ASSOCIATION OF AGRONOMIC CHARACTERS IN *CURCUMA AERUGINOSA* ROXB. (PINK AND BLUE GINGER)

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ABSTRACT *Curcuma aeruginosa Roxb., belonging to the family Zingiberaceae is an underutilized, wild starchy tuber crop credited with several pharmaceutical potentialities and food values. Studies on the genetics of the agronomic characters of Curcuma aeruginosa are very sparse and no experiments on the association of agronomic characters have been reported. In this context character association of fifteen major growth and yield characters of this species has been carried out presently with the aid of factor analysis by means of principal component analysis. Sixty eight genotypes of Curcuma aeruginosa collected from various locations of different districts of Kerala state of India formed the material for the study. Factor analysis resulted in the grouping of the fifteen agronomic characters into four factors based on positive factor loading. Characters having higher factor loading could be regarded as lead characters and the present study showed that number of primary fingers, number of tillers, length of secondary fingers and number of leaves per tiller with higher factor loadings constitute the lead characters in this species and while practicing selection and further crop improvement in Curcuma aeruginosa these characters should be given priority so that the bulk of characters for analysis could be reduced without affecting the outcome of research.*

Keywords: *Curcuma aeruginosa Roxb., agronomic characters, character association, factors, lead characters.*

INTRODUCTION

Wild plants have sustained human population in each of the inhabited continents and the use of them has been documented from antiquity to the current era (Khyade *et al*., 2009). The use of wild edible plants is an age old practice and the diversity in them provides diversityto family diet and also accounts for household food security (Radha *et al*., 2013). Popularizing the use of wild edible plants not only strengthens multifunctional agricultural policies for food and livelihood security and environmental sustainity in rural areas but also helps in maintaining rural landscapes, biodiversity and cultural heritage. Assuring adequate food supply in rural areas is a major problem associated with the developing countries but the use of wild edible plants of such regions still remains an important but ignored aspect of food supply (Saha *et al*., 2014). The members of the family Zingiberaceae are well known for their multipurpose uses as medicines, spices, colouring agents, food and ornamentals. There exist several unexploited/underutilized taxa of wild edible plants, and many of them are new to the modern world and are not domesticated, and many of them are on the verge of extinction due to loss of habitats and other anthropogenic activities.

Curcuma aeruginosa Roxb., the so called "pink and blue ginger" is an aromatic, herbaceous, perennial, unexploited, wild starchy tuber crop of the family Zingiberaceae, is highly reputed for its edible and medicinal rhizomes. The rhizomes with pink tips and greyish blue or blue centres, and the leaves with purple or reddish brown patch along the sides on the distal half of the midrib on the upper side of the lamina which fades at maturity form the major identifying features of this species (Anonymous, 2011a; Sabu, 2006). The plant is a triploid, 2n=63 (Joseph *et al*., 1999) and forms one of the oldest named species of the genus *Curcuma* and the striking greenish blue colour of the rhizomes gives the specific epithet "*aeruginosa*" (Singh, 2011). It is a native of Myanmar and is widely cultivated in Malaysia and common occurrence is found throughout South East Asia. In India it grows in West Bengal, Bihar, Coromandal coast and South Karnataka and is fairly common in Kerala also (Sabu, 2006; Srivastava *et al*., 2006).

The plant is one of the most eminently used medicinal plants in Bangladesh, India, Myanmar, Indonesia, Malaysia and Thailand (Hossain *et al*., 2015). In South India the rhizomes are widely used for the extraction of East Indian arrowroot or Travancore starch (Sabu, 2006). 100g of the rhizome showed a caloric value of 86kcal, 76.8g moisture, 2.4 g protein, 0.4g fat, 18.3g of carbohydrate, 1.1g fibre, 1g ash, 0.02mg thiamine, 0.09mg riboflavin and 4.22mg ascorbic acid (Zanariah *et al*., 1997). The rhizomes are also eaten by some tribes (Sujatha and Renuga, 2013) and the starch extracted from the rhizome is used as a substitute for arrowroot (Ranjini and Vijayan, 2006; Sabu, 2006). It is an efficacious remedy for infantile diarrhoea and is

also recommended for children and invalids (Ranjini and Vijayan, 2005) and during the periods of famine, the starch is being used as a substitute for cassava and maize (Wardini and Prakaso, 2016).

