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Evaluation of Yield and Yield Related Traits of Grain Amaranth (*Amaranthus* spp.) Accessions in Garhwal Hills of Uttarakhand

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Abstract

The field study was conducted during July to November 2017at Crop Improvement Block of College of Forestry, VCSG Uttarakhand University of Horticulture and Forestry, Ranichauri, Uttarakhand, India. The experiment was setin an augmented block design along with 4 check varieties Annapurna, PRA-2, PRA-3 and Durga. The check varieties were planted after every 05 germplasm accessions to evaluate the yield variation among different germplasm accessions of grain amaranth for crop improvement. Data on yield and other parameters were recorded as per the standard procedure and were analyzed by analysis of variance using statistical software to establish the significant variations. There was quite high variation among the germplasm accessions for plant growth, seed yield and yield contributing characters like 10 ml test weight, Inflorescence length, No. of finger plant^{-1}, Finger length and seed yield. Seed yield of the germplasm accessions ranged from 0.94-25.00 g plant^{-1}. Conditions for seed setting and filling of grains in grain amaranth were, in general, poor that resulted in low seed yields. The promising germplasm accession for higher seed yield plant^{-1} was found in accession IC037156 which was more than the best check Durga. So, IC037156 can be preferred for further crop improvement regarding promotion of the genotype

Keywords: Amaranth, accessions, augmented, Durga, germplasm, PRA-2, PRA-3, seed yield

1. Introduction

Grain amaranth (*Amaranthus hypochondriacus* L.), popularly known as "Chaulai" is an important multifarious-utility protein rich cash crop with high nutritive value in the higher hills of mid Himalaya where, it is grown mainly as a mix crop with finger millet and rice bean. In some pockets, it is also grown as pure crop. It is one of the disremembered food crops of the world. It has potentiality as subsidiary food and plays a vital role in feeding the hunger world (Gunjal, 2011). It belongs to the family *Amaranthaceae* and genus *Amaranthus.* The genus consists of 60 species of annual herbs, which are native of America and are distributed in the tropics, of which 25 species occur in India.In African countries, it is a vital nutritious food in regards to treat those suffering from HIV/AIDS (Alegbejo, 2013). Nigeria is considered to be centre of diversity for *Amaranthus* spp. (Dulloo and Engles, 2003). There are four cultivated species of grain amaranth *viz*., *A. hypochondriacus* (L)., *A. cruentus* (L)., *A. caudatus* (L). and *A. edulies* (L). In India *A. hypochondriacus* is known as the 'king grain' (Narwade and Pinto, 2018). The crop is grown both for its green and grain. It holds cultural significance in remote and tribal areas in many part of India particularly in the Himalayan region. In India, it is grown from tropical lowlands to 3500 m above mean sea level height in the Himalayas (Sauer, 1967). As per statistical report of Agriculture Department, Govt. of Uttarakhand (2020−21), the grain amaranth is grown over an acerage of 5799 ha with production of 7723 mt over productivity of 1332 kg ha^{-1}. Amaranths have outstanding nutritional value because of their high content of important micronutrients, protein 14−19%, carbohydrates 62−66%, fibre 4−5%, fat 6−7%, 2.5−4.4% ash (Mlakar et al., 2009), vitamins such as iron, calcium, β-carotene, vitamin C and folic acid (Priya et al., 2007) and essential amino acids (Ozsoyet al., 2009) like lysine (4.9 to 6.1 g 100 g^{-1} protein) with high digestibility (approx. 90%) which is usually deficient in other conventional cereal grains (Joshi and Rana, 1991). It is also rich in fiber and bioactive compounds (Repo-Carrasco, 2011).

Amaranth is quantitative short day plant, highly adaptable, drought tolerant, pest and disease resistant, fast growing C4 plant with high yielding potential having high mineral uptake (Grubben and Denton, 2004). In Uttarakhand, grain amaranth is mainly used in preparation of laddu, halwa and chapati mixed with wheat flour. The most important constraints to good crop stand is majorly by poor variety selection. Improved varieties development thus could improve the productivity of grain amaranth. However, despite the nutritional and agricultural importance of this crop (Bhuvaneswari et al., 2001), it is still one of the underexploited crops in Africa (Dubois and Stoilova, 2015). It shows wide variation in the yield within its species (Grubben, 2004). For effective genetic improvement of grain yield, it is important to understand how the proportion of genetic component (Hamdi et al., 2003; Jangde et al., 2018). Considering adverse effect of changing climatic conditions, amaranth is a promising agricultural crop with the ability to withstand negative effects of growing conditions (Alemayehu et al., 2014). Its plants show morphological and phonological variability (Idowu-Agida et al., 2020). Therefore, current research was focused to evaluate the variation in the yield and its attributes among the 25 grain amaranth accessions for crop improvement.

