ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 14, Issue, 11, pp.228017-22819, November, 2022
DOI: https://doi.org/10.24941/ijcr.44386.11.2022

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

A STUDY ON THE GENETIC CONTROL AND POTENTIAL OF THE IMPORTANT AGRONOMIC CHARACTERS OF *CURCUMA ZEDOARIA* ROSC.

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ARTICLE INFO

Article History:
Received 14th August, 2022
Received in revised form
08th September, 2022
Accepted 15th October, 2022
Published online 30th November, 2022

Key words:

Curcuma zedoaria, White turmeric, Genetic variability, Genetic control.

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ABSTRACT

This study intends to discover *Curcuma zedoaria* Rosc., also known as white turmeric is a promising member of the family Zingiberaceae. The plant is a source of several substances of medicinal and pharmacological significance. It has wide applications in the treatment of various diseases like diarrhoea, stomach ache, ulcer, cancer, etc. However, no attempt has been made to investigate the genetic variability and genetic control of the agronomic morphometric characters of the species. The present study showed that all the 15 morphometric characters studied displayed continuous frequency distribution, indicating polygenic control of the characters. Among the growth characters, number of tillers, number of leaves per tiller, leaf length and leaf area showed the accumulation of higher number of recessive alleles in the gene pool of the germplasm studied and plant height and leaf breadth showed the accumulation of higher number of dominant factors. All the yield characters studied such as yield per plant, number of primary fingers, number of secondary fingers, length of primary finger, circumference of primary finger, length of secondary finger, circumference of secondary finger, length of mother rhizome and the circumference of mother rhizome showed skewness towards the proximal side of the distribution with the accumulation of higher number of recessive factors. All the characters studied, however, displayed a relatively wide distribution of factor combinations, indicating that the plant species under study has a broad genetic base. The skewed nature of the distribution pattern of the morphometric characters towards the proximal side of the curve indicates the need of selection of genotypes with higher number of dominant alleles for the improvement of agronomic characters.

Citation: ***Litty R., Mohammed Irfan T.K., Radhakrishnan V.V. and Mohanan K.V.*** **2022.** "A study on the genetic control and potential of the important agronomic characters of *Curcuma zedoaria* Rosc.*". International Journal of Current Research*, 14, (11), 228017-22819.

INTRODUCTION

After cereals and grain legumes, tuber crops are the third most significant class of food crops worldwide. Globally tuber crops were grown in an area of 67 million ha with a production of 887 million tonnes in 2017 (FAOSTAT, 2019). *Curcuma zedoaria* Rosc. known in English as white turmeric or zedoary is a perennial rhizomatous herbaceous plant belonging to the family Zingiberaceae. During the sixth century, Arabs brought the plant to Europe. It has various vernacular names in India, including Sutha, Gandamatsi, and Krachura (Nadkarni, 1999). The plant comprises of a subterranean rhizome part as well as an upright pseudostem. The leafy stalk can grow as tall as 1 m. The inner part of rhizomes is creamy white in colour. It has apical buds that appear as inflorescence above the ground. Yellow flowers with appealing red or green bracts are present in the inflorescence (Bhutia and Sharangi, 2017). Southeast Asian nations cultivate zedoary as a spice, vegetable, and component of perfumes. This plant's rhizome has been used as a stimulant, stomachic, carminative, diuretic, anti-diarrheal, anti-emetic, anti-pyretic and depurator, as well as an ointment for ulcers, wounds and other skin problems (Matthes *et al*., 1980). Analgesic, antiulcer, antiasthmatic, antiarthritic, diuretic and antipyretic properties are all reported in the case of the plant. It is also used to alleviate pain (Matsuda*et al*., 2004; Navarro *et al*., 2002; Gupta *et al*., 2003; Pathan *et al*., 2015). The species is used to prepare herbal medicines that have anti-inflammatory, anti-hepatotoxic, neuroprotective, anti-microbial and antimutagenic properties. It has cytotoxic effects on human ovarian cancer cells and is effective against Salmonella/ microsomal system mutations induced by benzopyrene (Syu *et al*., 1998). Antibacterial medicines contain the essential oil made from the dried rhizome of zedoary as an active ingredient. Chinese medicine utilizes the rhizome extract to treat extradural haemorrhages (Asolkar *et al*., 1992). Helminthiasis is relieved by administering a mixture made of macerated leaves of the plant and lime water. For headache relief and vision improvement, macerated rhizomes are applied to the forehead (Karim *et al*., 2011). A thin paste prepared from rhizome is used to treat dermatitis and sprains (Rahmatullah *et al*., 2009). Small rhizome pieces of zedoary are employed as an antidote and given orally (Bantawa *et al*., 2009). In spite of its varied economic importance, *Curcuma zedoaria* is a less studied crop with respect to its genetic diversity and genetic regulation of the agronomic morphometric characters. The current study was conducted to examine the genetic variability and genetic regulation of such traits in the species.

