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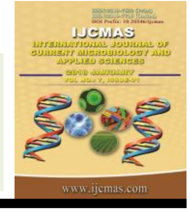

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Variability, association and genetic divergence analysis in Chench (*Corchorus acutangulus* Lam.): A Popular Leafy Vegetable of Chhattisgarh, India- A Review

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ABSTRACT

Keywords

Chench, *Corchorus acutangulus* Lam., genetic variability. Divergence, Correlation and Path analysis

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In India, the leaves of a large number of wild and cultivated plants are used as leafy vegetables. They have a very high protective food value and are very easy to grow. The use of leafy vegetables as food has been formed an integral part of the culture and tradition of many indigenous communities of the world. It constitutes an essential component in the diet and food security of many tribal and local communities particularly people living around the forest fringe. In Chhattisgarh, the life and economy of the tribal and local people are intimately connected with the natural vegetation. Leafy vegetables play a major role in the nutritional requirement of the tribal and local population in remote parts of the Chhattisgarh. Leafy vegetables are not only important as food but it also fulfill the regular requirement of nutrients

Introduction

Chench (*Corchorus acutangulus* Lam.) is one of the unexploited and underutilized leafy vegetable and also know as vegetable jute in India. In Chhattisgarh, it is popularly known as *Chench Bhaji and* belongs to the family Tiliaceae. Chench is an annual herb, green leaves along with tender petiole and soft stem from a wide range of plants are consumed as a leafy vegetable.

The 100 g of fresh edible portion of chench bhaji contain is water (81.4 g), energy (58 kcal), protein (5.1 g), fat (1.1 g), carbohydrate (8.1 g), fibre (1.6 g), Ca (241 mg), P (83 mg), Fe (7.2 mg) and ascorbic acid (80 mg) (Gopalan *et al.*, 2004). The bitterness in *Corchorus* Leaves is due to Corchorin Glycosides. Green leafy vegetables are good source of folic acid and antioxidant properties. The roots and leaves are said to cure gonorrhea and urethral discharge the seeds are stomachic and used in pneumonia. The plant is said to possess anticancer antipyretic, anticonvulsant, stomachic and digitalis glycoside like action whereas, leaves and arial parts of *Corchorus acutangulus* Lam. possess antibacterial potential (Patel, 2011). Moreover, *Corchorus* is known to contain high levels of iron and folate which are useful for the prevention of anaemia (Steyn *et al.*, 2001).

The information on the genetic variability and its components and the correlation component characters with green leaf yield is required. It is a well known fact that the yield is a polygenic trait and greatly affected by environment. Thus the selections based on yield component have better chance of success. It is therefore, necessary to have knowledge of direct and indirect influences of yield attributing characters, which help to select best performing genotype.

Genetic variability

The genetic improvement in any crop plants primarily depends on the magnitude of available genetic variability. There are two kinds of variability in crop plants, genetic and non genetic. The study of genetic variability was made for the first time by the great biologist, Fisher (1918) and subsequently the estimates of genotypic and phenotypic variations were used to predict the expected genetic response.

