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Short communication

Genetic divergence and cluster analysis in Khedha (*Amaranthus dubius* Mart.)

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Abstract
The present investigation entitled "Genetic divergence and cluster analysis in khedha (*Amaranthus dubius* Mart.)." was conducted during the year 2014-15 and 2015-16 at Research and Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment II was conducted during Kharif Season. The experiment was comprised of twenty five genotypes of khedha (*Amaranthus dubius* Mart.). laid out in Randomized Block Design (RBD) with three replications. The data were analyzed to work out the genetic variability, correlation coefficient, path analysis and genetic divergence for the character viz., plant height, number of leaves per plant, leaf length, leaf breadth, petiole length, number of branch per plant, stem girth, fresh leaf weight, dry matter percentage of plant, harvest index %, test weight, yield kg per plot, yield tonne ha-1, seed yield tonne ha-1, duration of crop and fibre content %. The distributing pattern indicated that the maximum number of genotypes (11) was included in cluster (I) followed by cluster II, cluster III contains (7) genotypes, while cluster IV contains minimum (1) genotypes. The pooled analysis of data shows that the maximum number of genotypes was grouped into cluster II included twelve genotypes, were highly divergent from all other genotypes and may be used as parents in transgenic breeding programme and may directly be used as a pure line variety for yield and its component characters in khedha for Chhattisgarh plain condition. Hence, germplasm/genotypes collected from different districts of Chhattisgarh were evaluated in two consecutive years.

Keywords: Genetic divergence, cluster analysis, khedha (*Amaranthus dubius* Mart.)

Introduction
khedha (*Amaranthus dubius* Mart.) are leafy vegetable locally known as chaulai bhaji (lal & green) belongs to the family Amranthaceae. The green Amaranthus consist of approximately 60 species out of which about 18 species are occurring in India. There are three major producing Amaranthus species, A. caudatus, A. cruentus and A. hypochondriacus, all believed to originate from Central and South America; and three major leafy vegetable species, A. tricolor, A. dubius and A. blitum (*A. lividus*), of which A. tricolor is thought to originate from India or Southern China, A. blitum from Central Europe and A. dubius from Central America (Yadav *et al*., 2014) [20]. The plant height varies from 0.3 m to 5m among various species. Leaves are oblong to elliptical with color ranged from light to dark green with some expressing red pigment throughout the genus.

India is the largest producer of vegetable crops next to China. Leafy vegetables are cultivated in an area of 9205 thousand hectare with an annual production of 162187 thousand MT (Anon., 2013) [3]. In Chhattisgarh, vegetables occupied an area of 377.21 thousand hectare with an average production of 4965.33 thousand MT out of these, leafy vegetables are cultivated in an area of 7688 hectare with an average production of 72902 MT (Anon., 2014) [4]. Despite such a huge production in the country, less than the appropriate requirement of balanced diet is provided to every individual.

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. 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 particularly people living around the forest fringe. It is estimated that in India about 800

species are consumed as wild edible plants over the country (Singh and Arora, 1978) [17]. Vegetable amaranth serves as an alternative source of nutrition for people in developing countries since it is a rich and inexpensive source of carotenoid, protein, vitamins and dietary fibre (Prakash and Pal, 1991; Shukla *et al*., 2003) [13, 16]. It has been rated equal or superior in taste to spinach and is considerably higher in protein (14 - 30% on dry weight basis), minerals (Fe, Mn and Zn), and antioxidants like beta-carotenoid (90 - 200 mg kg-1) and ascorbic acid (about 28 mg/100 g) compared to any other leafy vegetables. Amaranth vegetables contribute greatly to the nutritional well-being of rural people by providing the essential nutrients required for body growth and development and for prevention of diseases associated with nutritional deficiencies such as blindness due to vitamin A deficiency (Varalakshmi, 2011) [19].

Materials and Methods

This chapter deals with a concise description of the material used and the technique adopted during the course of investigation. The present investigation entitled "Evaluation and Characterization of Leafy Vegetables (Amaranthus spp.) grown in Chhattisgarh" was conducted at Research and Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the experiment 1 conducted during rabi season of 2014-2015 and 2015-16 while experiment 2 was conducted during kharif season of the both year. Raipur district is situated in the central part of Chhattisgarh, agroclimatologically known as Chhattisgarh plains and lies between 21o 16' N latitude and 81o 36' E longitude with an altitude of 289.56 meters above the mean sea level. Twenty five indigenous genotypes and check variety CO- 1 of khedha (*Amaranthus dubius* Mart.) where collected from different place of Chhattisgarh during May to June 2014. The observations on different growth parameters and leaf yield attributes were recorded on ten randomly selected competitive plants from each plot of all replications. The Mahalanobis (1936) [11] D^2 statistic was used to measure the genetic divergence between the populations. The D2 value was estimated on the basis of "P" character by the formula:

$$D^2P = \sum_{i=1}^{P}\sum_{j=1}^{P} = (\Lambda ij)\, \Lambda i \Lambda j$$

Where,
(i, j) is the reciprocal or (i, j), the pooled common dispersion matrix (i.e. Error matrix)
I = the difference in the mean value for the i^{th} character
J = the difference in the mean value for the j^{th} character

