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Morphological characterization of potential pseudo-cereal: Grain amaranth (*Amaranthus hypochondriacus* L.)

Vinita Thakur, PK Chandrakar and RK Yadav

Abstract
Grain amaranth (*Amaranth hypochondriacus* L.) is a traditionally and economically pseudo-cereal crop with good nutritional value. Characterization was carried out by studying 13 qualitative traits. Categorical differences among 27 genotypes including five standard checks *viz.*BGA-2, RMA-7, GA-2, GA-5 and C.G. Rajgira-1 were observed in traits such as stem colour, petiole colour, inflorescence colour, leaf colour, early plant vigour and plant growth habit (except root colour, stem surface, inflorescence compactness and inflorescence shape). Several of traits are useful as a genetic markers and hybridization Programme.

Keywords: Characterization, checks, frequency, grain amaranth, genotypes, qualitative traits

Introduction
Grain amaranth is known by various names such as Rajgira, Ramdana etc., it is a potential pseudo-cereal crop with high protein grown in hilly and plain zone in India. The exact information about statistics on acreage and production in India is unknown, However, it is estimated to be grown about 40-50 thousand hectares with 1200kg/ha in India (Dua *et al.*, 2009) [1] and 2000 kg/ha productivity in plain zone of Chhattisgarh (Yadav, 2016) [3]. For any use of the diversity of grain amaranth, it is essential to be able to distinguish the genotypes and characterize the descriptors so that they can be utilized as genetic markers. Thus DUS characterizations through qualitative traits was planned in the study.

Materials and Methods
Twenty seven genotypes with five standard checks named BGA-2 (C1), RMA-7 (C2), GA-5 (C3), GA-2 (C5) and C.G. Rajgira-1 (C5) named obtained from Ranchi, Gujarat, Bhubaneswar, Rajasthan and main Centre, IGKV, Raipur. They were evaluated in Randomized Block Design with three replications during *rabi* 201-22. Each genotype had 4 rows, 45 cm apart with 15 cm plant distance. Recommended package of practices was adopted and data were recorded on 5 randomly selected plant (Table 1.). Observations were made on qualitative traits using character descriptors as out lined by project Director, NBPGR (2015) [2]

Result and Discussion
Table 1 depict the cumulative information on qualitative traits amongst the 27 genotypes including checks. It was observed that the early plant vigour was dominant being present in 19 lines and C2, C3, C4, C5(70.37%) while poor was present in 6 genotypes and c1 (22.22%). Only 2 genotypes revealed very good early plant vigour (7.40%) respectively.
Plant growth habit was observed erect type with 18 genotypes and C1, C3, C4, C5(66.66%) whereas spreading was with 8 genotypes and C2 (29.62%). Only 1 noted semi dropping growth habit (3.70%).
Variation was observed in stem surface smooth with 18 genotypes and C1, C5(66.66%) while ridge surface was with 9 genotypes and C2, C3 and C4(33.33%) out of 27 genotypes including 5 checks ie. C1, C2, C3, C4 and C5 showed no variation in root colour (100%).
Stem colour was noted as yellow with 15 genotypes and C1, C2(55.55%); yellowish green with 3 genotypes and C5 (11.11%); pink colour with 7 genotypes and C3, C4 (25.92%); and reddish green with 2 genotypes (7.40%) respectively. 13 genotypes were found yellow colour of petiole with C1, C2 (48.14%); 7 genotypes with C3, C4 (25.92%); 5 genotypes with C5 (18.51%); and 2 genotypes (7.40%) respectively.
Colour is separating commercial varieties from the genotypes. Variation noted in yellowish green leaf colour for 16 genotypes (59.25%); 6 genotypes with C3, C4 (22.22%); 3 genotypes

(11.11%); and only one variety C1 (3.70%) respectively.
Inflorescence colour was observed in 14 genotypes and C1, C2 (51.85%); pink colour in 9 genotypes and C3, C4 (33.33%); light yellow in 3 genotypes (11.11%); and 1 variety C5 with (3.70%) respectively.
22 genotypes with C1, C2, C3 were found having lax type of inflorescence compactness (81.48%) while 5 genotypes with C5 intermediate compactness (18, 51%).
Variation was observed for globose type of inflorescence shape in 22 genotypes with C2, C3, C4 (81.48%) whereas semi- dropping in 5 genotypes with C1, C5 (18.51%).
Smooth type of inflorescence spininess was exhibited in 5 genotypes with C1 (18.51%) while spiny type in 22 genotypes with C5, C2, C3, C4 (81.48%).
Creamish seed colour had 26 genotypes with all 5 checks i.e, C1, C2, C3, C4, C5 (96.29%) and only 1 genotype exhibited in black colour (3.70%).
Simillary popping ability of seed was good for most of the genotypes with all checks (92.59%) while medium popping ability in 2 genotypes (7.40%).
Differences in qualitative characteristics in genotypes and standard checks are useful as marker in validating the effectiveness of crosses in breeding Programme. Similar categorical differences among genotypes were also observed in stem colour, petiole colour, inflorescence colour, leaf colour by Yadav, 2021 [4] and kamini and Yadav [5] for early plant vigour, plant growth habit, leaf colour, inflorescence colour and stem colour, Dissimilar findings were noted by kamini and Yadav, 2023 [5] for the traits like root colour, stem colour, inflorescence compactness and inflorescence shape, The genetic variation suggest a positive and significant response to direct selection for the trsits studies in grain amaranth.

