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Seed polymorphism in South Indian horsegram (*Macrotyloma uniflorum* (Lam.) Verdc.): A comprehensive study

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ABSTRACT

The seeds samples of fifty accessions of horsegram germplasm originating from different states of Southern India were evaluated for seed polymorphism and the effect of seed colour on various physical and physiological attributes were analyzed. The accessions were significantly different for the seed characters studied. The influence of environment on inheritance of these characters was marginal as indicated by a narrow difference between phenotypic and genotypic coefficient of variation. Correlation studies were done in order to analyze the relationship between the seed physical and physiological characters in horsegram accessions. All the physiological attributes showed non-significant correlation with the seed physical characters except for germination percentage which showed highly significant positive correlation with hundred seed weight. Out of 13 seed colour categories noticed, three colours such as light brown, mottled cream, and cream were the most commonly found ones in the population while mottled grayish cream colour was present only in one accession (IC320010). Maximum number for colour polymorphism was exhibited by IC47135, having seeds 9 colour patterns. Minimum number of seed colour categories (2) was noticed in IC68591, IC47137 and IC71793A. Among the seed colours, mottled grey cream and intermediate light brown colour exhibited high values for both seed physical and physiological parameters. Thus for improvement in yield contributing characters, these colours can be given due preference during selection.

1.INTRODUCTION

Horsegram (*Macrotyloma uniflorum* (Lam) Verdc.) belonging to the family Fabaceae is known as a poor man's pulse and is distributed mainly in Deccan plateau and plains and coastal areas in southern India rarely extend to central India. It is a traditional hardy annual tropical grain legume adapted to drier situations and naturally found in rain shadow areas of Western Ghats as an important component in natural grasslands and in rocky crevices in mountain slopes at lower elevations. It is a multi utility crop used as human food, feed, fodder and green manure. It forms the cheap source of vegetable protein, vitamins, calcium and iron and owing to its diuretic property it is good for patients suffering from urinary and kidney problems. Giving due credit to its above-mentioned values and its underutilized status, National Bureau of Plant Genetic Resources has taken up survey, collection, conservation and characterization of this crop far back. In total 911 collections, comprising of both indigenous and exotic accessions of this crop have been augmented at this regional station. Being a leguminous crop, seed polymorphism has been noticed in the crop within and between populations with respect to seed coat colour and seed size. The seed polymorphism plays an important role in crop improvement programme since the variability in seed quantitative characters exhibit a direct relation with the seed yield of the crop. Visual quality is one of the most important determinants of the seed polymorphism and is considered as important breeding objectives too. Hence knowledge of genetic parameters such as phenotypic and genotypic variation, heritability, genetic advance and genetic gain are imperative for breeding for new varieties. Moreover, seed colour is a simple and excellent indicator of seed quality [1]. The association of seed coat colour and seed quality were reported [2] and [3] and between seed quality and storability [4,5], in various crops. The aspect of seed polymorphism was thoroughly investigated by many workers in the past. The genetic basis of seed polymorphism was studied in Washington lupin by [6]. The inheritance behaviour of seed coat colour was reported as monogenic [7], digenic [8] both in lentil and polygenic control of seed polymorphism in field pea by [9]. Further, correlation of seed coat characters along with physiological parameters. The variability in seed characters, their genetic parameters and correlation among the characters are dealt with. Accession wise and colour wise computation of the quantitative data on seeds for mean were made in order to see the effect of seed coat color on these characters.

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2. MATERIALS AND METHODS

Out of 911 accessions maintained in the station's Medium Term Storage (MTS) facility, 50 originating from Andhra Pradesh, Karnataka, Kerala and Tamil Nadu states of Southern India were randomly selected for the study. Seeds harvested from the previous season's crop were used for the study. Two random replicated bulk samples of seeds were taken from each accession. Seed physical characters such as seed length, breadth and thickness were measured using Zoom Digimatic Caliper on 10 randomly selected seeds from each replication, both collection wise as well as seed coat colour wise. The seeds were classified in to thirteen colour categories based on visual observation. Finally, germination study was carried out in completely randomized design using 25 seeds per treatment replicated twice under the room temperature. Seeds were kept in petriplates lined with Whatman No1 filter paper moistened every alternate day with distilled water. The seeds were considered to be germinated if 1mm radical had emerged and germination count on the fourth day was taken. The data on germination percentage were transformed to arcsine values before statistical analysis. The seedling vigour in terms of length of radicle and plumule were measured in centimeter [10] and calculated on the basis of total number of seeds plated. Vigour index was computed by adopting method of [11]. Accession wise and colour wise computation of mean of the quantitative data of seeds were made in order to see the effect of seed coat color on these characters. Pearson correlation coefficient was computed in order to analyze the relationship between the seed physical and physiological characters. Freely downloadable OPSTAT Package developed by CCS Haryana Agricultural University, Hisar, India was used for statistical analysis (http://www.hau.ernet.in/opstat.html).

