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# Genetic studies for biochemical and quantitative characters in Bathua (*Chenopodium album* L.)

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**Abstract**
India, being blessed with a variety of natural surroundings and varying climates and seasons, has a number of species of edible leafy vegetables of which bathua is also an important underutilized leafy vegetable gaining popularity in different parts of India and world. However, lack of studies on nutritional composition of leaves with absolutely no information on the qualitative improvement of foliage yield with special reference to minerals. Studies on correlation among the minerals as well as with yield also lacking. Hence, Twenty four genotypes of bathua (*Chenopodium album* L.) were evaluated for salient biochemical and quantitative traits. Our study showed that bathua is a rich source of Vitamin-A (389.16±17.19 mg/100g), Vitamin-C (43.07±1.11 mg/100g), Protein (4.11±0.16 mg/100g), Calcium (1202.19 ± 42.51 mg/100g), Magnesium (597.56±23.57 mg/100g), Iron (6.19 ±0.37 mg/100g), zinc (0.114 ±0.01 mg/100g). The heritability estimates were high for Zinc and magnesium, while comparatively lower value were recorded for vitamin-C and leaf area. Foliage yield per plant had significant positive correlation with all traits. Protein exhibited significantly positive association foliage yield per plant, Leaf area, magnesium and calcium content. Calcium content shows strong positive association with magnesium, zinc, iron content and foliage yield per plant. This study would be of use in determination of chemical composition of leaf is necessary for variety evaluation, on the basis of high nutritive value for human diet.

**Keywords:** Biochemical, bathua, *Chenopodium album* L.

## Introduction
Malnutrition, a major nutritional problem in India and other developing countries is responsible for about 40-50 per cent of the infant deaths all over the World (Singh *et al.* 2007). The major reason for this is increasing gap between food supply and population growth. In the present scenario it is important for diversification towards traditional crops because the current dependence on a few major crops may result in food scarcity. The current day need is to look upon novel high quality but inexpensive food sources and less familiar crops which may provide reasonable productivity and reliability as well as nutritional and medicinal benefits. Underutilized crops like bathua, buckwheat, and amaranth have recently gained worldwide attention in this respect as these contain abundant amounts of all the common nutrients required for normal human growth. Simultaneously, these crops do not require large inputs and can be grown in agriculturally marginal lands.
Chenopodium (Family *Chenopodiaceae*) includes over 250 wild and weedy species native to Western Asia (Risi and Galwey 1986) [9]. In India, it is represented by about 21 species, of which some are cultivated for an end use as vegetable and a few for the grains obtained from the plant (Yadav *et al.* 2007). The species used as vegetable types have short plants with large smooth leaves, small auxiliary inflorescences, and succulent stems. The leaves of bathua constitute an inexpensive and rich source of protein, carotenoid, vitamin C, and dietary fiber. But in spite of being a rich and cheap source of nutrients and the ability to grow in marginal environments, the neglected status of *C. album* still persists. Although reports on morphological variability in *C. album* are available (Bhargava *et al*. 2003) [2], the information on quality traits is totally missing. Keeping in view the immense nutritive importance of bathua, the present investigation was undertaken to ascertain the mineral composition of different strains of Bathua and to find out possible ways for their enhancement, thereby resulting in qualitative improvement of the foliage.

## 2. Material and Methods

The material consisted of 24 accessions of bathua (*Chenopodium album* L.), these were evaluated during kharif 2018 at the experimental field of KRCCH, Arabhavi in a randomized block design with three replications. The plot size for each genotypes w 2 m$^2$ with row-to-row distance 25 cm and plant-to-plant distance was 15cm. Normal cultural practices were followed during the experimentation. After 4$^{th}$ week of sowing, 1$^{st}$ cutting of foliage started and subsequent cuttings were done at the interval of 15 days. A total of three cuttings were done and data on foliage yield (Kg) was recorded on plot basis separately for each cutting and then pooled for total foliage yield. Twenty plants from each accession of each replication were taken randomly for recording observations on Vitamin-A, Vitamin-C, Protein, Calcium, Magnesium, Iron, zinc, Leaf area and Foliage yield per plant.

