.82	365.26**	77.65
2.	No. of branches plant^{-1}	2.33	25.08**	2.83
3.	Days to 50% flowering	150.04	40.26**	18.37
4.	No. of fruits plant^{-1}	616.78	454.08**	229.90
5.	Weight of the fruit (g)	1.56	2.02**	0.73
6.	1000 seed weight (g)	7.26	18.29**	9.38
7.	Fruit yield plant^{-1} (g)	370.04	5996.79**	148.45

**: Indicates (p=0.01) level of significance

all the characters *viz*., plant height (cm), number of branches plant^{-1}, days to 50% flowering, number of fruits plant^{-1}, average fruit weight (g), 1000 seed weight (g) and fruit yield plant^{-1} (g).

3.1. Mean performance of genotypes of Roselle for yield and yield attributes

Among the nine germplasm (Table 2), SAS-14139-1 was tallest with 139.67 cm height. More is the height, more number of fruits and leaves are produced. Hence, it's always desirable to have taller plants or realizing more yields. SAS-14139-1 can be utilized in breeding programmes for yield improvement. SAS-14153 (106 days) was earliest to flower. To fit into, multiple cropping systems, duration of crop should be completed early.

Number of branches per plant always has positive bearing on yield. With respect to number of branches for plant, germplasm SAS-14186 produced highest number of branches (16.33). SAS-14139 (84) followed by SAS-14186 (79.67), SAS-14139-1 (78.33) and SAS-14154 (76.33) produced more fruits per plant.

Highest average fruit weight was performed by PSH03 (10.33 g), indicating there is positive alleles in this genotype for yield, which is a polygenic character. Another yield contributing character is seed weight. High yielding varieties are always accompanied with more seed weight. The 1000 seed weight was higher in the accession PSH03 (28 g) followed by SAS-14153 and SAS-11424 with 27.67 g each (Figure 1).

Table 2: Mean performance of nine genotypes of Roselle for yield and yield attributes

Sl. No.	Germplasm	Plant height (cm)	Days to 50% flowering	No. of branches plant^{-1}	No. of fruits plant^{-1}	Average weight of the fruit (g)	Test weight (g)	Fruit yield plant^{-1} (g)
1.	SAS-11424	125.00	118.33	10.67	60.00	7.67	25.00	236.67
2.	SAS-14139	121.00	112.00	8.33	84.00	9.00	18.00	231.67
3.	SAS-14139-1	139.67	111.67	14.00	78.33	8.17	24.33	345.00
4.	SAS-14153	101.67	106.00	8.67	51.67	9.83	27.67	292.00
5.	SAS-14154	105.67	110.00	13.00	76.33	8.50	22.00	221.67
6.	SAS-14186	118.33	109.00	16.33	79.67	9.17	21.00	253.00
7.	PSH01	121.67	114.33	9.00	51.67	8.50	28.00	242.33
8.	PSH02	115.00	115.00	9.67	63.33	9.00	27.67	207.00
9.	PSH03	115.67	110.00	8.33	63.00	10.33	24.67	205.33
	SEm±	5.09	2.47	0.97	8.75	0.49	1.77	7.03
	CD (p=0.05)	15.25	7.42	2.91	26.24	1.48	5.30	21.09

Yield per plant is the ultimate indicator of variety acceptance by the farmer. SAS-14139-1 performed best among all the nine Roselle accessions with a production of 345 grams of fruits. Elsadig and Ibrahim, 2013 reported the similar reports for yield and its characters in Roselle genotypes.

The Roselle accession, SAS-14139-1 (Figure 2) was the best performance for yield, number of fruits per plant and plant height among all the genotypes studied. Hence, it should be tested further among locations and seasons for possible release for commercial cultivation to the farmers for yield exploitation. Similar results are reported earlier (Pidigam et al., 2019 in yardlong bean and Saidaiah et al., 2021a and 2021c in vegetable cowpea and tomato).