3. RESULTS AND DISCUSSIONS

The statistically analyzed data (Table 1) revealed highly significant differences with respect to treatments and mean sum of squares for all the traits indicating presence of sufficient variation among the accessions, providing scope for improving these characters through breeding.

Table. 1: ANOVA for seed characters of horse gram accessions.

	Mean sum of squares		
Source of Variation	**Replication**	**Treatment**	**Error**
DF	1	49	49
Length(L) (mm)	0.045	0.398**	0.163
Breadth(B) (mm)	0.007	0.380**	0.103
Thickness (T) (mm)	0.000	0.041**	0.016
Seed Volume (V)	1.748	131.066**	29.224
100 seed wt(g)	0.000	0.373**	0.000
Plumule Length(PL) (cm)	0.003	3.599**	0.430
Radicle Length(RL) (cm)	0.767	4.532**	0.842
Vigour Index	598.732	62186.106**	6,365.48

DF= Degrees of freedom; ** Significant at 1% level.

The range, mean (accession wise), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance (GA) and GA as percentage of mean (Genetic gain, GG) are presented in Table 2. Except for hundred seed weight (HSW), PCV was marginally higher than their corresponding GCV, reflecting narrow influence of environment indicating that selection on a phenotypic basis will hold good for a genetic basis. High PCV and GCV (>20%) were recorded for plumule length, radicle length and vigour index. In contrast to our results, [12] reported low GCV for seedling radicle and plumule length in horsegram. Both seed length and thickness recorded low estimate for both PCV and GCV indicating narrow range of variability. Heritability of 100% was recorded for hundred seed weight. High heritability coupled with high genetic gain for seed volume, hundred seed weight, germination percentage, plumule length, radicle length and vigour index indicate that these characters are controlled by additive gene action. [13] reported high heritability associated with high genetic advance for yield per plant, number of pods per plant and seeds per pod in horsegram. Nevertheless, low PCV, GCV, genetic gain and moderate heritability were observed for seed length and thickness. Similar studies on genetic variability in terms of GCV, heritability and genetic advance were assessed in diverse genotypes of horsegram for yield contributing characters by many workers [14, 15, 16].

Collection wise mean for various characters indicated (Table. 3) that highest values for seed length (6.08 mm), seed breadth (4.35 mm), seed thickness (2.32 mm) , germination % (90%), vigour index (610), plumule length (6.33), radicle length (7.37), hundred seed weight (4.03) and number of seed coat colour categories (9), were observed in IC47135, IC43503, IC56136, IC71727, IC145326, IC277643, IC68588, IC56127 and IC47135 respectively. Usually seed health is represented by seed size as a composite expression of seed length, breadth, thickness and seed volume and is reflected in the seed viability which is assessed physiologically in germination studies. In the present study, collections such as IC24841, IC50712, IC68590, IC68593, IC71812, IC43503, IC43512, IC47135, IC56147, IC277610, IC277626, IC256114, IC264704, IC320017, IC10934B and IC44021A showing less germination percentage (< 85%) do not qualify for storage either in MTS or in LTS (Long term Storage) as a standard practice. This could be attributed to genotype differences between accessions as well as several other factors like seed size and 100 seed weight, seed-coat colour etc.

Out of 13 seed colour categories (Cream, Intermediate brown, Light brown, Dark brown, Grey, Mottled grey, Mottled brown, Mottled cream, Greenish brown, Chocolate, Black, Mottled greyish cream and White) noticed, three colours such as light brown, mottled cream and cream were the most commonly found ones in the population (Table 4). However, frequency of seed colour, expressed as a fraction of total number of seeds was highest for mottled brown (32.46) followed by mottled cream (24.49) and cream (14.04). Mottled grayish cream (1.15) was the least represented colour among the accessions, being present only in one accession (IC320010). Maximum number for colour polymorphism was exhibited by IC47135, having seeds 9 colour patterns. Minimum number of seed colour categories (2) was noticed in IC68591, IC47137 and IC71793A.

Table. 2: Statistical and genetic parameters for seed characters of 50 horse gram accessions.