The experiment was conducted during 2019-2020 in the Genetics and Plant Breeding Division of Department of Botany, University of Calicut (11.134N, 75.888E), India to determine the genetic structure of its populations based on various morphometric characters.

MATERIALS AND METHODS

Curcuma zedoaria germplasm maintained at the above location was used to develop the experimental population for the above study. The germplasm was developed from 57 accessions of the species collected from various locations of Thrissur, Kottayam, Ernakulam, Alappuzha, Kozhikode and Malappuram districts of Kerala state of India.The experimental material composed of nine plants from each of the 57 *Curcuma zedoaria* accessions. The planting material was made up of fresh, disease-free seed rhizome fingers that were 25 g to 30 g of weight and 3 cm to 5 cm long. The rhizomes were planted in 38 cm x 35 cm poly bags filled with cow dung, sand and garden soil in the ratio of 3:1:1 during the first week of May 2018 before the onset of south west monsoon. Irrigation was carried out once on every non-rainy day and weeding was done as needed. Each plant was applied with 2 g of N:P:K (18:18:18) at monthly intervals beginning on the 30th day of growth and continuing through the fifth month. Harvesting was done simultaneously after six months of growth. At the time of maturity, field observations were made on morphometric traits like plant height, number of tillers, number of leaves per tiller, leaf length and leaf breadth. Leaf area was calculated using a conversion factor calculated for the purpose (leaf length x leaf breadth x conversion factor). The conversion factor was calculated using graphical method, where the areas of five leaves were measured randomly and the mean calculated. The conversion factor in the case of *Curcuma zedoaria* has been calculated as 0.60. After harvest, measurements of the yield per plant, number of primary fingers, number of secondary fingers, length of primary finger, circumference of primary finger, length of secondary finger, circumference of secondary finger, length of mother rhizome and circumference of mother rhizome were recorded. Data were pooled and analysed using frequency distribution analysis to study the genetic control of the characters as well as to determine the pattern of distribution of dominant and recessive alleles in the study gene pool.

RESULTS AND DISCUSSION

The frequency distribution of 15 morphometric characters of *C. zedoaria* was used to determine the genetic control of these characters. The studied characters included 6 growth characters and 9 yield characters. The growth characters include plant height, number of tillers, number of leaves per tiller, leaf length, leaf breadth and leaf area. The yield characters studied were yield per plant, number of primary fingers, number of secondary fingers, length of primary fingers, circumference of primary finger, length of secondary finger, circumference of secondary finger, length of mother rhizome and the circumference of mother rhizome. According to the frequency curves for each character shown in Figure 1, all the characters exhibited continuous frequency distribution. Continuous frequency distributions with all possible intermediates indicate that these characters are under polygenic control. When the allelic combinations are distributed in the gene pool of the population according to the principles of probability and when the frequencies of the dominant and recessive alleles are equal, quantitative characters with polygenic control exhibit normal frequency distribution. A skewness in the bell-shaped normal distribution curve is observed when the frequency of the dominant and recessive alleles varies within the distribution (Chahal and Ghosal, 2002).

Genetic control of growth characters: Among the growth characters studied, number of tillers, number of leaves per tiller, leaf length and leaf area showed continuous distribution with the accumulation of higher number of recessive contributing factors which indicate that the gene pools of these characters exhibit skewness towards the proximal side of the distribution curve. This shows that the population under study has higher accumulation of recessive contributing alleles.