The rhizome is being used as a medicine for asthma, cough, scurvy and mental derangement in peninsular Malaysia and for colic in Indo China. The rhizome forms a major ingredient of a decoction given to women after child birth to accelerate lochia. Due to the depurative activity of the rhizome, it has been used both internally and externally for the treatment of exanthema and also as poultice for treating itch. It has wild applications against obesity, rheumatism, etc. (Wardini and Prakaso, 2016). It is used as a natural herbal medicine to overcome appetite, skin diseases like scabies, rash and ulcers, stomach pains (colic), mouth sores, cough, shortness of breath and intestinal worms (Anonymous, 2011b).

Scientific attempts to study the genetics and the relation between major agronomic characters and thereby to practice crop improvement programmes have not been reported in this valuable species. Most of the agronomic characters of crop plants are polygenic in nature and the same is the case of this plant also. Such characters show different levels of association due to sharing of common genes. Further, study of association of characters is helpful in grouping of variables and data reduction so as to find out lead characters that can be useful in conducting breeding experiments. Under this perspective a study has been laid out in *Curcuma aeruginosa* Roxb. to analyze the association of agronomic characters using fifteen agronomic characters with the aid of factor analysis by means of principal component analysis so as to categorize the agronomic characters into different groups with maximum gene sharing and to identify the lead characters.

MATERIALS AND METHODS

The present experiment was conducted in the experimental plot of the Genetics and Plant Breeding Division of the Department of Botany, University of Calicut, Kerala, Indiaduring the first crop season of 2013-14 adopting standard agronomic practices.University of Calicut is located at 11^0 25'- 11^0 45' N latitude and 75^0 45'-75^0 50' E longitude in the Malappuram district of Kerala and enjoys humid tropical climate and good annual rainfall (Umamaheswari and Mohanan, 2011). Sixty eight genotypes of *Curcuma aeruginosa* Roxb. collected from different locations of the northern districts of Kerala viz. Kasaragod, Kannur, Wayanad, Kozhikode, Malappuram, Palakkad and Thrissur duringNovember-December 2012 formed the base material for the study. The experimental population, consisting of 3672 plants was raised in the first crop season of 2013 following standard cropping procedure. Fresh and disease free seed rhizome fingers of approximately 3cm - 5cm length and 25g - 30g weight were used as the planting material. The rhizomes were sown in 38cm x 35cm polybags filled with garden soil, sand and cow dung in 3:1:1 ratio. Irrigation was carried out once a day on all non-rainy days and weeding was done as and when required. 2g of N:P:K (18:18:18) was applied to each plant at monthly intervals starting from the 30th day of planting up to the 5th month of growth and the plants were harvested simultaneously after six months of growth.

The study used six growth characters such as plant height, number of tillers, number of leaves per tiller, leaf length, leaf breadth and leaf area, and nine yield characters such as number of primary fingers, number of secondary fingers, length of primary fingers, diameter of primary fingers, length of secondary fingers, diameter of secondary fingers, length of mother rhizome, diameter of mother rhizome and yield per plant. Observations on growth characters were made in the field after six months of maturity of the crop and those of yield characters after harvest of the rhizome. Leaf area was calculated graphically with the aid of conversion factor. Data analysis was carried out using factor analysis by means of principal component analysis (Sneath and Sokal, 1973) using the statistical software STATISTICA.

RESULTS AND DISCUSSION

Polygenic characters show different levels of association among them because of the influence of same sets of alleles on different characters. Grouping of such characters based on their association each other is an efficient tool not only for grouping of variables but also to reduce the inconvenience of handling the bulk of variables. It is carried out through the identification of lead characters from each group under study (Nikhila *et al*., 2008). Factor analysis is an efficient tool to determine character association, to group different variables into different factors and for data reduction by identifying lead characters. Grouping is carried out based on the extent of relative contribution of variance by a variable to each factor based on factor loading calculated for the purpose. Characters with higher factor loading could be considered as lead characters and based on this selection of promising genotypes could be easily practiced in such a way that other characters associated with the lead characters get automatically selected (Hrideek *et al*., 2008).

Fifteen agronomic characters of *Curcuma aeruginosa* studied could be grouped in to four factors based on positive factor loading (Tables 1-3). The first factor group was occupied by only one variable, the number of leaves per tiller. The second factor group consisted of five variables such as the number of tillers, number of primary fingers, number of secondary fingers, diameter of primary fingers and diameter of mother rhizome. The third factor group consisted of three variables namely, leaf breadth, length of secondary fingers and yield per plant are grouped under the third factor. Four characters namely plant height, number of leaves per tiller, length of primary fingers and diameter of secondary fingers were grouped under the fourth factor.

