



Varietal Identification and Seed Quality Estimation through Biochemical Characterisation of Amaranth (*Amaranthus hypochondriacus* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted during *kharif* of 2021 at College of Forestry, Ranichauri, Tehri Garhwal of VCSG Uttarakhand University of Horticulture & Forestry, Bharsar, Pauri, Garhwal, Uttarakhand, to investigate the biochemical characteristics of different varieties of amaranth. The laboratory experiment was conducted in completely randomized design (CRD) with three

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replications comprising seven varieties to assess the seed quality and biochemical characters of grain amaranth. In laboratory condition, the seed quality attributes under standard germination test, viz., germination percentage, seedling total length, seedling fresh and dry weight, and seedling vigour indices were recorded higher with the treatment T₅(PRA-2). Under stress test, viz., accelerate ageing, cold test and water sensitivity test, significantly higher value of seed quality parameters were recorded with the treatment T₆(PRA-3). On the basis of this investigation, it could be concluded that treatments T₄ (PRA-1), T₅(PRA-2), T₆(PRA-3) and T₇(Annapurna) are performing overall better for biochemical and seed quality of amaranth.

Keywords: Cold test; stress test; seedling vigour indices; Uttarakhand.

1. INTRODUCTION

Amaranthus (*Amaranthus* spp.) is considered one of the important leafy vegetables. *Amaranthus* is also referred to as "*Chaula*". The genus *Amaranthus* consists of approximately 60 species, out of which, 18 species are present in India [1,2,3]. There are three grain amaranth species namely (*A. hypochondriacus*, *A. caudatus* and *A. cruentus*), which are self-pollinating diploids, having chromosome 2n = 32, 2n=34 and 2n= 64, respectively. *A. cruentus*L. and *A. hypochondriacus*L. are originates from Central America and North America, respectively, whereas *A. caudatus*L. is originates from South America. Amaranth can be grown from temperate to tropical conditions due to its high adaptability and versatility. Besides these species, one of the grain amaranth species is *A. edulis*. Further, there are three weedy species, i.e. *A. hybridus*, *A. powelli* and *A. quitensis* associated with the crop [4].

It is a crop that grows quickly, has a quick potential yield, and may be rotated with any other vegetable crop. In the last 20 years, amaranth has been rediscovered as a promising food crop, mainly due to its resistance to heat, drought, diseases and pests, and the high nutritional value of both seeds and leaves [5], (Saunders and Becker, 1984). The composition of amaranth is particularly rich in essential aminoacids, and its protein content is much higher than conventional food sources like wheat, barley and maize [6].

Amaranthus has prominent nutritional value due to the high content of important micronutrients among them, protein (14-19%), carbohydrates (62-66%), fiber (4-5%), fat (6-7%) and ash (2.5-4.4%) [7]. *Amaranthus* is mainly grown from tropical-low-lands to 3,500 m above mean sea level in the Himalayas [8]. *Amaranthus* proteins are globular, which mean that they take a longer time than random-coil proteins (like casein) to unfold and absorb onto the oil/water interface [9].

In an overall point of view, seed is an essential element in agriculture, which decides the success of any crop production programme, and the use of good quality seeds for planting is necessary for the successful production of any crop. So, quality testing has a great importance for the evaluation of varietal superiority in the environment [10,11].

2. MATERIALS AND METHODS

The lab experiment was conducted at Seed Science Lab, College of Forestry, Ranichauri. The laboratory experiment was conducted in Completely Randomized Block Design (CRD) with three replications. It comprised seven varieties viz., VL-110, Rudrakshya, Durga, PRA-1, PRA-2, PRA-3 and Annapurna to assess the seed quality and biochemical characters of grain amaranthus. In laboratory condition (under standard germination test) the following variables: germination percentage, seedling total length, seedling fresh and dry weight, seedling vigour indices, protein content and electrical conductivity. In order to evaluate the ability of seeds to emerge under favourable conditions, a standard germination test was used (ISTA, 2003).

3. RESULTS AND DISCUSSION

The statistical analysis showed highly significant differences among the varieties for all the traits studied. The mean values for all the experiments are presented in the Tables. According to the findings of this study, T₅(PRA-2) had a significant effect on the first count and germination percent of seeds. Similar information were presented in wheat [12] and bean seed [13]. Genetic variations among the varieties might explain the differences in the first count and germination percentage. However, seed germination is a biological process influenced by numerous factors, including the distinct behaviours of different varieties. Similar results were also reported by Kumar et al. [10] in amaranthus.