3.2. Assessment of quality characters

Out of the nine Roselle *sabdarifa* sub-species (Table 3), seven accessions *viz*., SAS-11424, SAS-14139, SAS-14139-1, SAS- 14186, PSH01, PSH02 and PSH03 have dark red colour

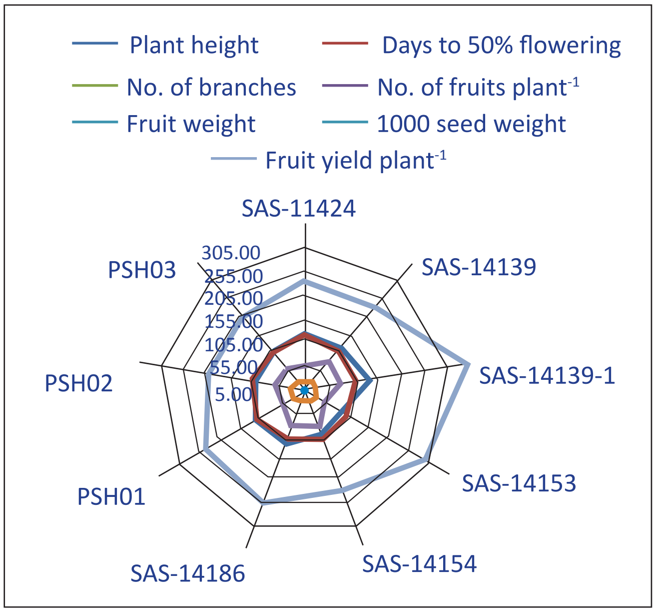

Figure 1: Mean performance of Roselle genotypes for yield related traits

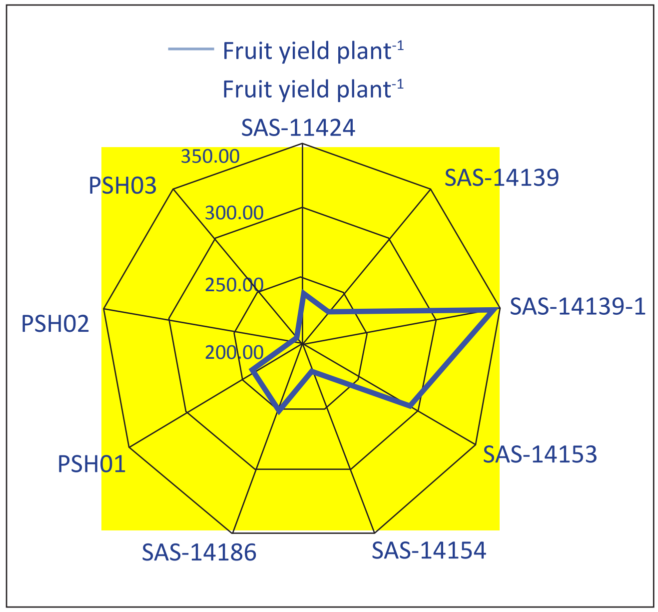

Figure 2: Mean performance of 9 Roselle genotypes for yield plant^{-1}

Table 3: Quality characters of nine genotypes of Roselle

Sl. No.	Germplasm	Stem colour	Fruit colour	Calyx colour	Plant stature
1.	SAS-11424	Dark red	Dark red	Green with red	Dwarf
2.	SAS-14139	Dark red	Dark red	Green with red	Dwarf
3.	SAS-14139-1	Dark red	Dark red	Green with red	Dwarf
4.	SAS-14153	Light green	Light green	Green	Dwarf
5.	SAS-14154	Light green purple spots	light green	Green	Dwarf
6.	SAS-14186	Dark red	Dark red	Green with red	Dwarf
7.	PSH01	Dark red	Dark red	Green with red	Dwarf
8.	PSH02	Dark red	Dark red	Green with red	Dwarf
9.	PSH03	Dark red	Dark red	Green with red	Dwarf

stem and fruit. While SAS-14153 had light green colour stem and fruits, whereas SAS -14154 had light green colour stem with purple spots an its stem was light green colour.