### Biochemical Traits

For biochemical analysis such as estimation of Vitamin-A, Vitamin-C, Protein, Calcium, Magnesium, Iron, zinc, content multiple leaves of each accession were plucked randomly from multiple plants. The extraction and estimation of minerals like calcium, magnesium, iron and zinc were done by using atomic absorption spectrophotometer method as suggested by Perkin-Elmer (1982) [8]. Total protein content of leaf was estimated following the method of Lowry *et al.* (1951). Ascorbic acid content was estimated by using 2, 6,-dichlorophenol indophenols dye by volumetric method. Colorimetric estimation of vitamin-A with trichloroacetic acid method (Bayfield, *et al.*, 1980) [1].

### Quantitative Traits

Twenty plants from each accession were taken to compile the observations on foliage yield plant per plant. From these five plants were involved for Leaf area and Foliage yield per plant. Correlation coefficients and path coefficient for Vitamin-A, Vitamin-C, Protein, Calcium, Magnesium, Iron, zinc, Leaf area and Foliage yield per plant were analyzed by the method of Dewey and Lu (1959) [3].

## 3. Results

The analysis of variance revealed significant differences among the genotypes for all the nine characters, which validated further statistical analysis (data not shown). The vitamin and mineral content of the leaves of 24 genotypes of bathua is presented in (Table 1).

**Table 1:** Mean performance of bathua genotypes for Quality parameters

| S. N | Genotype | VA (mg) | VC (mg) | PR (g) | Ca (mg) | Mg (mg) | Fe (mg) | Zn (mg) | LA (cm$^2$) | FYP (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | EC-359444 | 345.73 | 37.83 | 3.78 | 879.83 | 5.34 | 456.90 | 0.076 | 40.65 | 33.60 |
| 2 | NC-50229 | 341.33 | 43.51 | 3.85 | 1079.83 | 2.96 | 456.90 | 0.033 | 64.48 | 43.13 |
| 3 | HUB – 1 | 353.83 | 43.58 | 3.90 | 1159.83 | 5.26 | 336.90 | 0.133 | 40.72 | 52.13 |
| 4 | HUB – 2 | 410.50 | 43.77 | 3.89 | 1359.83 | 4.99 | 456.90 | 0.133 | 67.19 | 64.80 |
| 5 | EC-359445 | 381.93 | 43.70 | 3.75 | 1279.83 | 7.03 | 456.90 | 0.066 | 43.66 | 41.00 |
| 6 | IC-243192 | 334.00 | 43.58 | 4.09 | 1079.83 | 8.35 | 528.90 | 0.126 | 71.01 | 52.60 |
| 7 | HUB – 3 | 325.50 | 41.26 | 6.04 | 1319.83 | 4.53 | 792.90 | 0.116 | 69.81 | 54.06 |
| 8 | IC-341703 | 455.76 | 43.90 | 4.75 | 1439.83 | 8.75 | 432.90 | 0.120 | 67.73 | 69.86 |
| 9 | HUB – 4 | 250.56 | 44.41 | 4.21 | 1079.83 | 8.31 | 240.90 | 0.116 | 68.70 | 72.66 |
| 10 | IC-109249 | 248.83 | 40.35 | 3.24 | 1226.50 | 9.70 | 192.90 | 0.116 | 41.10 | 48.33 |
| 11 | NIC-22506 | 329.16 | 41.16 | 4.64 | 879.83 | 2.36 | 576.90 | 0.116 | 57.36 | 53.66 |
| 12 | HUB – 5 | 365.40 | 43.07 | 3.95 | 1279.83 | 1.75 | 504.90 | 0.116 | 44.33 | 42.50 |
| 13 | NC-58616 | 308.30 | 44.51 | 4.20 | 1159.83 | 4.71 | 456.90 | 0.126 | 56.45 | 56.66 |
| 14 | NIC-22492 | 463.40 | 40.50 | 3.32 | 799.83 | 1.43 | 72.90 | 0.096 | 41.80 | 49.33 |
| 15 | IC-109235 | 429.73 | 40.76 | 4.02 | 1199.83 | 4.26 | 528.90 | 0.110 | 39.92 | 44.70 |
| 16 | HUB-6 | 467.10 | 45.96 | 4.63 | 1399.83 | 8.99 | 1272.90 | 0.116 | 73.74 | 92.83 |
| 17 | HUB – 8 | 497.56 | 46.10 | 4.68 | 1599.83 | 9.62 | 1360.90 | 0.156 | 75.04 | 117.00 |
| 18 | IC-415477 | 409.50 | 43.25 | 3.84 | 1199.83 | 9.76 | 888.90 | 0.130 | 57.54 | 53.58 |
| 19 | IC-540831 | 423.76 | 45.08 | 4.47 | 1159.83 | 7.73 | 792.90 | 0.123 | 69.40 | 84.00 |
| 20 | NIC-22517 | 475.33 | 44.50 | 4.06 | 1349.83 | 8.93 | 216.90 | 0.146 | 59.38 | 64.70 |
| 21 | HUB – 7 | 523.73 | 46.27 | 5.50 | 1559.83 | 11.60 | 1440.90 | 0.156 | 76.04 | 144.66 |
| 22 | IC-540842 | 465.36 | 45.25 | 4.22 | 1359.83 | 8.28 | 888.90 | 0.123 | 48.94 | 85.00 |
| 23 | IC-4152393 | 345.00 | 40.66 | 2.85 | 1199.83 | 1.41 | 216.90 | 0.096 | 56.83 | 44.75 |
| 24 | HUB – 9 | 388.70 | 40.73 | 2.84 | 799.83 | 2.54 | 768.90 | 0.096 | 59.08 | 46.33 |
| | Mean | 389.16 | 43.07 | 4.11 | 1202.19 | 6.19 | 597.56 | 0.114 | 57.95 | 62.99 |
| | S.Em± | 17.19 | 1.11 | 0.16 | 42.51 | 0.37 | 23.57 | 0.0017 | 2.96 | 4.87 |
| | CD (0.05) | 48.95 | 3.16 | 0.47 | 121.02 | 1.06 | 67.09 | 0.0048 | 8.44 | 13.88 |
| | CV (%) | 7.65 | 4.47 | 6.99 | 6.12 | 10.42 | 6.83 | 2.56 | 8.86 | 13.4 |