A beneficial indicator of seed vigour is the length of the seedlings roots, shoots, and overall length, leading towards better plant establishment. Significantly higher seedling root length, seedling shoot length and total seedling length was recorded in T₅(PRA-2) (Table 1). Similar findings were reported by Kumar [14] with chia seeds and Naseem et al. [15] with buckwheat. Variation in seedling root length, seedling shoot length, and overall seedling length of the different varieties were also considerable. Certainly, these variations should be due to different genetic potential among the different varieties studied. The results were in conformity with Naseem et al. [15] with buck wheat.

Maximum seedling growth resulted in better seedling establishment, higher plant growth and higher yield in the field, results supported by Moshatati et al. [12] with wheat. Again, significantly highest seedling fresh weight and seedling dry weight was recorded in T₅(PRA-2). One cause for this variation might be the food reserves used more effectively and quickly, resulting in seedlings with higher fresh weight. These findings agreed with Naseem et al. [15] with buckwheat, Arivazhagen and Kadarmohideen [16] with French bean and Panwar [17] with quinoa. Kumar and Panwar (2023) also reported that seedling dry weight might be higher due to change in moisture percentage. The significantly higher seedling vigour index I and seedling vigour index II were also recorded in T₅ (PRA-2) (Table 1). These results might be due to genetic potential of the variety to produce higher seedling root length, seedling shoot length, total seedling length, seedling fresh weight, seedling dry weight and germination percent. These were in consistent with the findings of Krishnappa et al. [18] with finger millet and Panwar [17] with quinoa seeds.

Electrical conductivity was found to be maximum in the T₁(VL-110) which was statistically *at par* with T₂(Rudrakshya) and minimum in T₅(PRA-2) (Table 2). The similar findings were reported by Kumar [14] with chia seeds. According to Pandey [19], working with sorghum, weak seeds generally possess poorer membrane structure, which results in greater electrolyte loss and higher conductivity measurement. Lower amount of leachates released by soaking solution indicates high seed vigour and *vice-versa* in soybean [20]. The difference in electrical conductivity in the different amaranth varieties might be due to variability in genetic constitution,

moisture content and temperature. Crude protein as found maximum in T₁(VL-110) which was significantly at par with T₂(Rudrakshya) (Table 2). Similar findings were reported by Bressani [21] with amaranth, and Gimplinger et al. [22] with amaranth seeds. Seeds with higher seed weight resulted in decreased crude protein. The grain of amaranth is covered by the seed coat and a poorly developed endosperm. It is known that the germ fraction contributes significantly on amounts of protein to the whole seed [21]. Increasing seed size, predominantly affects the starchy portion of the perisperm, as opposed to the germ. Hence, it can have an effect of reducing seed protein [23]. The protein content of amaranth seems to be negatively correlated with yield, like it is in other grain crops [24].

The seeds germination percentage, seedling length, dry weight and vigour index-I and vigour index-II were significantly influenced by the cold test (Table 4). The significantly higher seeds germination percentage was recorded in T₆(PRA-3), but was statistically at par with T₅(PRA-2) and again, higher seedling length was recorded in T₆(PRA-3). Again, higher seedling dry weight was observed in T₆(PRA-3), but was statistically at par with T₄(PRA-1), T₅ (PRA-2) and T₇ (Annapurna). Higher seedling vigour index-I and II was recorded in T₅(PRA-2) and T₆(PRA-3) (Table 1). When compared to the standard germination test, the cold test had no adverse effects on seedling dry weight, vigour index-I and vigour index-II. This might be due to seeds of amaranth being able to resist conditions of cold stress. The current findings were in consistent with the findings of Ilyas et al. [25] with *Brassica napus* and Panwar [17] with chia seeds. In numerous species, seed ageing has been recognised as the principal cause of decreased germination, vigour and viability. The highest qualities of the seeds were found at physiological maturity, after that it starts decreasing with time/storage. In the current study with amaranth, it was observed lower seeds germination, seedling length, fresh weight, dry weight and vigour under the accelerated ageing test, when compared with standard germination test (Table 3). Germination percentage was recorded higher with T₆(PRA-3). The current findings were in consistence with Panwar [17] with chia seeds, Kapoor et al. [26] with chickpea and Samrah and Al-Kofahi [27] with barley seeds. According to Gidrol et al. [28], genetic potential of varieties to perform under stress condition and degradation of mitochondrial membrane, lead to reduction in energy supply required for germination.