Traits	Range			PCV	GCV	h^2	Genetic advance	Genetic gain
	Minimum	Maximum	Mean	(%)	(%)	(%)		(%)
Length(L) (mm)	4.450	6.080	5.355	9.887	6.408	42.005	0.458	8.555
Breadth(B) (mm)	2.550	4.360	3.497	14.062	10.640	57.248	0.580	16.584
Thickness (T) (mm)	1.460	2.320	1.975	8.550	5.559	42.275	0.147	7.446
Seed volume	21.770	56.050	37.384	23.947	19.088	63.536	11.717	31.343
100 seed wt (g)	1.440	4.040	2.994	14.417	14.417	100.000	0.889	29.699
Germ Percentage (%)	10.00 (18.49)	90.00 (71.60)	56.63 (48.84)	15.006	12.654	71.101	12.448	21.979
Plumule Length (PL) (cm)	1.040	6.330	4.233	32.350	28.383	76.981	2.172	51.300
Radicle Length (RL) (cm)	1.320	7.370	4.256	37.369	30.528	66.739	2.187	51.376
Vigour Index	35.410	837.120	493.249	37.534	33.870	81.429	310.555	62.961

Table. 3: Estimates of mean for seed characters of 50 horse gram accessions.

IC No.	Length (L) (mm)	Breadth (B) (mm)	Thickness (T) (mm)	Seed volume (mm^3)	Hundred seed wt (g)	Germ Percentage (%)	Plumule Length (PL) (cm)	Radicle Length (RL) (cm)	Vigour Index	No. of seed coat colours
024841	5.63	3.30	2.01	37.26	2.85	48.94	1.04	1.88	142.86	7
024842	5.40	3.33	2.03	36.24	3.31	56.85	2.73	4.04	387.20	4
044017	5.15	3.84	1.98	39.03	3.41	60.74	3.55	4.51	489.24	4
045715	5.04	3.37	1.87	31.82	2.68	59.52	4.46	4.69	543.78	5
050712	4.46	2.75	1.91	23.29	2.39	54.74	4.95	4.46	512.88	5
050728	5.35	3.57	2.06	39.39	2.68	56.85	4.98	7.16	689.30	6
068588	5.10	3.07	2.05	32.05	2.73	62.21	5.56	7.37	784.93	4
068590	4.60	2.63	2.01	24.17	2.80	53.92	4.73	5.34	539.22	4
068591	4.45	3.20	2.03	29.07	2.56	60.74	5.06	6.02	671.15	2
068593	5.47	3.14	1.89	32.24	2.80	51.24	2.44	2.18	237.92	7
068596	5.69	3.66	1.94	40.19	2.89	58.50	3.11	4.13	416.68	5
068597	5.46	3.67	1.90	37.99	3.54	59.52	4.89	5.69	628.23	3
068598	4.77	2.92	2.13	29.63	2.55	60.74	5.38	5.05	631.78	4
068601	5.79	4.01	2.01	46.54	3.15	57.87	5.26	5.21	605.73	5
068606	5.50	3.42	2.02	38.04	3.20	58.50	4.94	4.95	580.90	5
088995	6.06	3.97	2.04	49.05	2.90	62.21	5.33	4.78	634.29	6
089001	5.89	3.62	1.46	31.16	2.87	59.57	5.11	7.24	736.61	4
071723	5.18	3.84	1.87	37.02	2.90	59.09	6.21	5.92	716.79	6
071727	5.80	3.88	2.01	45.09	2.90	71.60	5.25	4.78	718.17	5
071733	5.45	3.97	1.97	42.51	3.17	55.96	5.37	5.53	610.23	6
071812	4.63	2.77	1.84	23.39	2.40	55.14	5.90	5.68	636.94	5
071817	5.14	2.94	1.89	28.55	2.90	58.50	4.29	4.39	513.89	4
145326	5.56	3.53	1.87	36.35	2.80	62.38	6.23	6.03	764.77	6
145333	4.72	3.52	1.87	31.05	2.76	66.99	2.46	3.51	402.01	5
145322	5.22	3.22	1.82	30.42	3.12	62.38	5.27	4.90	634.40	5
010982	5.08	3.89	2.12	41.96	3.21	55.96	2.79	3.17	330.73	4
043503	6.03	4.36	2.14	55.98	3.76	53.16	3.10	2.09	281.99	5
043512	5.42	3.99	2.02	43.47	2.58	46.34	2.92	2.72	261.93	6
047120	5.53	3.48	2.11	40.38	3.03	56.85	3.79	4.51	471.12	6
047132	5.79	3.95	2.04	46.53	2.90	55.63	4.99	3.98	498.70	7
047135	6.09	3.62	1.80	39.35	3.18	46.34	2.65	2.17	231.11	9
047137	4.75	2.55	1.80	23.92	3.81	62.38	5.13	5.11	638.76	2
047138	5.54	3.73	2.03	42.29	3.26	56.65	4.53	3.50	454.90	5
056127	5.99	3.94	2.31	54.27	4.04	56.85	4.51	3.94	483.07	3
056132	5.90	3.81	2.13	47.70	2.81	59.52	4.31	3.64	475.75	5
056136	5.50	3.57	2.32	45.83	3.41	56.85	4.00	3.68	435.47	3
056147	4.65	3.55	1.70	27.98	2.69	49.01	2.64	2.77	270.46	5
277610	5.41	3.97	2.09	44.74	2.95	43.48	4.41	1.32	248.19	7
277626	5.12	3.47	2.03	35.73	3.11	54.61	3.60	3.06	363.73	4
277643	5.36	3.02	2.02	32.77	3.40	66.99	6.33	5.95	819.60	3
277651	5.17	3.07	1.94	30.55	2.58	56.65	5.87	4.70	598.79	3
260721	4.87	2.81	1.98	26.93	2.71	54.61	4.74	3.30	439.09	5
256114	5.49	3.09	1.87	31.43	3.59	53.65	4.76	3.54	446.51	7
264704	4.90	3.67	2.02	36.23	2.84	53.92	2.76	3.11	315.06	6
320010	4.99	3.49	2.10	36.46	3.50	71.60	3.49	4.59	578.54	5
320017	5.70	2.99	1.78	29.87	1.44	18.44	0.91	1.03	35.78	3
010934B	5.41	3.92	1.97	41.95	2.85	53.72	3.46	3.40	367.52	7
026132A	5.92	3.77	2.05	45.57	3.01	52.43	3.02	2.99	317.43	6
044021A	5.87	4.05	1.98	46.98	3.51	60.74	5.18	5.10	624.56	6
071793A	5.85	4.10	2.05	48.91	3.27	60.74	3.28	4.01	443.90	2