VA- Vitamin-A VC-Vitamin-C PR-Protein Ca- Calcium Mg-Magnesium Fe- Iron Zn-Zinc LA- Leaf area FYP-Foliage yield per plant

### Vitamins

Vitamin-A, Vitamin-C and Protein content were estimated (Table 1) for all 24 genotypes which showed that HUB – 7 had maximum Vitamin-A content (523.73 mg/100g) followed by HUB-8 (497.56 mg/100g) and NIC-22517 (475.33 mg/100g), HUB-7 had maximum Vitamin-C content (46.27 mg/100g) followed by HUB-8 (46.10 mg/100g) and HUB-6 (45.96 g/100g) and HUB-3 had maximum Protein content (6.04 mg/g) followed by HUB-7 (5.50 g/100g) and IC-341703 (4.75 g/100g).

### Minerals

***Calcium***: HUB-8 had the highest calcium content (1599.83mg/100g), followed by HUB-7 (1559.83 mg/100 g) and IC-341703 (1439.83 mg/100 g). The lowest amount of calcium was found in HUB-9 (799.83 mg/100 g). The mean calcium content for 24 strains was 1202.19 mg/100 g. The coefficient of variability for calcium was 6.12%

**Iron:** The iron content among the genotypes ranged from 1.41mg/100g to 11.60 mg/100g with an average of 6.19 mg/100g. Highest amount of iron was found in HUB–7, while lowest amount in the leaves of IC-4152393. Among all the four minerals analysed, coefficient of variability was maximum for iron (10.42%)

**Magnesium:** The magnesium content averaged 597.56 mg/100g the highest being found in HUB–7 (1440.90 mg/100g) followed by HUB-8 (1360.90 mg/100g) and HUB-6 (1272.90 mg/100g). The coefficient of variability for magnesium 6.83%.

**Zinc:** Zinc ranged from 0.03 mg/100g to 0.15 mg/100g in all the 24 genotypes. The mean zinc content among the genotypes was 0.11 mg/100g, the richest source of zinc was HUB-7 (0.15 mg/100g), followed by HUB-8 (0.15mg/100g) and NIC-22517 (0.14mg/100g).