Table 1. Factor analysis in the case of *Curcuma aeruginosa* Roxb.- factor loadings

	Factors			
Characters	1	2	3	4
Plant height	-0.213274	-0.037373	-0.874589	0.092712
Number of tillers	-0.245954	0.617874	0.567924	-0.117544
Number of leaves per tiller	0.119810	-0.300063	-0.009320	0.854766
Leaf length	-0.415844	-0.813754	-0.324965	-0.038975
Leaf breadth	-0.415772	-0.739028	0.286110	-0.337015
Leaf area	-0.452719	-0.839967	-0.002040	-0.230857
Number of primary fingers	-0.444783	0.644550	-0.451514	-0.163666
Number of secondary fingers	-0.771929	0.385951	-0.283945	-0.103172
Length of primary fingers	-0.773438	0.122562	-0.050899	0.169746
Diameter of primary fingers	-0.767024	0.159298	0.114663	0.124356
Length of secondary fingers	-0.759607	-0.073481	0.312551	0.248852
Diameter of secondary fingers	-0.887083	-0.094690	0.142889	0.263041
Length of mother rhizome	-0.795810	-0.121686	-0.025280	-0.147575
Diameter of mother rhizome	-0.833245	0.293208	-0.091955	-0.046730
Yield per plant	-0.882500	0.041622	0.189039	0.036449

Number of primary fingers and number of tillers with the maximum factor loadings are considered as the lead characters in the second factor. Length of secondary fingers credited with the maximum factor loading constitutes the lead character in the third factor. Number of leaves per tiller constituted the lead character in the fourth factor. These lead characters could be given due consideration while conducting selection and other crop improvement programmes since the improvement of these lead characters will lead to the simultaneous improvement of the other characters associated with them. The characters leaf length, leaf area and length of mother rhizome didn't contribute any positive factor loading to any of the four factors identified.

Table 2. Factor analysis in the case of *Curcuma aeruginosa* Roxb- eigen values, percentages of total variance, cumulative eigen values and cumulative percentages of variance

Factors	Eigen value	% of total variance	Cumulative Eigen value	Cumulative % of variance
1	6.121655	40.81103	6.12165	40.81103
2	3.108785	20.72523	9.23044	61.53626
3	1.738160	11.58773	10.96860	73.12399
4	1.159547	7.73032	12.12815	80.85431

Table 3. Factor analysis in the case of *Curcuma aeruginosa* Roxb.- characters showing association as per factor analysis

Factors	Characters
1	Number of leaves per tiller
2	Number of primary fingers, number of tillers, number of secondary fingers, diameter of mother rhizome, diameter of primary finger
3	Length of secondary finger, leaf breadth, yield per plant
4	Number of leaves per tiller, diameter of secondary finger, length of primary finger, plant height

The percentage of variance contributed by the characters of the first factor is 40.81, that contributed by the characters of the second factor is 20.73, that contributed by the characters of the third factor is 11.59 and that contributed by the characters of the fourth factor is 7.73. These four factors cumulatively contribute 80.85% of the total variance of the present study population based on the characters studied (Table 2).

Factor analysis is an efficient tool to assess character association prevailing in crop plants and it has been widely used for grouping of variables by earlier investigators like Tadesse and Bekele (2001) in grasspea, Hrideek *et al*. (2006) in chilli, Radhakrishnan *et al*. (2004) and Hrideek *et al*. (2008) in small cardamom, Nikhila *et al*. (2008) in robusta coffee, Yol *et al*. (2010) in sesame, Denton and Nwangburuka (2011) in *Solanum anguivi* and Umamaheswari and Mohanan (2011) in *Vanilla planifolia*. Study of association of characters in different crops is an important approach in determining the relationship between quantitative morphometric characters of agronomically important plant species since such studies could provide genetic foundation for further breeding and improvement in such species.

CONCLUSION

Based on the present study the characters such as number of primary fingers, number of tillers, length of secondary fingers and number of leaves per tiller with higher factor loadings constitute the lead characters which could be given due consideration while practicing selection and further crop improvement in *Curcuma aeruginosa* so that the bulk of the characters for analysis could be reduced without affecting the outcome of research.

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