Table 1: Parameters (descriptors) of agro-morphological traits studied in grain amaranth genotypes

Traits	Descriptors (parameters)	Name of genotypes	No. of genotypes	Frequency % of genotypes
Early plant vigour	1. Poor	AGA-20-1, AGA-20-2, RMA-135, BGA-2(C), BGA-16, BGA-7	6	22.22
	2. Good	SKNA-1407, SKNA-1503, SKNA-1701, BGA-21, BGA-29, RMA-9, RMA-62, RMA-120, RMA-7(C), GA-5(C), GA-2(C), BGA-26, BGA-9, BGA-7-1, CGA-18-2, RGA-18, SKNA-1804, SKNA-1803, CG Rajgira-1(C)	19	70.37
	3. Very good	CGA-18-1, RGA-24	2	7.40
Plant growth habit	1. Erect	SKNA-1407, SKNA-1701, BGA-16, BGA-21, BGA-29, BGA-2(C), GA-5(C), GA-2(C), RMA-135, BGA-26, BGA-9, BGA-7, CGA-18-2, CGA-18-1, AGA-20-1, SKNA-1804, SKNA-1803, CG Rajgira-1(C)	18	66.66
	2. Spreading	SKNA-1503, RGA-24, BGA-7-1, RMA-9, RMA-62, RMA-120, RMA-7(C), RGA-28	8	29.62
	3. Semi dropping	AGA-20-2	1	3.70
	99. others	-	-	-
Stem surface	1. Smooth	SKNA-1407, SKNA-1503, SKNA-1701, RGA-24, BGA-21, BGA-29, RMA-9, RMA-62, RMA-120, BGA-2(C), RMA-135, BGA- 26, BGA-7-1, AGA-20-1, RGA-28, SKNA-1804, SKNA-1803, CG Rajgira-1(C)	18	66.66
	2. Ridge	BGA-7, BGA-16, RMA-7(C), GA-5(C), GA-2(C), BGA-9, CGA-18-2, GA-18-1, AGA-20-2	9	33.33
	99. others	-	-	-
*Root colour	1. Creamy	All genotypes including checks.	27	100
*Stem colour	1. Yellow 2. Yellowish green	SKNA-1407, SKNA-1503, BGA-29, RMA-9, RMA-62, RMA-120, RMA-7(C), BGA-2(C), RMA-135, BGA-26, CGA-18-2, CGA-18-1, SKNA-1804, SKNA-1803, BGA-7-1 SKNA-1701, CG Rajgira-1(C), BGA-7	15 3	55.55 11.11
	4. Pink	BGA-9, AGA-20-2, AGA-20-1, RGA-28, RGA-24, GA-5(C), GA-2(C)	7	25.92
	6. Reddish green	BGA-16, BGA-21	2	7.40
*Petiole colour	1.Yellow	SKNA-1407, SKNA-1503, RMA-9, RMA-62, RMA-7(C), BGA-2(C), RMA-135, BGA-26, BGA-7-1, CGA-18-2, CGA-18-1, SKNA-1804, SKNA-1803	13	48.14
	2. Pinkish green	BGA-9, AGA-20-2, AGA-20-1, RGA-28, RGA-24, GA-5(C), GA-2(C)	7	25.92
	3. Yellowish green	CG Rajgira-1(C), BGA-29, RMA-120, SKNA-1701, BGA-7	5	18.51
	4. Pink	BGA-16, BGA-21	2	7.40
Leaf colour	1. Yellow	BGA-2(C)	1	3.70
	2. Yellowish orange	-	-	-
	3. Yellowish green	SKNA-1407, SKNA-1503, SKNA-1701, BGA-7, BGA-29, RMA-9, RMA-62, RMA-120, RMA-7(C), RMA-135, BGA-26, BGA-7-1, CGA-18-2, CGA-18-1, SKNA-1803, SKNA-1804.	16	59.25
	4. Orange	-	-	-
	5. Green	CG Rajgira-1(C)	1	3.70
	6. Greenish orange 7. Pink	- -	- -	- -
	8. Pinkish green	GA-5(C), GA-2(C), AGA-20-2, AGA-20-1, RGA-28, BGA-9.	6	22.22
	9. Reddish yellow	RGA-24, BGA-16, BGA-21.	3	11.11