Table 1. Mean performance for different varieties of amaranth on seed quality for standard germination

S. N ^o	Treatment	Standard Germination								
		First Count	Seedling shoot length (cm)	Seedling root length (cm)	Seedling length (cm)	Fresh wt. of seedling (mg)	Dry wt. of seedling (mg)	Germination (%)	Vigour Index-1	Vigour Index- 2
T ₁	VL-110	10.67	2.09	1.31	3.40	31.67	16.67	74.67	253.99	1245.33
T ₂	Rudrakshya	17.00	2.15	1.46	3.61	43.67	23.67	84.00	303.50	1986.00
T ₃	Durga	25.33	2.19	1.56	3.75	53.33	25.00	86.67	325.13	2166.00
T ₄	PRA-1	29.67	2.48	2.42	4.90	50.33	25.00	82.67	405.31	2068.00
T ₅	PRA-2	39.33	2.88	3.30	6.18	63.33	27.33	92.00	568.75	2516.00
T ₆	PRA-3	30.33	2.84	2.64	5.48	57.67	25.33	88.00	482.36	2229.33
T ₇	Annapurna	32.00	2.87	3.15	6.02	56.33	27.33	90.67	545.81	2479.33
C.D. @ 1%		2.47	0.17	0.15	0.23	4.03	2.08	8.38	49.76	289.87
SE(m) ±		0.81	0.05	0.05	0.08	1.32	0.68	2.74	16.25	94.65
C.V. (%)		5.31	3.74	3.78	2.72	4.48	4.83	5.54	6.83	7.81

Table 2. Mean performance for different varieties of amaranth on seed quality for electrical conductivity and crude protein

Treatment	Electrical Conductivity (µS/cm))	Crude Protein (%)
T ₁ : VL-110	10.06	15.82
T ₂ : Rudrakshya	10.16	14.98
T ₃ : Durga	9.60	14.32
T ₄ : PRA-1	9.57	13.77
T ₅ : PRA-2	7.15	11.88
T ₆ : PRA-3	7.93	12.58
T ₇ : Annapurna	8.06	13.72
C.D. @ 1 %	0.19	1.16
SE(m) ±	0.06	0.38
C.V. (%)	1.23	4.72

Table 3. Mean performance of different varieties of amaranth on seed quality for accelerated aging test

Treatment	Accelerating aging test				
	Total Seedling length (cm)	Dry wt. of seedling (mg)	Germination %	Vigour Index-1	Vigour Index- 2
T ₁ : VL-110	3.04	11.67	62.67	190.51	732.00
T ₂ : Rudrakshya	3.07	12.67	71.33	219.22	903.33
T ₃ : Durga	3.06	13.33	75.00	229.83	1001.00
T ₄ : PRA-1	4.38	14.33	79.67	348.75	1141.67
T ₅ : PRA-2	6.04	19.33	82.00	495.29	1584.67
T ₆ : PRA-3	6.09	21.00	87.67	533.59	1839.33
T ₇ : Annapurna	5.05	17.67	80.67	407.11	1425.33
C.D. @ 1%	0.35	1.16	3.76	31.59	92.95
SE(m) ±	0.11	0.38	1.23	10.32	30.35
C.V. (%)	4.51	4.17	2.76	5.16	4.27

Table 4. Mean performance of different varieties of amaranth on seed quality for cold test

S. No	Treatment	Cold Test				
		Seedling length (cm)	Dry weight of seedling (mg)	Germination (%)	Vigour Index-1	Vigour Index- 2
T ₁	VL-110	3.45	23.33	85.33	294.09	1990.00
T ₂	Rudrakshya	3.72	22.67	86.00	320.18	1949.33
T ₃	Durga	3.83	23.67	87.33	334.74	2066.00
T ₄	PRA-1	4.68	26.00	87.33	409.22	2272.67
T ₅	PRA-2	6.03	26.67	94.00	567.21	2507.33
T ₆	PRA-3	6.44	27.00	96.00	618.62	2593.33
T ₇	Annapurna	5.04	26.00	88.00	443.47	2287.33
C.D. @ 1%		0.10	1.39	5.51	28.95	198.73
SE(m) ±		0.03	0.45	1.80	9.45	64.89
C.V. (%)		1.21	3.14	3.50	3.84	5.02