Das and Kumar (2012) studied 32 jute (*Corchorus* spp.) varieties comprised of 18 *olitorius* and 14 *capsularis* and found PCV and GCV were highest for 1000 seed weight (33.78 and 33.29% respectively) followed by fibre fineness (27.11 and 26.70% respectively). Low variability was recorded in case of plant height. Denton and Nwangburuka (2012) revealed fifteen accessions of leaf *C. olitorius* and found high variability between number of leaves per plant, plant height at maturity, fresh leaf weight, total plant weight and harvest index. Ghosh *et al.* (2013) studied 63 jute genotypes, including 2 varieties with 37 accessions of *C. capsularis* and 1 variety with 23 accessions of *C. olitorius,* were evaluated to assess the extent and patterns of variability and found that seed traits exhibited a wider range of variation than fiber traits and the genotypes in *C. olitorius* varied the most than those in *C. capsularis.* Hasan *et al.* (2013) evaluated seventeen genotypes of stem amaranth (*Amaranthus tricolor* L.). The genotypes varied significantly for all the characters studied. High GCV and PCV were observed in leaf weight (77.54 and 80.14 %, respectively) and dry weight without rind (74.42 and 74.47 %, respectively). Khurana *et al.* (2013) observed that the analysis of variance was highly significant differences for all the parameters in 24 genotypes of *Amaranthus* spp. Phenotypic coefficient of variation (PCV) was higher than those of genotypic coefficient of variation (GCV) in both seasons for all the characters in all the cuttings. Gerrano *et al.* (2014) studied 32 genotypes *Amaranthus spp.* and reported the analysis of variance showed highly significant differences among the *Amaranthus species* for all phenotypic traits, indicating the existence of high genetic variability. Praveen *et al.* (2014) studied eight genotypes of *Amaranthus spp.* and found existence of considerable amount of genetic variability for all the traits except leaf length in 60 days. PCV is highest in the character no. of leaves/plant in 60 days and lowest in the character no. branch number/ plant in 90 days. Sarkar *et al.* (2014) studied genotypic variability in 30 vegetable amaranth genotypes for nutrient composition, antioxidant content and 12 yield contributing traits. High range of variability and high genotypic variance were observed for all the traits except content of Ca, protein and beta carotenoid. Vujacic *et al.* (2014) reveled 10 amaranth genotypes and found variability in total leaf mass per plant ranging from 94.05 g to 246.81 g, grain yield per plant ranging from 45.56 g to 67.55 g, as well as total grain yield ranging from 2220 kg/ha to 3200 kg/ha.

Heritability and genetic advance

The term heritability in broad sense can be defined as the ratio of genetic variance to the total phenotypic variance (Lush, 1940). It is generally expressed in percentage. Thus the heritability is the heritable portion of phenotypic variance which is good index of the transmission of characters from parents to their offspring (Falconer, 1960). Depending upon the components of variance used as numerator in the calculation, heritability is of two type's *viz.* broad sense heritability and narrow sense heritability.

Heritability estimate provides the information regarding the amount of transmissible genetic variation to total variation and determines genetic improvement and response to selection Shukla *et al*. (2005) evaluated 29 strains of vegetable amaranth (*A. tricolor*) and observed the heritability estimates were in general high for all the characters in the entire cuttings and ranged from 74.87% to 93.33%. Genetic advance was maximum for foliage yield (42.50%) followed by leaf size (31.02%) and stem diameter (21.13%). Shukla *et al*. (2006) studied twenty nine strains of vegetable amaranth (*Amaranthus tricolor* L.). The high heritability was estimates for all the traits in all the cuttings as well as on pooled basis. Highest expected genetic advance was noticed for ascorbic acid (57.48%) followed by foliage yield (48.30%) and leaf size (29.51%). Anuja and Mohideen (2007 a) studied genetic variability and heritability in 100 genotypes of amaranthus germplasm and found heritability estimates in general were high for most of the characters. High heritability coupled with high genetic advance (as percent of mean) was observed for number of leaves, root length, root weight, leaf weight and stem weight. Pan *et al*. (2008) evaluated 24 indigenously collected germplasm of *A. tricolor* including two released varieties and found that heritability was high for leaf stem ratio, width of leaf, length of leaf, days to 1st clipping, number of clipping, girth of stem and total yield of greens per plot. High heritability along with high genetic advance was observed for leaf-stem ratio, width of leaf, total yield of greens/plot and length of leaf. Varalakshmi and Devaraju (2010) revealed eleven germplasm lines of the Indian spinach (basella) and found that moderate heritability along with high genetic advance was recorded for leaf weight and total plant weight, indicating the presence of additive gene effects. Das and Kumar (2012) studied 32 jute (*Corchorus* spp.) varieties comprised of 18 *olitorius* and 14 *capsularis* and high heritability was recorded for time of 50% flowering (99%) followed by fibre fineness and seed weight (97%). Navangburuka and Denton (2012) evaluated 15 genotypes of *Corchorus olitorius* and reported high estimates of broad sense heritability was recorded in no of leaves (96.99 %), plant height at maturity (95.61 %), leaf weight per plant (94.74 %), total weight per plant (97.02 %) and harvest index (75.00 %) suggesting additive gene effect in the expression of these characters. Ahammed *et al.* (2013) evaluated 22 genotypes of stem amaranth and found heritability estimates in broad sense were higher for leaf weight per plant (91.10%) followed by leaves per plant (86.83%), primary branches per plant (86.42%), stem weight per plant (82.56%) and yield per hectare (78.70%). Leaf weight per plant, stem weight per plant and yield per hectare exhibited high value of heritability (91.10%, 82.56% and 78.70% respectively) along with high genetic advance 49.38%, 134.12% and