Out of the nine accessions, seven accessions *i.e*., SAS-11424, SAS-14139, SAS-14139-1, SAS-14186, PSH01, PSH02 and PSH03 had green colour calices with random red strings, whereas SAS-14153 and SAS-14154 produced complete green calyces. For industrial purpose, red colour calices are preferred. So, accessions with red colour calices with yield potential can be selected for further testing for their genetic potential for yield.

3.3. Estimation of genetic variability of traits

In order to improve a population, the assessment of phenotypic and genotypic variability is of great importance to apply efficient selection method. This is because selection of favorable genotypes for certain characters depends on the amount of variation existing in the material under investigation. Such variation can be assessed by estimating its different components. In addition, the relative magnitude of these components determines the genetic properties of population, which is accomplished by estimating the role of heredity versus environment in determining the phenotype.

Keeping the above in view, the nine accessions were studied for the simple measures of variability like range and the major components of variability such as phenotypic and genotypic coefficients of variation (PCV and GCV), heritability in broad sense (h^2_{bs}), genetic advance and genetic advance as % of mean and are presented in Table 4. All the seven characters under study exhibited high variability as evident from the estimates of range, coefficients of variation, heritability and genetic advance. Wide range of variability was observed for plant height (101.67 cm-139.67 cm), number of fruits plant^{-1} (51.67-84), average fruit weight (7.67 g-10.3 g), 1000 seed weight (8 g-28 g) and fruit yield per plant (205.33 g-345 g). Significant differences (p<0.05) observed for yield and its

Table 4: Genetic variability parameters of nine genotypes of Roselle for yield and yield attributes

Variability parameter	Plant height (cm)	Days to 50% flowering	No. of branches plant^{-1}	No. of fruits plant^{-1}	Weight of the fruit (g)	1000 seed weight (g)	Fruit yield plant^{-1} (g)
Range	101.67-139.67	106-118.33	8.33-16.33	51.67-84	7.67-10.33	8-28	205.33-345
Environmental variance (Ve)	77.65	18.37	2.83	229.90	0.73	9.38	148.45
Genotypic variance (Vg)	95.87	7.30	7.42	74.73	0.43	2.97	1949.44
Phenotypic variance (Vp)	173.52	25.67	10.25	304.63	1.16	12.35	2097.90
Genotypic coefficient of variation (GCV %)	8.00	2.00	25.00	13.00	7.00	7.00	18.00
Phenotypic coefficient of variation (PCV %)	11.00	5.00	29.00	26.00	12.00	14.00	18.00
Heritability (H_2 %)	55.00	28.00	72.00	25.00	37.00	24.00	93.00
Genetic advance (GA)	14.99	2.97	4.77	8.82	0.82	1.74	87.68
GA percent of mean (GAPM)	13.00	3.00	44.00	13.00	9.00	7.00	35.00

attributes of the accessions studied. This is an indication that there is a store of genetic variability that can be exploited for the improvement of Roselle. The presence of pronounced variation in yield and associated parameters, suggested the possibility for development of higher yield variants of Roselle through proper selection. Ibrahim and Hussein, 2006 detected significant differences among genotypes for plant height, number of branches and seed weight. In general, estimates of phenotypic variances were higher than their respective genetic ones for all the parameters studied. This result reveals that a large proportion of the phenotypic variance for such traits was due to environmental effects, so selection for these traits will be ineffective and solely would be very low (Elsadig and Ibrahim, 2013).

