International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 11; November 2017; Page No. 7328-7331
DOI: http://dx.doi.org/10.24327/ijcar.2017.7331.1126

Research Article

FACTOR ANALYSIS IN *MARANTA ARUNDINACEA* L.

***Shintu P.V., Radhakrishnan V.V. and Mohanan K.V.**

Genetics and Plant Breeding Division, Department of Botany, University of Calicut, Kerala - 673 635, India

A R T I C L E I N F O

Article History:
Received 17th August, 2017
Received in revised form 29th September, 2017
Accepted 30th October, 2017
Published online 28th November, 2017

Key words:

Character association, factor analysis, *Maranta arundinacea* L., tuber, arrowroot

A B S T R A C T

Arrowroot (*Maranta arundinacea* L.) is a widely cultivated tuber crop for its easily digestible starch which finds use in the ayurvedic system of medicine as well as in the area of food industry. It has been widely distributed throughout the tropical countries. In spite of its varied economic importance, studies on the association of agronomic characters in the crop are very scanty. In this background, a study on the association of fourteen morphological and yield contributing characters of *Maranta arundinacea* was carried out in the Genetics and Plant Breeding Division, Department of Botany, University of Calicut, Kerala, India. Among the 14 characters studied, 9 characters were identified as having maximum influence on growth and yield of arrowroot.

INTRODUCTION

Agriculture is the corner stone of Indian economy, contributing about 29.1% towards GDP, forming 20% of exports and providing livelihood to 65% to 75% of the population. India has a major agribusiness sector, which has achieved extraordinary success over the last three and a half decades. One third of mankind today lives in an environment of relative abundance; while two third remains in poverty. In countries, especially where population growth is rapid, hunger and unhealthy diet are often critical problems. In the developing countries rapid population growth makes it hard for agricultural production to keep pace with the rising demand for food. Food security has always ranked top of the agenda of the Government of India, which has made concerted efforts to implement programmes in order to provide access to a basic nutritious diet to the poorest in the country (FAO, 2012). Agriculture is an important source of raw material for many agri-based industries. India's geography is special for agriculture because it provides many favourable conditions such as plain areas, fertile soil, long growing season and wide variation in climatic conditions. Apart from the distinct geographical conditions, India has been consistently making innovative efforts by using science and technology to increase agricultural production.

Roots and tuber crops occupy a remarkable position in the food security of the developing world due to their high carbohydrate content and calorific value. They form the third principal group of food crops in the world after cereals and grain legumes.

Corresponding author:* **Shintu P.V.
Genetics and Plant Breeding Division, Department of Botany, University of Calicut, Kerala - 673 635, India

Nearly 550 million people throughout the world depend upon these crops and the area of cultivation is about 50.85 million hectares and produces 679 million tonnes of tubers every year. Tubers are often considered as a contrary crop of the future as they permit local production of carbohydrates, which can replace expensively imported cereals (Lebot, 2009). They also form a vital source of energy in developing countries in relation to rapid population growth and high urbanization rate. Majority of the tuber crops are already cultivated, but others grow wild as a neglected group of economic plants. They are often used as food or serve as a source of raw material for the production of alcohol and animal feed. Many wild plants form an important starchy food for the tribal people inhabiting near to forest tracts. Some are important due to their medicinal as well as industrial applications. Many of these crops have not spread farther than their native habitat due to physiological constraints or lack of adaptability (Sujatha and Renuga, 2013). Low productivity, limited added value and poor access to market due to their perishable nature are the major constrains of these crops. Most of the tuber crops are capable to produce economic yields in a variety of marginal soils and environmental conditions. For majority of the food crops of the world, the information regarding their potential yield, the food and feed value of the crop and the way the crop can be processed is already available. However, tropical roots and tubers have been largely neglected. In this context, the cultivation of tuber crops needs more attention to overcome food scarcity and also to improve the agricultural economy.

Being a medicinal plant and a good source of quality starch, *Maranta arundinacea* L. is suitable for cultivation in Kerala. *Maranta arundinacea* is a tropical perennial, herbaceous, rhizomatous monocot belonging to the family Marantaceae.

It is a widely cultivated crop for its starchy rhizome that forms the source of extraction of easily digestible starch. It is believed to have originated in the North Western part of South America and the Lesser Antilles. It has been widely distributed throughout the tropical countries like India, Sri Lanka, Indonesia, Philippines, Australia and West Indies. The largest cultivation of arrowroot is reported in West Indies and that is why it has got the name West Indian arrowroot. The rhizome of *Maranta arundinacea* finds extensive use in the indigenous system of medicine and food industries. It is an under-exploited tuber crop which is valued as food stuff as well as a source of starch (Thamburaj and Singh, 2001).

The present study aims to group 14 important variables representing morphological and yield contributing characters of *Maranta arundinacea* by factor analysis in order to identify the lead characters that could be used for effective and efficient breeding programmes for the genetic upgradation of the crop in future.