56.00% for leaves per plant, stem diameter and stem weight per plant, respectively. Hasan *et al*. (2013) evaluated seventeen genotypes of stem amaranth (*Amaranthus tricolor* L.) and observed high heritability coupled with high genetic advance as percent of mean was registered for number of leaf, leaf weight and marketable yield which in fact demonstrated the presence of additive gene effects. Praveen *et al.* (2014) studied 8 of *Amaranthus spp*. and found that high estimate of heritability was also observed for the characters of seed yield/plant, length of inflorescence and genetic advance shows the character seed weight of 1000 seeds, seed yield/plant, and inflorescence/plant. Sawarkar *et al.* (2014) studied thirty genotypes of tossa jute (*Corchorus olitorius* L.) and found high values of heritability (>90%) for almost all characters like plant height (93.01%), bark thickness (98.33%), base diameter (94.82%), green weight (91.64%), stick weight (99.20%) and fibre weight (96.48%). The high heritability with moderate to high genetic advance over percentage of mean was observed in bark thickness (98.33 and 38.86 %), stick weight (99.20 and 56.87 %) and fibre weight (96.48 and 25.02 %) which indicate preponderance of additive genetic action. Venkatesh *et al.* (2014 b) studied one hundred germplasm accessions of grain amaranth, all the traits studied exhibited high heritability. High genetic advance as per cent of mean was observed for days to 50 percent flowering, stem girth, number of leaves per plant, plant height, panicle length, panicle width and grain yield per plant Vujacic *et al* (2014) studied ten amaranth genotypes and observed that heritability varied from 86% (grain weight per plant) to 92% (leaf mass per plant).

Correlation coefficient studies

Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variables. The original concept of correlation was represented by Galton (1888) and he suggested the need of coefficient of correlation to describe the degree of association between variables. Later the theory of correlation was developed by Pearson (1904). Thereafter, Searle (1961) described the mathematical implications of correlation coefficient at phenotypic, genotypic and environmental level.