**Leaf area: T**he leaf area varied from 39.92 $cm^2$ (IC-109235) to 76.04 $cm^2$ (HUB – 7) with an overall mean of 57.95 ± 2.96 $cm^2$. Only 12 out of 24 genotypes had leaf area higher than the mean value. The coefficient of variability for leaf are was 8.86%.

**Foliage yield:** The genotypes of bathua under study yielded abundant foliage yield that ranged from 33.60 g/plant (EC-359444) to 144.66 g/plant (HUB – 7), with an overall mean of 62.99 ± 4.87 g/plant. Out of 24 genotypes, 10 had foliage yield >62 g/plant, while six had low yield <50g/plant.

**Variability studies**

Variability plays an important role in crop breeding programs. The extent of diversity in crop determines the limits of selection for improvement. In any crop-breeding program, it is prerequisite to have a large variation in the material at the hand of breeder. The characters of economic importance are generally quantitative in nature and exhibit considerable degree of interaction with the environment. Thus, it becomes necessary to compute variability present in the material and its partitioning into genotypic, phenotypic, and environmental effects. The values of phenotypic coefficient of variability (PCV) were greater than the corresponding genotypic coefficient of variability (GCV) values, though in many cases the differences were small. Magnesium, Iron, foliage yield/plant showed high genotypic coefficient of variation values, while rest of the traits exhibited moderate GCV and PCV values (Table 2). The heritability estimates were high for most of the traits, with Zinc and magnesium showing high values (98.86 % and 98.77%, respectively), while comparatively lower value were recorded for vitamin-C and leaf area (Table 2). The expected genetic advance as percentage of mean ranged from 1.05 % to 749.32 %. Maximum genetic gain was observed for Magnesium (749.32 %), followed by calcium (409.48%) and vitamin (137.65%). Leaf area and foliage yield per plant also showed high genetic gain (23.04% and 50.0% respectively) (Table 2).

**Table 2:** Selection parameters for various economic traits in bathua

| Sl. No. | Character | GCV (%) | PCV (%) | $h^2$ | GA |
|---|---|---|---|---|---|
| 1. | Vitamin- A (mg) | 18.57 | 20.08 | 85.48 | 137.65 |
| 2. | Vitamin –C (mg) | 4.36 | 6.24 | 48.80 | 2.70 |
| 3. | Protein (g) | 17.21 | 18.58 | 85.82 | 1.35 |
| 4. | Calcium (mg) | 17.51 | 18.55 | 89.10 | 409.48 |
| 5. | Magnesium (mg) | 61.24 | 61.62 | 98.77 | 749.32 |
| 6. | Iron (mg) | 49.56 | 50.65 | 95.77 | 6.18 |
| 7. | Zinc (mg) | 23.88 | 24.01 | 98.86 | 1.05 |
| 8 | Leaf area ($cm^2$) | 20.95 | 22.75 | 84.83 | 23.04 |
| 9 | Foliage yield per plant (g) | 40.58 | 42.73 | 90.16 | 50.00 |

$h^2$ – Broad sense heritability GA- Genetic advance GCV- Genotypic co-efficient of variation PCV- Phenotypic co efficient of variation

**Correlation studies**

The genotypic correlation among various characters are presented in Table 3. The perusal of (Table 3) revealed that Foliage yield per plant had significant positive correlation with Vitamin A, Vitamin C, Protein, Calcium, Iron, magnesium, zinc and leaf area. Vitamin A was positively correlated with calcium and vitamin C content, however, it was significantly with foliage yield per plant, magnesium content while Vitamin C was found to have a positive and significantly association with foliage yield per plant, Leaf area magnesium, iron and calcium content. It was also significantly and positively associated with protein and zinc content. Protein exhibited significantly positive association foliage yield per plant, Leaf area, magnesium and calcium content.