Plant height (Table 4) was recorded with high phenotypic and genotypic variances of 95.87 and 173.52 respectively, coupled with moderate PCV and GCV of 8 and 11 per cents, respectively. This trait showed moderate heritability (55%), high genetic advance (14.99) and high GA as % mean (13%). Days to 50% flowering showed low phenotypic and genotypic variances (25.67 and 7.30 respectively) with less PCV (5%) and GCV (2%). Less heritability (28%), less genetic advance (2.97) and low GA as per cent mean (3) estimates were recorded for this trait. Number of branches per plant recorded low phenotypic and genotypic variances of 10.25 and 7.42 respectively with high PCV (29%) and GCV (25%). The high heritability (72%), low genetic advance (4.77) and high GA as per cent mean (44) were also reported for this trait. Number of fruits per plant showed high phenotypic and genotypic variances (304.63 and 74.73, respectively) with high PCV (26%) and GCV (13%). Moderate heritability (25%), low genetic advance (8.82) and moderate GA as per cent mean (13) estimates were recorded for this trait. With respect to weight of the fruit (g), low phenotypic (1.16) and less genotypic (0.43) variances, low PCV (12%) and low GCV (7%), moderate heritability (37%), low genetic advance (1.74) and low GA as % of mean (9).

Low phenotypic and genotypic variances (12.35 and 2.97) along with low PCV (14%) and GCV (7%) were recorded for 1000 seed weight. The character also showed very low heritability (24%), low genetic advance (1.74) as well as low GA as per cent mean (For fruit yield per plant, very high phenotypic and genotypic variances (2097.90 and 1949.44) were recorded in Roselle genotypes with low PCV and GCV (18%). Fruit yield per plant also showed high heritability (93%) but very high genetic advance (87.68) and high GA as per cent mean (35). The present results are in line with the earlier reports of Hari Satyanarayana et al., 2017. Falconer, 1980 concluded that more variable condition reduce heritability, whereas uniform conditions increase it. The low heritability days to 50 per cent flowering, number of fruits per plant and 1000 seed weight is due to the fact that it depends on many components which are greatly influenced by environment. Similar results are pointed out by Louis et al., 2013, Sasmal and Chakraborty, 1977, Dutta et al., 1973 and Mostofa et al., 2002, Elsadig and Ibrahim, 2013, Pidigam et al., 2019.

Except for yield per plant, all the other parameters studied tested for low values of genetic advance. This result indicates that the genetic advance from selection for a trait depends on the amount of genetic variability of such traits. Similar conclusions have been drawn by Wong and Baker, 2006 and Saidaiah et al., 2011.

However, the association of the genetic advance and heritability does not follow the same pattern as that between genetic advance and genotypic coefficient of variation. Increase in heritability value was not always accompanied with increase in genetic advance. Similar results were obtained by Gasim and Khidir, 1998 and Elsadig and Ibrahim, 2013, but high heritability with high genetic advance were observed in yield per plant, whereas high heritability with low genetic advance was detected in number of branches per plant and plant height. The nature of association between heritability and genetic advance was explained by Panse, 1957, who reported that the association of high heritability with a high genetic advance is an indication of additive gene effects and consequently a high genetic gain from selection could be expected. On the other hand, the association of low heritability with low genetic advance is an indication of non-additive gene effects and consequently, a low genetic gain, would be expected from selection. However, Johnson et al., 1955 stated that heritability does not provide an actual measurement of the amount of genetic variation, as the magnitude of heritability depends on the degree of association between the genotypic and phenotypic variances regardless of being high or low, while the genetic gain depends on the amount of genetic variability. Similar ideas were expressed by Allard, 1960.

4. Conclusion

The Roselle accessions SAS-14139-1 (dark red fruits) and SAS-14153 (light green fruits) were the better performers for yield. Wide range of genetic variability was associated plant height, followed by number of fruits per plant and average fruit weight. Fruit yield plant^{-1} showed high heritability and GAM revealing it's governed by additive gene effects. The identified germplasm SAS-14139-1 and SAS-14153 can be used for new varietal development and use as parents in further breeding programmes in Roselle in India.

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