Pan *et al.* (2008) studied 24 indigenously collected germplasm of (*A. tricolor)* and reported that the total yield of greens/plot was found to be positively and significantly correlated with duration of harvest. Shukla *et al.* (2010) evaluated 39 distinct cultivars of vegetable amaranth (*A. tricolor*). Among the agronomic traits, plant height and number of inflorescence exhibited significant positive association with foliage yield, while chlorophyll a, chlorophyll b, carotenoid, fiber and ascorbic acid were positively correlated with foliage yield. Chlorophyll a and chlorophyll b exhibited significant positive association with carotenoid, fiber and ascorbic acid. Ascorbic acid was positively correlated with fiber and carotenoid. Navangburuka and Denton (2012) evaluated 15 genotypes of *Corchorus olitorius* and reported strong positive genotypic and phenotypic correlation between no. of leaves per plant and plant height at maturity (0.43, 0.45), leaf weight per plant (0.86, 0.87), total plant weight (0.81, 0.82) and harvest index (0.33, 0.38). Ahammed *et al.* (2013) evaluated 22 genotypes of stem amaranth and reported leaf weight per plant and plant height exhibited highly significant positive correlation with yield per hectare both at genotypic and phenotypic level. Akaneme and Ani (2013) studied 5 accessions of *Amaranthus hybridus* and reported that days to 50% flowering were positively correlated with leaf length and stem diameter. Arif *et al.* (2013) studied 35 different accessions of spinach for various traits. The evaluation was based on 20 qualitative and quantitative parameters and found number of leaves per plant showed positive and significant correlation with leaf length and leaf width. It was significant only with earliness of bolting and days to flowering. The existing of was reported positive and significant correlation between days to flowering and days to harvesting was reported. Earliness of bolting also remained significantly correlated with days to flowering. A negative association among several traits was also observed which was non-significant. Ghosh *et al.* (2013) evaluated 63 jute (*C. capsularis*) genotypes and found significant positive correlations of fiber yield with days to 50% flowering (0.60), plant height at average flowering (0.72), plant base diameter (0.74) and fresh weight (0.90), whereas, leaf angle was negatively (-0.52) correlated. Seed yield was significantly positively correlated with pod length (0.72) and seeds per pod (0.79). Khurana *et al*. (2013) studied 24 genotypes of *Amaranthus* spp. and reported that total green yield was negatively correlated with oxalate content and leaf blight incidence. Plant height was positively correlated with number of branches per plant (0.6491), leaf length (0.3381), leaf width (0.41954), number of leaves per plant (0.5254), leaf area index (0.5604), total green yield (0.5632) and protein content (0.4271). Number of leaves per plant was positively correlated with leaf area index (0.9210), total green yield (0.9529) and protein content (0.7836).Number of leaves was negatively correlated with oxalate content (-0.3429) and leaf blight incidence (-0.8577). Kendre *et al*. (2013) studied twenty genotypes of amaranth and revealed that, plant height and petiole length exhibited positive and significant association with the yield in amaranth which indicated their relative importance in leaf yield. However, there were exhibited significant correlation coefficient value, which indicated that the indirect effects of plant height Hasan *et al.* (2013) evaluated 17 genotypes of stem amaranth (*Amaranthus tricolor* L.) were revealed that green yield was positive correlated with leaf weight, stem weight, stem diameter, dry weight with rind, and dry weight without rind. Sarkar *et al*. (2014) studied thirty vegetable amaranth genotypes and reported that foliage yield had significant positive correlation with plant height, leaves per plant, diameter of stem base, fiber content and leaf area. Nutrient content and antioxidant had insignificant genotypic correlations with foliage yield. Hailu *et al.* (2015) evaluated 36 accessions of *Amaranthus spp.* and found that the green leaf yield per plant showed positive and significant relationship with stem diameters, plant height, inter nod length, top branch and average branch length and highly significant relation with days to emergence, days to green harvest, days to flowering, number of leaf per plant, biomass per plant, days to seed harvest, leaf width, leaf area, primary and secondary branch per plant.

Path coefficient analysis

Path coefficient analysis is carried out using the estimates of correlation coefficient. The concept of path coefficient analysis was originally developed by Wright in 1921, but the technique was first used for plant selection by Dewey and Lu (1959). Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. In other hands, it measures the direct and indirect contribution of various independent characters on a dependent character.

Pan *et al*. (2008) 24 indigenously collected germplasm of (*A. tricolor)* including two released varieties. Path coefficient analysis of different characters contributing towards total yield of greens revealed that duration of harvest had maximum positive direct effect on total yield. The indirect effect of duration of harvest *via*. number of clippings was maximum and positive. Shukla *et al.* (2010) evaluated 39 distinct cultivars of vegetable amaranth (*A. tricolor*). Protein was associated with plant height, branches per plant and 500 seed weight. Chlorophyll a, carotenoid and inflorescence length revealed high positive direct effect on foliage yield, while branches plant per plant, leaf size, seed yield, chlorophyll b, moisture content and ascorbic acid showed negative path coefficient with foliage yield. Varalakshmi and Devaraju (2010) evaluated eleven germplasm lines of the Indian spinach (Basella) and reported that higher plant weight was found to be significantly and positively associated with branch number, leaf number, leaf weight and stem weight. Leaf number had the maximum direct positive effect on total plant weight, followed by leaf length. Indirect effects of other characters through these characters were also seen to be positive. Selvaraj and Kanthaswamy (2012) studied 74 genotypes of amaramthus and path analysis revealed that the highest direct effect of number of leaves, leaf length, and leaf breadth, stem girth and plant weight towards weight of leaves. The indirect effect of most of the characters through number of leaves, leaf length and leaf breadth. Hasan *et al.* (2013) evaluated seventeen genotypes of stem amaranth (*Amaranthus tricolor* L.) were evaluated that path analysis indicated that stem weight had maximum direct effect on marketable yield followed by leaf weight, leaf number and dry weight without rind. Kendre *et al*. (2013) studied twenty genotypes of amaranth path analysis revealed that, the character *viz.* stem diameter exerted highest direct effect over yield followed by petiole length, leaf area and number of leaves. While, plant height character exhibited the negative direct effect on yield, however exhibited significant correlation coefficient value, indicated that the indirect effects of plant. Sarker *et al*. (2014) studied thirty vegetable amaranth genotypes and reported that the fiber content (0.616), leaf area (0.464), diameter of stem base (0.420) and betacarotenoid (0.347) had high positive direct effect on foliage yield. Hailu *et al.* (2015) studied 36 accessions of *Amaranthus spp.* and found that the highest and positive direct effect was exerted by biomass per plant followed by average branch length and characters had significant correlations with green leaf yield.