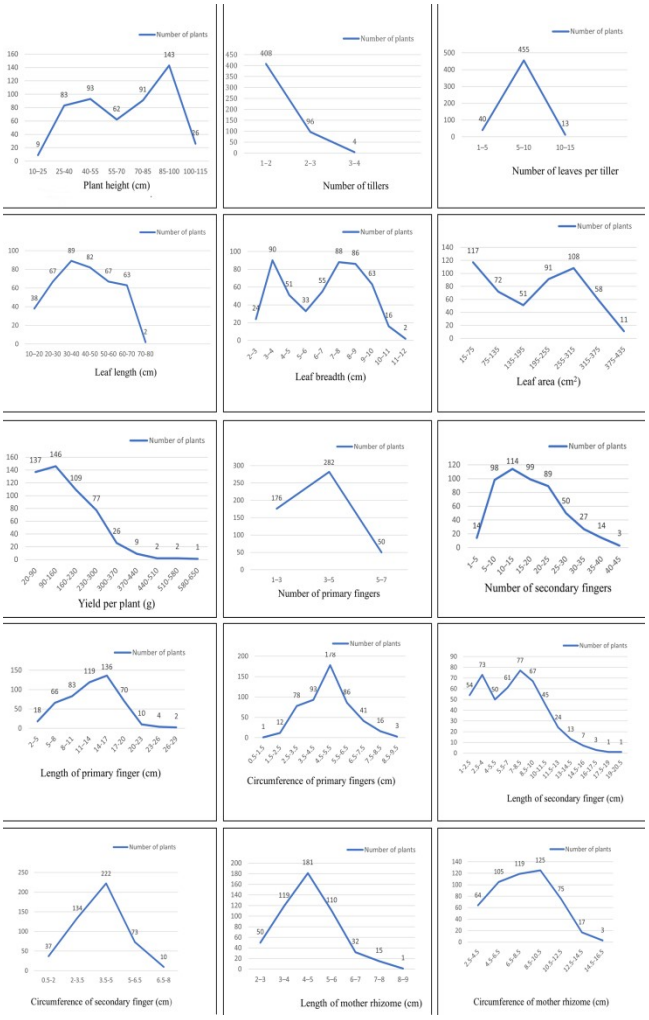

Fig. 1. Frequency curves of the morphometric characters of *Curcuma zedoaria* studied

The accumulation of the dominant contributing factors for these characters is very low. Therefore, scientific selection processes should be employed to generate varieties with higher accumulation of dominant alleles of these characters. Plant height and leaf breadth showed continuous distribution with skewness towards the distal side of the distribution. This distribution indicates that the gene pools of these characters show accumulation of higher number of dominant alleles even when maintaining fairly good genetic base ranging from comparatively lower to higher values. The frequencies of the classes with higher values are, however, relatively low. The development of promising varieties depends on conservation with maximum accumulation of dominant contributing factors while maintaining a broad genetic base for selection of promising genotypes.

Genetic control of yield characters: The yield characters of *C. zedoaria* studied have shown that yield per plant, number of primary fingers, number of secondary fingers, length of primary finger, length of secondary finger, circumference of secondary finger, length of mother rhizome and the circumference of mother rhizome showed skewness towards the proximal side of the distribution. It indicates the accumulation of higher number of recessive contributing alleles in the population studied. Additionally, it indicates the need to select for better genotypes and phenotypes with higher number of dominant contributing alleles for developing superior varieties. However, the frequency curves of these characters also show broad spreads, suggesting that such distributions are advantageous from conservation point of view. It can be seen that while the vegetative growth characters of the species exhibit improved genetic potential, the majority of their agronomic characters exhibit wide variability, severely limiting the crop's yield due to the presence of a very high frequency of recessive alleles in the gene pool of the natural populations.

This indicates that improved and high-yielding varieties of this species should be developed through a selection process so that farmers can cultivate this crop in an organized way and gain higher yields without being forced to stop for economic reasons. The approach of analysing frequency distributions of the phenotypes for genetic analysis has previously been carried out by various researchers in different crops like Coffee (Dharmaraj and Sreenivasan, 1992; Sreenivasan and Santha Ram, 1993; Nikhila *et al*., 2002 and Raghu *et al*., 2003), *Cassia tora* (Chandramohanan and Mohanan, 2005), vanilla (Umamaheswari and Mohanan, 2004), *Maranta arundinacea* (Shintu *et al*., 2016), *Curcuma aeruginosa* (Soorya *et al*., 2016) and *Curcuma aromatica* (Neethu *et al*., 2017). Such works have been helpful in understanding the genetic control of agronomic traits and the distribution of alleles in the relevant gene pools. In addition, such studies have become potential incidents that facilitated assessment of genetic diversity and initiation of further breeding programmes.

CONCLUSION

Curcuma zedoaria, a potentially important species in medicine and pharmacology, contains a variety of compounds that promote health, including antioxidants. To maintain the genetic potential of this species, it is crucial to conserve its genetic base in its natural habitats, homestead farms and also in organised conservatories. The current study demonstrates that the genetic basis of *C. zedoaria* in the study area is relatively large, and there is no threat of narrowing of its genetic diversity presently. However, marginal crops, such as *C. zedoaria*, are severely threatened in their natural habitats and traditional homesteads where they are conventionally cultivated, due to crop conservation and shift to monocropping and industrialised agriculture. So, it is necessary to protect the species in their natural habitats in order to maintain the species diversity. The majority of the studied characters showed the accumulation of a high percentage of recessive alleles. Therefore, in order to produce improved cultivars that are beneficial to both organised cultivators and farmers, selection for genotypes with the highest accumulation of dominant contributing factors is essential. This will increase crop yield and make the crop more popular for both nutraceutical and commercial reasons. Therefore, selection process should be initiated aiming at higher accumulation of dominant factors for producing improved and high yielding varieties of the species.

ACKNOWLEDGEMENTS

The first author acknowledges the University Grants Commission (UGC) for granting UGC-JRF for the study.

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