Varietal identification and seed quality estimation through biochemical characterisation of Amaranth (*Amaranthus hypochondriacus* L.)

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 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 treatmentT_5(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 treament T_6(PRA-3).On the basis of this investigation, it could be concluded that treatments T_4 (PRA-1), T_5(PRA-2), T_6(PRA-3) and T_7(Annapurna)are performing overall better for biochemical and seed quality of amaranth.

Keywords: Cold test, Stress test, Seedling vigour indices, Uttarakhand.

INTRODUCTION

Amaranthus*(Amaranthus spp.)* is considered one of the important leafy vegetables. Amaranthus is also referred to as "*Chaulai*". The genus *Amaranthus* consists of approximately 60 species, out of which, 18 species are present in India[28,29,30]. 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. hypchondriacus*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(Rastogi and Shukla, 2013).

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 (National Research Council, 1984, 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,barleyandmaize(VenskutonisandKraujalis,2013).

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%)(Mlakar*etal.*2009). Amaranthus is mainly grown from tropical-low-lands to 3,500 m above mean sea level in the Himalayas(Sauer, 1967). 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 (Kierulf *et al.* 2020).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 (Kumar *et al*. 2015 and Manikandan *et al*. 2015).

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).

RESULT 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, T_5(PRA-2) had a significant effect on the first count and germination percent of seeds. Similar information were presented in wheat (Moshatati *et al*. 2012) and bean seed (Kolasinska*et al*. 2000). 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*. (2015) 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 T_5(PRA-2) (Table 1).Similar findings were reported by Kumar (2023)with chia seeds and Naseem *et al*. (2007)with buckwheat.Variation in seedling root length, seedling shoot length, and overall seedling length of the different varieties were also considerable.Certainty, these variations should be due to different genetic potential among the different varieties studied. The results were in conformity with Naseem *et al*. (2007)with buckwheat.

Maximum seedling growth resulted in better seedling establishment, higher plant growth and higher yield in the field, results supported byMoshatati *et al*. (2012)with wheat. Again, significantly highest seedling fresh weight and seedling dry weight was recorded in T_5(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*. (2007)with buckwheat, Arivazhagen and Kadarmohideen (2006)with French bean and Panwar (2023)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 T_5(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*. (2001)with finger millet and Panwar (2023)with quinoa seeds.

Electrical conductivity was found to be maximum in the T_1(VL-110) which was statistically *at par* with T_2(Rudrakshya) and minimum in T_5(PRA-2) (Table 2). The similar findings were reported by Kumar (2023)with chia seeds. According to Pandey (1992), working with sorghum, weak seeds generally possess poorer membrane structure, which results in greater electrolyte loss and higher conductivity measurement. Loweramount of leachates released by soaking solution indicates high seed vigour and *vice-versa*in soybean(Adriana *et al*.,2012). 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 maximumin T_1(VL-110) which was significantly at par with T_2(Rudrakshya) (Table 2). Similar findings were reported by Bressani (1994)with amaranth, and Gimplinger*et al*. (2007) 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 (Bressani, 1994).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 (Brenner *et al*., 2000).The protein content of amaranth seems to be negatively correlated with yield, like it is in other grain crops (Feil, 1998).

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 T_6(PRA-3),but was statistically at par with T_5(PRA-2) and again, higher seedling length was recorded in T_6(PRA-3).Again, higher seedling dry weight was observed in T_6(PRA-3),but was statistically at par with T_4(PRA-1), T_5 (PRA-2) and T_7 (Annapurna). Higher seedling vigour index-I and II was recorded in T_5(PRA-2) and T_6(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*. (2022)with *Brassica napus* and Panwar (2023) 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 T_6(PRA-3).

The current findings were in consistence with Panwar (2023) with chia seeds, Kapoor *et al*. (2010) with chickpea and Samrah and Al-Kofahi (2008)with barley seeds. According to Gidrol*et al*. (1998), genetic potential of varieties to perform under stress condition and degradation of mitochondrial membrane, lead to reduction in energy supply required for germination.

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 T_6 (PRA-3),which was statistically at par with T_3(Durga),T_4(PRA-1), T_5(PRA-2) and T_7(Annapurna) and which means T_6 (PRA-3)is not significantly superior than T_3 (Durga), T_4 (PRA-1), T_5 (PRA-2) and T_7 (Annapurna). The higher seedling length and dry weight was recorded in T_6(PRA-3), which was statistically at par with T_5(PRA-2) and T_7(Annapurna) means T_6 (PRA-3) is not significantly superior than T_5 (PRA-2) and T_7 (Annapurna)(Table 6). Vigour index-I and vigour index-II were observed in T_6(PRA-3) as statistically at par with T_4 (PRA-1), T_5(PRA-2) and T_7(Annapurna) meansT_6 (PRA-3) is not significantly superior than T_4 (PRA-1), T_5 (PRA-2) and T_7 (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 (2022) in quinoa, Panwar (2023) in chia seeds and Tzortzakis (2009) in grain amaranth.

CONCLUSION

Based on the experimental findings, it could be concluded that T_4 (PRA-1), T_5(PRA-2), T_6(PRA-3) and T_7(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 (T_4), PRA-2 (T_5), PRA-3 (T_6) and Annapurna (T_7) are recommended in hills of Uttarakhand for the cultivation.

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Details of the AI usage are given below:

1.

2.

3.

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

S. Nº	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-1	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

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