Calculating the D^2 values, the variance and covariance were calculated. The genotypes were grouped into different clusters by Tocher's method. The population was arranged in order of their relative distances from each other. For including a particular population in the clusters, a level of D^2 was fixed by taking the maximum D^2 values between any two populations in the first row of the table where D^2 values were arranged in increasing order of magnitude.

Result and Discussion

Divergence analysis of khedha (*Amaranthus dubius* Mart.)

The concept of D2 statistics was originally developed by Mahalonobis (1936) [11]. Then Rao (1952) [14] suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is being extensively used in vegetable breeding also to study the selection of different parents. Genetic variability and selection of parents from diverse breeding material including germplasm and there diverse parents, can be used for the development of variety in khedha.

On the basis of D2 analysis, twenty five genotypes and check variety CO-1 were grouped into four clusters [Table1]. During 2014-15 maximum number of genotypes was grouped into cluster I IGKB-2014-34, IGKB-2014-41, IGKB-2014-43, IGKB-2014-44, IGKB-2014-45, IGKB-2014-46, IGKB-2014-50, IGKB-2014-52, IGKB-2014-53, IGKB-2014-54, IGKB-2014-55) included eleven genotypes and cluster II (IGKB-2014-38, IGKB-2014-40, IGKB-2014-42, IGKB-2014-47, IGKB-2014-48, IGKB-2014-49, IGKB-2014-51) included seven genotypes, cluster III (IGKB-2014-31, IGKB-2014-32, IGKB-2014-33, IGKB-2014-35, IGKB-2014-36, IGKB-2014-37, IGKB-2014-39). Whereas, cluster IV (Variety CO-1) included one variety in cluster. During the year 2015-16 [Table 3] ten of genotypes were grouped into cluster I (IGKB-2014-33, IGKB-2014-34, IGKB-2014-43, IGKB-2014-45, IGKB-2014-46, IGKB-2014-48, IGKB-2014-52, IGKB-2014-53, IGKB-2014-54, IGKB-2014-55) included eleven genotypes, whereas, cluster II (IGKB-2014-37, IGKB-2014-38, IGKB-2014-40, IGKB-2014-42, IGKB-2014-44, IGKB-2014-47, IGKB-2014-49, IGKB-2014-50, IGKB-2014-51)

As regards pooled analysis seven of genotypes were grouped into cluster II (IGKB-2014-83, IGKB-2014-40, IGKB-2014-41, IGKB-2014-45, IGKB-2014-47, IGKB-2014-48, IGKB-2014-49, IGKB-2014-50, IGKB-2014-51, IGKB-2014-54, IGKB-2014-55) included twelve genotypes, which is followed by cluster III (IGKB-2014-31, IGKB-2014-32, IGKB-2014-33, IGKB-2014-35, IGKB-2014-36, IGKB-2014-37, IGKB-2014-39) included seven genotypes, cluster I (IGKB-2014-34, IGKB-2014-43, IGKB-2014-44, IGKB-2014-46, IGKB-2014-52, IGKB-2014-53) included six genotypes and cluster IV (Variety CO-1) included one genotype in cluster.

Table 1: Composition of clusters of khedha: year 2014-15

Cluster Number	Number of genotypes included	Name of genotypes
I	11	IGKB-2014-34, IGKB-2014-41, IGKB-2014-43, IGKB-2014-44, IGKB-2014-45, IGKB-2014-46, IGKB-2014-50, IGKB-2014-52, IGKB-2014-53, IGKB-2014-54, IGKB-2014-55
II	7	IGKB-2014-38, IGKB-2014-40, IGKB-2014-42, IGKB-2014-47, IGKB-2014-48, IGKB-2014-49, IGKB-2014-51
III	7	IGKB-2014-31, IGKB-2014-32, IGKB-2014-33, IGKB-2014-35, IGKB-2014-36, IGKB-2014-37, IGKB-2014-39
IV	1	Variety CO-1

Table 2: Intra (bold) and Inter cluster distance values in khedha: Year-2014-15

Cluster Number	I	II	III	IV
I	2.814			
II	3.003	2.855		
III	2.920	3.677	2.947	
IV	6.215	6.847	7.119	-