2. Materials and Methods

The germplasm accessions trial were evaluated July to November 2017 in terraced fields at the Crop Improvement Block of College of Forestry, VCSG Uttarakhand University of Horticulture and Forestry, Ranichauri, Uttarakhand, India. The college is situated between an altitude of about 1600 m-2200 m ASL. The experiment was conducted in silty clay loam under low input, rainfed organic conditions. The soil of the experimental block is largely acidic in nature. The crop season experienced continuous high rainfall throughout the season particularly during June-August with a total of 1325.4 mm rainfall with 55 numbers of rainy days during the crop season but a short spell of drought was experienced particularly during the end of the season. The minimum and maximum temperature varied from 6.1−16.8°C and 17.5−25.4°C, respectively. Pre-monsoon showers were received resulting in timely sowing of experiments.

The field was ploughed followed by harrowing and leveling. Twenty-five accessions of grain amaranth received from NBPGR, Shimla were used as treatments for the germplasm evaluation trial. The experiments were laid out in an augmented block design along with 4 check varieties Annapurna, PRA-2, PRA-3 and Durga. The check varieties were planted after every 05 germplasm accessions each in paired rows of 3 m row length. The seeds were sown at the spacing of 50 cm followed by thinning at 15-20 days after sowing (DAS) and plant to plant distance was maintained at 15 cm. The seeds were sown on 15.07.2017 and harvested during 25.10.2017−05.11.2017 as per maturity of the germplasm accessions.

The crop was raised using standard package and practices recommended for the region. The crop was fertilized with RDF NPKS @ 60:40:20:20 kg ha^{-1} using Urea, DAP, MOP and Bentonite Sulphur. Chemical pest control measures were also not undertaken except for leaf webber control in grain amaranth. Data on yield and other parameters were recorded using standard procedure. Data observed were analyzed by analysis of variance using statistical software to establish the significant variations.

3. Results and Discussion

There were differences among the germplasm accessions for plant growth, seed yield and its contributing characters. The range of variations were quite high the results of germplasm accessions for days taken to flowering varied from (63.00 days−72.00 days), maturity period (120.00 days−140.00 days), plant height (24.7 cm−145.8 cm), inflorescence length (10.0 cm−40.2 cm), etc. Seed yield $plant^{-1}$ of the entries ranged from (0.94 g−25.00 g).

The germplasm accessions IC037313 and IC038172 were early in 50% flowering (63.0 days) and were at par with the best check Durga (64.0 days). However, the check PRA-3 was recorded to be very late at 50% flowering (71.3 days) followed by check PRA-2 and accession IC038252 (69.0 days). The longest inflorescence was produced on germplasm accessions IC037156 (40.2 cm) followed by IC037314 (37.6 cm), IC037153 (37.0 cm), IC037158 (36.4 cm) and IC037313 (36.2 cm) that were better than the best check Durga (25.9 cm), while the shortest length was obtained from IC035590 (11.0 cm) (Table 1).

Accession IC037156 (145.8 cm) has obtained maximum plant height and was followed by IC037314 (99.8 cm), IC037324 (92.0 cm), IC037158 (89.0 cm) and IC037155 (88.4 cm) that were better than the best check Durga (80.4 cm). Number of fingers per plant were observed maximum in accession IC03714 (35.8) followed by accession IC037155 (32.0), IC038173 (24.2), IC037153 and IC037324 (23.0) which were better than the best check PRA-2 (18.9) (Table 2). Germplasm accession IC037146 (16.4 cm) produced longest finger length followed by IC037314 (11.0 cm), IC037156 (10.6 cm), IC038173 (10.4 cm) and IC035612 (10.2 cm) that were better than the best check Durga (8.73 cm) (Table 2), while the shortest length was obtained from IC038155 (3.20 cm) (Table 1). The seed yield per plant was found maximum in accession IC037156 (25.0 g) and was more than the best check Durga (15.5 g) (Table 2).

However, none of the germplasm accessions was better than the best check Durga (124.7 days) for days to maturity and check PRA-2 (11.29 g) for 10ml test weight (Table 2).

This is important with respect to maintain, evaluate and utilize the accessions for hybridization purpose. Also morphological characterization is important for germplasm classification (Smith and Smith, 1989) as it is required for breeding purpose that depends on the magnitude of genetic variability (Smith et al., 1991). Several scientists has reported strong positive relationship of diverse variation in crops like vegetable amaranth (Shukla et al., 2010), maize (Alika et al., 1993) and groundnut (Ntundu et al., 2006). Researchers also reported variability in the grain amaranth yields depending upon the genotypes and agronomic practices. Yao et al., 2008 observed differences in agronomic parameters could be due to environment (Prasch and Sonnewald, 2015), variety and cultural practices.