Table 5. Mean performance of different varieties of amaranth on seed quality under water sensitivity for low moisture (9 ml)

S. No	Treatment	Low moisture (9 ml)				
		Germination (%)	Total seedling length (cm)	Dry weight of seedling (mg)	Vigour Index-1	Vigour Index-II
T ₁	VL-110	83.33	6.65	16.67	554.24	1358.67
T ₂	Rudrakshya	83.33	6.93	23.67	577.43	1926
T ₃	Durga	87.33	7.11	25.00	620.59	2134.67
T ₄	PRA-1	92.00	8.65	25.00	795.39	2250.67
T ₅	PRA-2	88.00	8.12	27.33	715.21	2352
T ₆	PRA-3	94.00	9.39	27.33	882.99	2515.33
T ₇	Annapurna	92.67	8.76	25.33	812.28	2296
C.D. @ 1%		6.73	0.35	2.08	67.87	279.9
SE(m) ±		2.20	0.12	0.68	22.16	91.4
C.V. (%)		4.29	2.52	4.83	5.42	7.47

Table 6. Mean performance of different varieties of amaranth on seed quality under water sensitivity for high moisture (18 ml)

S. No	Treatment	High moisture (18 ml)				
		Germination (%)	Total seedling length (cm)	Dry weight (mg)	Vigour Index-I	Vigour Index-II
T ₁	VL-110	81.33	5.42	16.00	441.19	1338.00
T ₂	Rudrakshya	81.33	5.68	24.00	462.37	2003.33
T ₃	Durga	85.33	6.09	24.00	520.07	2094.67
T ₄	PRA-1	90.00	7.21	26.00	648.78	2421.33
T ₅	PRA-2	86.00	6.65	22.67	572.29	1990.67
T ₆	PRA-3	92.00	7.39	26.33	680.25	2444.67
T ₇	Annapurna	90.67	7.35	26.33	666.39	2441.33
C.D. @ 1%		6.73	0.21	2.01	51.21	245.54
SE(m) ±		2.20	0.07	0.66	16.72	80.18
C.V. (%)		4.39	1.78	4.80	5.08	6.60

Germination percentage, seedling length, dry weight, vigour index-I and vigour index-II increased more in low moisture condition than in high moisture condition under water sensitivity test (Table 5). That might be due to the ability of Amaranth plants to grow better under less moisture conditions. The highest germination percentage was recorded in T₆ (PRA-3), which was statistically at par with T₃(Durga), T₄(PRA-1), T₅(PRA-2) and T₇(Annapurna) and which means T₆ (PRA-3) is not significantly superior than T₃ (Durga), T₄ (PRA-1), T₅ (PRA-2) and T₇ (Annapurna). The higher seedling length and dry weight was recorded in T₆(PRA-3), which was statistically at par with T₅(PRA-2) and T₇(Annapurna) means T₆ (PRA-3) is not significantly superior than T₅ (PRA-2) and T₇ (Annapurna) (Table 6). Vigour index-I and vigour index-II were observed in T₆(PRA-3) as statistically at par with T₄ (PRA-1), T₅(PRA-2) and T₇(Annapurna) means T₆ (PRA-3) is not significantly superior than T₄ (PRA-1), T₅ (PRA-2) and T₇ (Annapurna). The ability of amaranth to germinate under low moisture stress and the positive association ship between seedling fresh weight, dry weight, and genetic variation among the varieties might also contribute to this. The above results are in conformity with the study of Yamuna Devi G [29] in quinoa, Panwar [17] in chia seeds and Tzortzakis [30] in grain amaranth.

4. CONCLUSION

Based on the experimental findings, it could be concluded that T₄ (PRA-1), T₅(PRA-2), T₆(PRA-3) and T₇(Annapurna) are of better performance for seed quality and biochemical characters. For being the higher in yield and good in quality, the genotypes PRA-1 (T₄), PRA-2 (T₅), PRA-3 (T₆)

and Annapurna (T₇) are recommended in hills of Uttarakhand for the cultivation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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