**Table 3:** Genotypic correlation coefficients between vitamins, proteins, minerals, leaf area and foliage yield in bathua.

| | Vit-A | Vit-C | Protein | Ca | Fe | Mg | Zn | LA | FY |
|---|---|---|---|---|---|---|---|---|---|
| Vit-A | 1.000 | 0.457* | 0.257 | 0.474* | 0.310 | 0.554** | 0.368 | 0.250 | 0.613** |
| Vit-C | | 1.000 | 0.452* | 0.685** | 0.590** | 0.532** | 0.485* | 0.603** | 0.740** |
| Protein | | | 1.000 | 0.528** | 0.397 | 0.567** | 0.418* | 0.562** | 0.579** |
| Ca | | | | 1.000 | 0.617** | 0.516** | 0.531** | 0.425* | 0.658** |
| Fe | | | | | 1.000 | 0.471* | 0.526** | 0.409* | 0.649** |
| Mg | | | | | | 1.000 | 0.389 | 0.562** | 0.755** |
| Zn | | | | | | | 1.000 | 0.352 | 0.630** |
| LA | | | | | | | | 1.000 | 0.647** |
| FY | | | | | | | | | 1.000 |

*Significant at 5% **Significant at 1%

Calcium content was found to have a positive and significantly association with foliage yield per plant, magnesium, zinc, iron content. Iron was found to have a positive and significantly association with foliage yield per plant, zinc content. It was also significantly and positively associated with magnesium and leaf area. Magnesium was found to have a positive and significantly association with foliage yield per plant and leaf area. Zinc and leaf area was found have a positive and significantly association with foliage yield per plant.

## 4. Discussion

In the present study, high GCV and PCV were observed for leaf area, foliage yield per plant, magnesium content, iron content, and zinc content of leaves. It shows the existence of broad genetic base, which would be suitable for further selection. The similar results were also observed by Panda *et al.* (2017) [7] for foliage yield per plant; Bhargava *et al.* (2010) for zinc content. Moderate GCV and PCV were observed for vitamin –A content, protein, and calcium content of leaves. This implied equal importance of additive and non-additive gene action in these characters. These results are in accordance with results of Bhargava *et al.* (2010) for calcium content; Selvin *et al.* (2013) for protein content; Bhargava *et al.* (2007) for vitamin –A content.

Coefficient of variation indicates only the extent of variability present in genotypes for different traits, but for the prediction of response to selection heritability estimates are useful. High broad sense heritability (> 60%) was observed for leaf area, foliage yield per plant, Vitamin-A, Protein, calcium, magnesium, iron, zinc. Heritability is the fundamental in practicability of selection, because it act as predictive instrument in expressing the variability of phenotypic value as guide to breeding value. Similar results were also obtained by Umakanta *et al.* (2014) [12] for leaf area; Hasan *et al.* (2013) for foliage yield per plant; Bhargava *et al.* (2008), for vitamin-A content; Bhargava *et al.* (2003) for protein content; Bhargava *et al.* (2010) for calcium, magnesium, iron, zinc content. The very high estimates of heritability coupled with high values of genetic advance over per cent mean were observed for traits such as leaf area, foliage yield per plant, vitamin-A, protein, calcium, magnesium, iron, zinc. These characters are under the influence of additive gene action. These results are in accordance with the findings of Meena *et al.* (2014) [6] for leaf area; Panda *et al.* (2017) [7] for foliage yield per plant; Umakanta *et al.* (2014) [12] for vitamin-A and calcium content; Selvin *et al.* (2013) for protein content; Bhargava *et al.* (2010) for magnesium, iron and zinc content.

Correlation studies indicate the degree of inter-relationship of plant characters for improvement of yield as well as important quality parameters in any breeding programme. Hence, In the present study, foliage yield per plant was significantly and positively correlated with leaf area, vitamin-A, vitamin-c, protein content, calcium content, magnesium content, iron content, zinc content genotypic level. Similar observations were made by Sarker *et al.* (2014) [10], Khurana *et al.* (2013) [5] for leaf area.

## 5. Conclusion

The present study screened out a Top five genotypes viz., HUB-7, HUB-8, HUB-6, IC-540842, and IC-540831 for high foliage yield per plant and quality parameters. However, our study showed that bathua is a rich source of Vitamin-A, Vitamin-C, Protein, Calcium, Magnesium, Iron, zinc. This brings to forth the nutritional superiority of bathua, which is presently “underutilized” in terms of consumption and trade, but offers exciting prospects for crop diversification and nutritional needs of the community.

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