MATERIALS AND METHODS

The experiment was carried out in the experimental field of the Genetics and Plant Breeding Division, Department of Botany, University of Calicut, Kerala, India during 2013-2015 (Figure 1).

Figure I An overview of the experimental field

University of Calicut is situated 24 km south of the historical city of Calicut located at 75° 46'E longitude and 11° 15'N latitude at an elevation of 50 m from MSL. The area has got a tropical climate enriched by South-West monsoon from June to August and North-East monsoon in October-November with occasional pre-monsoon showers in April and May and post-monsoon showers in December. During the period of study average temperature varied from 22°C to 36°C and annual rainfall was about 1500 mm (Anonymous, 2016). In Kerala State of India, cropping season in the case of annual crops commences during May before the onset of South-West monsoon and comes to an end by December.

Sixty accessions of *Maranta arundinacea* collected from different locations in the northern Districts of Kerala State formed the base material for the present investigation (Table 1). Disease free and healthy rhizomes of the plants were collected during the harvest season of 2012 and planted for multiplication in screening plots under standard manurial conditions so as to obtain sufficient planting materials for the field experiments.

Table I Accessions of *Maranta arundinacea* studied for character association

SI No.	Accession No.	Source	District
1	CUW 1	Chavakkad	Thrissur
2	CUW 2	Panambra	Malappuram
3	CUW 3	Varadoor	Wayanad
4	CUW 4	Areekode	Malappuram
5	CUW 5	Pathappiriyam	Malappuram
6	CUW 6	Kalikavu	Malappuram
7	CUW 7	Kuniyil	Malappuram
8	CUW 8	Puthurvayal	Wayanad
9	CUW 9	Villunniyal	Malappuram
10	CUW 10	Mundakkulam	Malappuram
11	CUW 11	Alinchuvadu	Malappuram
12	CUW 12	Vadakkummuri	Malappuram
13	CUW 13	Athinjal	Kasaragod
14	CUW 14	Kanjangad	Kasaragod
15	CUW 15	Thrikkarippur	Kasaragod
16	CUW 16	Puthiyiruthi	Thrissur
17	CUW 17	Eramangalam	Malappuram
18	CUW 18	Punnayurkulam	Thrissur
19	CUW 19	Kanjiramukku	Malappuram
20	CUW 20	Pananthara	Thrissur
21	CUW 21	Nayarangadi	Thrissur
22	CUW 22	Kizhoor	Thrissur
23	CUW 23	Nakkola	Malappuram
24	CUW 24	Edakazhiyoor	Thrissur
25	CUW 25	Kanippayyur	Trissur
26	CUW 26	Anjoor	Thrissur
27	CUW 27	Mayanad	Calicut
28	CUW 28	Mangalassery	Malappuram
29	CUW 29	Parambilpeedika	Malappuram
30	CUW 30	Puthiyatheru	Kannur
31	CUW 31	Pavaratty	Thrissur
32	CUW 32	Monnamkallu	Thrissur
33	CUW 33	Edakkara	Thrissur
34	CUW 34	Kaplengad	Thrissur
35	CUW 35	Erinjoli	Kannur
36	CUW 36	Mayyazhi	Kannur
37	CUW 37	Ponnyam West	Kannur
38	CUW 38	Ponnyam East	Kannur
39	CUW 39	Kathiroor	Kannur
40	CUW 40	Kollanpadi	Malappuram
41	CUW 41	Kalpetta	Wayanad
42	CUW 42	Vazhavatta	Wayanad
43	CUW 43	Munderi	Wayanad
44	CUW 44	Karaparamba	Calicut
45	CUW 45	Kannadikkal	Calicut
46	CUW 46	Thamburanpadi	Thrissur
47	CUW 47	Mangalam	Palakkad
48	CUW 48	Iritty	Kannur
49	CUW 49	Vavannoor	Palakkad
50	CUW 50	Mulayankavu	Palakkad
51	CUW 51	Kulukallur	Palakkad
52	CUW 52	Nhangattiri	Palakkad
53	CUW 53	Chalissery	Palakkad
54	CUW 54	Kodakara	Thrissur
55	CUW 55	Vetharkandam	Wayanad
56	CUW 56	Athichal	Wayanad
57	CUW 57	Kalluvayil	Wayanad
58	CUW 58	Thamarassery	Calicut
59	CUW 59	Cheruvathani	Thrissur
60	CUW 60	Meenangadi	Wayanad

Rhizomes multiplied in the experimental field were separated and rhizomes having a weight of 25-30 g were planted in 38 cm x 35 cm polybags filled with garden soil, sand and enriched compost in 3:1:1 ratio. 2 g of NPK (18:18:18) was applied at monthly intervals starting from the 30th day of planting till maturity. Weeding was carried out routinely as and when required and optimum soil moisture was maintained. A total of 540 plants representing the sixty accessions were raised in the experimental field during 2013 to study character association. Character association is a phenomenon resulting from common

sharing of alleles by polygenic characters. Analysis of association of characters is being carried out for data reduction so as to find out the lead characters that can be considered in selection in breeding programmes while searching for superior genotypes. For the present study, factor analysis by means of principal component analysis (PCA) has been done using the statistical software STATISTICA.