Table 3: Composition of clusters in khedha: Year-2015-16

Cluster Number	Number of genotypes included	Name of genotypes
I	11	IGKB-2014-33, IGKB-2014-34, IGKB-2014-43, IGKB-2014-45, IGKB-2014-46, IGKB-2014-48, IGKB-2014-52, IGKB-2014-53, IGKB-2014-54, IGKB-2014-55
II	9	IGKB-2014-37, IGKB-2014-38, IGKB-2014-40, IGKB-2014-42, IGKB-2014-44, IGKB-2014-47, IGKB-2014-49, IGKB-2014-50, IGKB-2014-51
III	5	IGKB-2014-31, IGKB-2014-32, IGKB-2014-35, IGKB-2014-36, IGKB-2014-39
IV	1	Variety CO-1

Table 4: Intra (Bold) and Inter cluster distance values in khedha: Year-2015-16

Cluster Number	I	II	III	IV
I	2.870			
II	2.590	2.947		
III	3.157	3.077	2.375	
IV	8.128	8.471	7.974	-

These results are in general agreement with the findings of Anuja *et al*., (2007) [5], Anuja (2011) [7] for number of leaves plant-1. Similar result shows Ahammed *et al.* (2013) [1] and Akther *et al.* (2013) [2]. In the year of 2014-15 (Table 7) cultivation intra-cluster distance varied from 2.814 to 2.947. The maximum intra cluster distance was shown by cluster III (2.947) followed by cluster II (2.855) and cluster I (2.814), which indicates distance within the cluster. In the year of 2015-16 (Table 8) cultivation intra-cluster distance varied from 2.375 to 2.947. The maximum intra cluster distance was shown by cluster II (2.947) followed by cluster I (2.870) and cluster III (2.375) which indicates distance within the cluster. In the pooled analysis (Table 8) intra-cluster distance varied from 0.003 to 2.976. The maximum intra cluster distance was shown by cluster III (2.976) followed by cluster II (2.815), cluster I (2.423) and cluster IV (0.003), which indicates distance within the cluster. The intra and inter-cluster distance among 25 genotypes revealed that Cluster III showed the maximum inter-cluster value (2.976) in pooled analysis, which is in confirmation to the finding of Chattopadhyay *et al*. (2013), Kallow (1980), Akther *et al*. (2013) [2].

Mean performance of clusters of khedha (*Amaranthus dubius* Mart.)

During the year 2014-15 plant height showed the lowest mean performance for cluster III (92.82), which was followed by cluster I (96.61), cluster II (101.02) and highest in cluster IV (111.07). Number of leaves plant^{-1} exhibited the lowest mean performance for cluster I.

(18.18), followed by cluster II (18.48), cluster III (22.29) and highest in cluster IV (28.33). Number of branches plant-1 exhibited the lowest mean performance for cluster I (3.18), followed by cluster III (3.38), cluster II (3.95) and highest in cluster IV (4.67). Leaf length showed the lowest mean performance for cluster III (2.83) followed by cluster I (3.55), cluster II (3.62) and highest in cluster IV (4.00). Leaf breadth exhibited the lowest mean performance for cluster III (2.54) followed by cluster II (3.07), cluster I (3.30) and highest in cluster IV (4.47). Petiole length showed the lowest mean performance for cluster V II (2.34), followed by cluster I (2.56), cluster III (2.79) and highest in cluster IV (3.53). Stem girth exhibited the lowest mean performance for cluster I (7.41), followed by cluster II (7.89), cluster III (8.40) and highest in cluster IV (10.67). Fresh leaf weight exhibited the lowest mean performance for cluster II (113.87), followed by cluster II (139.32), cluster I (150.75) and highest in cluster IV (195.50). Dry matter percent showed the lowest mean performance for cluster III (11.98), followed by cluster I (12.05), cluster IV (14.81) and highest in cluster II (17.41). Duration of crop showed the lowest mean performance for cluster IV (29.33), followed by cluster I (34.21), cluster III (38.95) and highest in cluster II (40.43). Harvest index showed the lowest mean performance for cluster II (4.41), followed by cluster II (5.97), cluster I (6.37) and highest in cluster IV (6.64). Fibre content exhibited the lowest mean performance for cluster III (7.28) followed by cluster II (10.04), cluster I (10.99) and highest in cluster IV (15.67). Yield plot-1 exhibited the lowest mean performance for cluster III (2.41), followed by cluster I (2.54), cluster II (2.54) and highest in cluster IV (2.94).