Genetic divergence

The concept of D^2 statistics was originally developed by Mahalonobis (1936). Then, Rao (1952) suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is extensively used in vegetable breeding for the study of genetic divergence in the various breeding material including germplasm. This analysis also helps in the selection of diverse parents for the development of hybrids. Cluster analysis helps to form groups of closely related individuals which help in determining genetic distance between them.

Ahammed *et al.* (2013) evaluated 22 genotypes of stem amaranth and grouped into four clusters. Cluster I, II, III and IV composed of two, four, seven and nine genotypes in succession. Maximum inter cluster distance (12.326) was observed between cluster I and III and it was minimum (3.526) between cluster I and II. The crosses between the genotypes of cluster I with that of cluster III and cluster II with cluster III would exhibit high heterosis and also likely to produce new recombinants with desired characters in stem amaranth. The yield contributing characters were leaves per plant, petiole length, stem diameter, leaf weight per plant and stem weight per plant. Leaf width, petiole length and 1000 seed weight showed maximum contribution to the total divergence. Akaneme and Ani (2013) studied five accessions of the *Amaranthus hybridus*. The dendrogram divided the accessions into cluster 1 comprising accessions 3 and 5 and cluster 2 comprising accessions 1, 2, 4. The qualitative traits differed among the accessions with the exception of growth habit, branching index and leaf shape. Akther *et al.* (2013) revealed seventeen genotypes of stem amaranth (*Amaranthus tricolor* L.). The genotypes under study fell into 4 clusters. The distribution pattern indicated that the maximum number of genotypes (6) was included in cluster (IV) followed by cluster III (5) and cluster II (5), and the minimum number was in cluster I (1). The inter cluster distance in most of the cases was higher than the intra cluster distance, which indicated wider genetic diversity among the accessions of different groups. The highest inter cluster distance was observed between IV and I, followed by the distance between cluster II and I showing wide diversity among the groups. The lowest inter-cluster distance was observed between clusters III and II suggesting a close relationship among the genotypes of these two clusters. The highest intra-cluster distance was observed for the cluster IV and the lowest for the cluster I. Arif *et al.* (2013) studied 35 different accessions of spinach the accessions under study fell into 4 cluster, cluster-I was the largest, comprising of 17 genotypes, cluster-II of 7 accessions, cluster-III 4 genotypes while cluster-IV contained 7 genotypes. The germplasm grouped in cluster-I were of medium plant height, late flowering, more tillers and late in bolting. The germplasm contained in cluster-II were characterized with more leaf per plant, longer leaves and the highest plant height. Spinach accessions grouped in cluster-III had high number of leaves per plant, larger leaf length and more plant height, while the germplasm in cluster-IV reflected the highest number of leaves per plant as well as leaf length and width, moderate plant height, moderate maturity and moderate petiole length. Ghosh *et al.* (2013) evaluated 63 jute (*C. capsularis*) genotypes and found the clustering patterns and suggested that the two jute species are distantly related. The highest diversity (0.69) was observed between clusters IX and IV, whereas clusters III and IV showed the greatest similarity (0.14).

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