RESULT AND DISCUSSION

Polygenic characters of crop plants display different levels of association between them due to the influence of same set of alleles on different characters. In this study, character association has been analyzed by factor analysis, an important statistical technique whose objective is to represent a set of variables in terms of smaller number of hypothetical variables. Hence, the complexity of recording, analyzing and interpreting a host of multivariate data, in field experiment can be reduced by adopting factor analysis where by the breeder benefits to concentrate on selected independent lead characters related to other characters by their similarity in inheritance and expression. In the present study, character association has been analyzed by factor analysis using fourteen growth and yield characters of *Maranta arundinacea* using principal component analysis (Sneath and Sokal, 1973). The results are presented in Tables 2, 3 and 4.

Table II Factor analysis in *Maranta arundinacea*-Factor loading

Character	Factor 1	Factor 2	Factor 3	Factor 4
Plant height	-0.866960	-0.304767	-0.180470	0.030250
Number of tillers	-0.425312	-0.670047	-0.387599	-0.241008
Number of leaves per tiller	-0.741381	-0.334054	0.185350	-0.024123
Leaf length	-0.869050	0.191559	-0.253833	-0.037463
Leaf breadth	-0.618701	0.663593	0.034896	-0.127976
Leaf area	-0.830031	0.479709	-0.097649	-0.085106
Yield per plant	-0.773995	-0.177448	0.257902	0.314754
Number of rhizomes	-0.589727	-0.698482	-0.110617	-0.027631
Length of rhizome	-0.412376	0.290709	-0.296202	-0.265507
Diameter of rhizome	-0.447731	0.329502	0.375103	0.468024
Number of primary fingers	0.384246	-0.367762	0.571328	-0.216910
Length of primary finger	-0.404091	0.002781	0.668825	-0.196909
Diameter of primary finger	-0.329762	0.006984	0.598675	-0.507145
Starch content	0.179869	0.229291	-0.198003	-0.626096

Four factors could be extracted in the analysis of 14 characters under study (Table 2). Out of the fourteen characters studied, one variable came under factor 1, five variables came under factor 2, four variables under factor 3 and three variables under factor 4. Variables such as number of tillers and number of rhizomes did not contribute positive factor loading to the factors extracted. The characters under study contributed a cumulative variance of 73.71% (Table 3).

Table III Factor analysis in *Maranta arundinacea* -Eigen values and cumulative variance

Factors	Eigen value	Percentage of total variance	Cumulative Eigen value	Cumulative percentage of variance
1	5.078540	36.27528	5.07854	36.27528
2	2.260937	16.14955	7.33948	52.42483
3	1.770889	12.64921	9.11037	65.07404
4	1.208995	8.63568	10.31936	73.70972

In factor 1, number of primary fingers showed maximum factor loading. In the 2nd factor group, leaf breadth and leaf area showed maximum factor loading followed by length of rhizome, starch content and leaf length thus making them lead characters in this group. Length of primary finger, diameter of primary finger, number of primary fingers and number of leaves per tiller were grouped under factor 3. The 4th factor group comprised of diameter of rhizome, yield per plant and plant height.

Table IV Factor analysis in *Maranta arundinacea* - factors identified

Factors	Characters
1	Number of primary fingers
2	Leaf breadth, leaf area, length of rhizome, starch content, leaf length
3	Length of primary finger, diameter of primary finger, number of primary fingers, number of leaves per tiller
4	Diameter of rhizome, yield per plant, plant height

Based on the above study, it could be concluded that leaf breadth, leaf area, length of primary finger, diameter of primary finger, number of primary fingers, diameter of rhizome and yield per plant are the lead characters that could be considered in crop improvement programmes in *Maranta arundinacea*.

Factor analysis for identifying the lead characters has been utilized in crops like rubber (Abraham *et al*., 2002), cardamom (Radhakrishnan *et al*., 2004; Hrideek, 2007), tea (Ramasubramanian, 2005), turmeric (Tomar *et al*., 2005; Rao *et al*., 2006), rice (Mini, 2006), chilli (Hrideek *et al*., 2006), coconut (Abdul Kadher *et al*., 2007), vanilla (Umamaheswari, 2008) and coffee (Nikhila, 2007).

CONCLUSION

Based on the present study, nine growth and yield characters such as number of primary fingers, leaf breadth, leaf area, length of primary finger, diameter of primary finger, number of primary finger, diameter of rhizome, yield per plant and plant height could be identified as the lead characters which can be considered for the crop improvement programme in *Maranta arundinacea*.

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How to cite this article:

Shintu P.V *et al* (2017) 'Factor analysis in Maranta arundinacea L.', *International Journal of Current Advanced Research,* 06(11), pp. 7328-7331. DOI: http://dx.doi.org/10.24327/ijcar.2017.7331.1126

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