During the year 2015-16 plant height showed the lowest mean performance for cluster III (92.12), which was followed by cluster I (93.65), cluster II (97.84) and highest in cluster IV (99.90). Number of leaves plant-1 exhibited the lowest mean performance for cluster I (16.65), followed by cluster II (17.34), cluster III (21.58) and highest in cluster IV (27.33). Number of branch plant-1 exhibited the lowest mean performance for cluster III (3.33), followed by cluster I (3.36), cluster II (3.56) and highest in cluster IV (5.67). Leaf length showed the lowest mean performance for cluster III (2.62) followed by cluster II (2.84), cluster I (3.31) and highest in cluster IV (4.03). Leaf breadth exhibited the lowest mean performance for cluster III (2.58) followed by cluster II (2.88), cluster I (3.31) and highest in cluster IV (4.97). Petiole length showed the lowest mean performance for cluster II (2.48), followed by cluster I (2.67), cluster III (2.93) and highest in cluster IV (3.97). Stem girth exhibited the lowest mean performance for cluster I (7.31), followed by cluster III (8.09), cluster II (8.30) and highest in cluster IV (11.97). Fresh leaf weight exhibited the lowest mean performance for cluster II (119.84), followed by cluster III (130.82), cluster I (133.28) and highest in cluster IV (199.11). Dry matter percent showed the lowest mean performance for cluster III (12.16), followed by cluster IV (13.44), cluster I (15.30) and highest in cluster IV (16.34). Duration of crop showed the lowest mean performance for cluster IV (30.00), followed by cluster I (34.61), cluster III (35.27) and highest in cluster II (39.96). Harvest index showed the lowest mean performance

for cluster II (4.42), followed by cluster III (4.64), cluster I (5.44) and highest in cluster IV (5.99). Fibre content exhibited the lowest mean performance for cluster III (5.27) followed by cluster I (9.51), cluster II (10.35) and highest in cluster IV (15.83). Yield plot-1 exhibited the lowest mean performance for cluster I (2.40), followed by cluster II (2.79), cluster III (2.87) and highest in cluster IV (3.37).

Table 5: Mean performance of genotypes in individual cluster for yield and its components in khedha : Year-2014-15

Cluster	Plant height (cm)	No. of leaves/ plant	No of branches/ plant	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)	Stem girth (mm)	Fresh leaf weight (g)	Dry matter %	Duration of crop	Harvest index %	Fibre content %	Yield/ plot (kg)
I	96.61	18.18	3.18	3.55	3.30	2.56	7.41	150.75	12.05	34.21	6.37	10.99	2.54
II	101.02	18.48	3.95	3.62	3.07	2.34	7.89	113.87	17.41	40.43	4.41	10.04	2.54
III	92.82	22.29	3.38	2.83	2.54	2.79	8.40	139.32	11.98	38.95	5.97	7.28	2.41
IV	111.07	28.33	4.67	4.00	4.47	3.53	10.67	195.50	14.81	29.33	6.64	15.67	2.94

Table 6: Mean performance of genotypes in individual cluster for yield and its components in khedha : Year-2015-16

Cluster	Plant height (cm)	No. of leaves/plant	No of branches/ plant	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)	Stem girth (mm)	Fresh leaf weight (g)	Dry matter %	Duration of crop	Harvest index %	Fiber content %	Yield/ plot (kg)
I	93.65	16.65	3.36	3.31	3.31	2.67	7.31	133.28	15.30	34.61	5.44	9.51	2.40
II	97.84	17.34	3.56	2.84	2.88	2.48	8.30	119.84	16.34	39.96	4.42	10.35	2.79
III	92.12	21.58	3.33	2.62	2.58	2.93	8.09	130.82	12.16	35.27	4.64	5.27	2.87
IV	99.90	27.33	5.67	4.03	4.97	3.97	11.67	199.11	13.44	30.00	5.99	15.83	3.37

Table 7: Mean performance of genotypes in individual cluster for yield and its components in khedha : Pooled Analysis

Cluster	Plant height (cm)	No. of leaves /plant	No of branches /plant	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)	Stem girth (mm)	Fresh leaf weight (g)	Dry matter %	Duration of crop	Harvest index %	Fibre content %	Yield/ plot (kg)
I	92.87	18.64	2.83	3.44	3.29	2.60	7.29	160.95	14.91	33.69	6.35	11.17	2.54
II	99.17	17.10	3.75	3.37	3.17	2.49	7.74	119.03	14.97	37.47	4.53	10.03	2.64
III	92.65	21.45	3.38	2.73	2.54	2.81	8.42	135.79	12.62	38.14	5.63	6.56	2.55
IV	105.40	27.83	5.00	4.02	4.72	3.75	11.17	197.31	14.13	29.67	6.32	15.75	3.16

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