Table 1: Morphological characters and yieldof 25 grain amaranth accessions

Sl. No.	Entry	Days to 50% flowering	Days to maturity	Plant height (cm)	10 ml test weight (g)	Inflores-cence length (cm)	No. of finger plant^{-1}	Finger length (cm)	Seed yield (g plant^{-1})
1.	IC035590	66	134	36.0	No seed set	11.0	6.0	3.50	No seed set
2.	IC035612	65	133	47.6	No seed set	21.2	14.2	10.20	No seed set
3.	IC036833	67	135	56.0	10.67	28.0	16.0	8.20	6.00
4.	IC037146	64	132	50.0	10.52	28.8	18.0	16.40	6.64
5.	IC037153	65	133	71.4	10.45	37.0	23.0	9.40	10.15
6.	IC037155	66	134	88.4	10.46	35.0	32.0	9.00	0.94
7.	IC037156	64	132	145.8	10.14	40.2	21.6	10.60	25.00
8.	IC037158	65	133	89.0	10.28	36.4	19.8	10.00	5.50
9.	IC037313	63	131	85.0	10.62	36.2	22.4	7.40	8.66
10.	IC037314	65	133	99.8	10.52	37.6	35.8	11.00	9.95
11.	IC037321	68	136	54.8	10.42	30.6	16.2	5.60	14.72
12.	IC037324	65	133	92.0	10.18	31.4	23.0	9.20	6.59
13.	IC038155	64	132	55.6	10.32	21.2	13.4	3.20	3.97
14.	IC038162	66	134	62.6	10.46	25.4	17.2	7.60	8.77
15.	IC038171	64	132	62.6	10.52	24.8	20.2	8.80	1.73
16.	IC038172	63	131	85.4	10.63	30.6	21.2	7.40	7.03
17.	IC038173	66	134	84.8	10.44	31.2	24.2	10.40	7.89
18.	IC038182	65	133	27.2	No seed set	18.0	8.4	4.20	No seed set
19.	IC038191	64	132	29.2	No seed set	15.0	8.2	5.60	No seed set
20.	IC038221	65	133	46.2	10.17	19.6	9.6	9.00	1.69
21.	IC038245	68	136	27.2	No seed set	13.6	11.2	3.60	No seed set
22.	IC038252	69	137	58.6	10.62	20.6	14.0	6.40	1.94
23.	IC038294	67	137	70.0	10.25	26.2	19.4	7.40	4.94
24.	IC038332	65	133	61.6	10.22	16.4	14.4	4.80	3.06
25.	IC038333	66	134	59.0	10.62	12.6	14.2	6.20	1.67
	Annapurna (c)	67.3	135.3	54.5	11.18	23.3	15.7	6.93	2.91
	Durga (c)	64.0	124.7	80.4	10.58	25.9	16.1	8.73	15.50
	PRA -2 (c)	69.0	137.0	56.6	11.29	23.0	18.9	7.30	10.56
	PRA -3 (c)	71.3	139.3	46.1	11.28	20.5	16.5	6.47	1.57
	Minimum	63.0	124.7	27.2	10.14	11.0	6.0	3.20	0.94
	Maximum	71.3	139.3	145.8	11.29	40.2	35.8	16.40	25.00
	Mean	65.7	133.6	64.9	10.53	25.6	17.6	7.74	6.97
	CV (%) Phen.	2.96	1.97	38.9	3.02	31.8	37.1	35.83	80.18

Table 2: Promising lines in grain amaranth germplasm for various characters

Sl. No.	Characters	Range Min	Range Max	Promising lines	Value of best check
1.	Days to 50 % flowering	63	71.3	IC037313 (63.0), IC038172 (63.0)	Durga (64.0)
2.	Days to maturity	124.7	139.3	-	Durga (124.7)
3.	Plant height (cm)	27.2	145.8	IC037156 (145.8), IC037314 (99.8), IC037324 (92.0), IC037158 (89.0), IC037155 (88.4)	Durga (80.4)
4.	10 ml test weight (g)	10.14	11.29	-	PRA-2 (11.29)
5.	Inflorescence length (cm)	11.0	40.2	IC037156 (40.2), IC-37314 (37.6), IC037153 (37.0), IC037158 (36.4), IC037313 (36.2)	Durga (25.9)
6.	No. of finger plant^{-1}	6.0	35.80	IC037314 (35.8), IC037155 (32.0), IC038173 (24.2), IC037153 (23.0), IC037324 (23.0)	PRA-2 (18.9)
7.	Finger length (cm)	3.20	16.40	IC037146 (16.4), IC037314 (11.0), IC037156 (10.6), IC038173 (10.4), IC035612 (10.2)	Durga (8.73)
8.	Seed yield plant^{-1} (g)	0.94	25.00	IC037156 (25.00)	Durga (15.50)

4. Conclusion

The grain amaranth yield had wide variation among germplasm accessionswith its potential responsive to the appropriate agronomic practices. Of 25 germplasm accessions, only accession IC037156 (25.0 g) has higher yields compared to best check Durga (15.5 g). Besides having longest inflorescence length, plant height and finger length. So, it can be recommended for hybridization purpose in crop improvement.

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