	10. Reddish green 11. Red 12. Dark red 99. Others	- - -	- - - - -	- - - - -
Inflorescence colour	1. Light yellow	SKNA-1503, BGA-7, BGA-29.	3	11.11
	2. yellow	- CG Rajgira-1(C)	1	3.70
	3. Yellow orange	-	-	-
	4. Yellowish green	SKNA-1407, SKNA-1701, RMA-9, RMA-62, RMA-120, RMA-7(C), BGA-2(C), RMA-135, BGA-7-1, CGA-18-1, CGA-18-2, SKNA-1804, SKNA-1803, BGA-26.	14	51.85
	5. Orange	-	-	-
	6. Pink	RGA-24, BGA-16, BGA-21, GA-2(C), GA-5(C), BGA-9, AGA-20-2, RGA-28, AGA-20-1.	9	33.33
	7. Pinkish green	-	-	-
	8. Purple	-	-	-
	9. Red	-	-	-
	10. Reddish	-	-	-
	11. Green	CG Rajgira-1(C)	1	3.70
	99. Others	-		
Inflorescence compactness	3. Lax	SKNA-1407, SKNA-1503, SKNA-1701, RGA-24, BGA-7, RMA-9, RMA-62, RMA-120, RMA-7(C), BGA-2(C), GA-5(C), GA-2(C), RMA-135, BGA-26, BGA-7-	22	81.48
		1, CGA-18-2, CGA-18-1, AGA-20-2, AGA-20-1, RGA-28, SKNA-1804, SKNA-1803, SKNA-1803		
	5. Intermediate	BGA-16, BGA-21, BGA-29, BGA-29, CG Rajgira-1 (C)	5	18.51
	7. Dense	-	-	-
	99. Others	-	-	-
Inflorescence shape	1. Globose	SKNA-1407, SKNA-1503, BGA-7, BGA-16, BGA-21, BGA-29, RMA-9, RMA-62, RMA-120, RMA-7(C), GA-5(C), GA-2(C), BGA-26, BGA-9, BGA-7-1, CGA-18-2, CGA-18-2, AGA-20-2, AGA-20-2, RGA-28, SKNA-1804, SKNA-1803.	22	81.48
	2. Semi-dropping	SKNA-1701, RGA-24, BGA-2(C), RMA-135, CG Rajgira-1(C)	5	18.51
	3. Completely dropping 4. Straight 99. Others	- - -	- - -	- - -
Inflorescence spininess	1. Smooth	SKNA-1407, RGA-24, BGA-2(C), RMA-135, BGA-26.	5	18.51
	2. Glabrous 3. Prickly	- -	- -	- -
	4. Spiny	CG Rajgira-1(C), SKNA-1503, SKNA-1701, BGA-7, BGA-16, BGA-21, BGA-29, RMA-9, RMA-62, RMA-120, RMA-7(C), GA-5(C), GA-2(C), BGA-9, BGA-7-1, CGA-18-1, CGA-18-2, AGA-20-2, AGA-20-1, RGA-28, SKNA-1804, SKNA-1803.	22	81.48
	99. Others	-	-	-
Seed Colour	1. White	-	-	-
	2. Creamish	SKNA-1407, SKNA-1503, SKNA-1701, RGA-24, BGA-7, BGA-16, BGA-21, RMA-9, RMA-62, RMA-120, RMA-135, RMA-7(C), BGA-2(C), GA-5(C), GA-2(C), BGA-26, BGA-9, BGA-7-1, CGA-18-2, CGA-18-1, AGA-20-2, AGA-20-1, RGA-28, SKNA-1804,SKNA-1803, CG Rajgira-1(C)	26	96.29
	3. Pale yellow	-	-	-
	4. Pink 5. Red	- -	- -	- -
	6. Brown	-	-	-
	7. Black	BGA-29	1	3.70
	8. Golden	-	-	-
	99. Others	-	-	-
Popping ability of seed	3. Poor	-	-	-
	5. Medium	SKNA-1503, BGA-26.	2	7.40
	7. Good	SKNA-1407, SKNA-1701, RGA-24, BGA-7, BGA-16, BGA-21, BGA-29, RMA-9, RMA-62, RMA-120, RMA-7(C), BGA-2(C), GA-5(C), GA-2(C), RMA-135, BGA-9, BGA-7-1, CGA-18-2, CGA-18-1, AGA-20-2, AGA-20-1, RGA-28, SKNA-1804, SKNA-1803, CG Rajgira-1(C)	25	92.59
	99. Others	-	-	-

Conclusion

The highest variation in qualitative traits was noticed in stem colour, petiole colour, inflorescence colour, leaf colour while the lowest variation was noted in early plant vigour, plant growth habit, stem surface, inflorescence compactness, inflorescence shape, inflorescence spininess, seed colour and popping ability of seed while remaining traits like root colour showed no differences. It is not only important for utilizing

the appropriate attribute-based donors in breeding programmes, but also in the present era for protecting the unique grain amaranth.

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