Table. 4: Distribution of seed coat colour in 50 horsegram accessions studied.

IC No.	Seed colour	No. of colours	Origin
024841	Bl, Ch, Cr, DB, LB, MC, W	7	Andhra Pradesh
024842	Cr, LB, MC, W	4	Andhra Pradesh
044017	Cr, DB, LB, MC	4	Tamil Nadu
045715	Bl, Cr, DB, LB, MC	5	Tamil Nadu
050712	Cr, DB, G, LB, MC	5	Karnataka
050728	Bl, Cr, DB, LB, MC, W	6	Karnataka
068588	Cr, DB, LB, MC	4	Kerala
068590	Cr, DB, LB, MC	4	Kerala
068591	MBr, MG	2	Kerala
068593	Cr, DB, G, LB, MC, MBr, MG	7	Kerala
068596	Bl, Cr, DB, LB, MC	5	Kerala
068597	Bl, Cr, DB	3	Kerala
068598	Cr, DB, LB, MC	4	Kerala
068601	Bl, Cr, DB, LB, MC	5	Kerala
068606	Bl, Cr, DB, LB, MC	5	Kerala
088995	Bl, Cr, DB, LB, MC, W	6	Kerala
089001	Cr, LB, MC, W	4	Kerala
071723	Cr, DB, G, LB, MC, W	6	Kerala
071727	Ch, Cr, DB, LB, MC	5	Kerala
071733	Bl, Ch, Cr, LB, MC, W	6	Tamil Nadu
071812	Cr, DB, LB, MC, W	5	Tamil Nadu
071817	G, LB, MC, W	4	Tamil Nadu
145326	Ch, G, DB, LB, MC, W	6	Tamil Nadu
145333	Br, Cr, G, LB, MC	5	Tamil Nadu
145322	Cr, G, LB, MC, W	5	Tamil Nadu
010982	Cr, DB, LB, MC	4	Tamil Nadu
043503	Cr,DB, LB, MC, W	5	Tamil Nadu
043512	Ch, Cr, DB,G, LB, MC	6	Andhra Pradesh
047120	Bl, Ch, Cr, G, LB, MC	6	Karnataka
047132	Bl, Ch, Cr, DB, LB, MC, W	7	Karnataka
047135	Bl, Br, Ch, Cr, DB, G, IBr, LB,MC	9	Andhra Pradesh
047137	Bl, Ch	2	Andhra Pradesh
047138	DB, G, IBr, LB, MC	5	Andhra Pradesh
056127	Cr, LB, W	3	Andhra Pradesh
056132	Cr, G, LB, MC, W	5	Andhra Pradesh
056136	Cr, LB, MC	3	Andhra Pradesh
056147	Cr, DB, LB, MC, W	5	Andhra Pradesh
277610	Bl, Ch, Cr, DB, LB, MC, W	7	Andhra Pradesh
277626	Cr, LB, MC, W	4	Karnataka
277643	G, LB, MC	3	Karnataka
277651	Cr, LB, MC	3	Karnataka
260721	Bl, Cr, DB, LB, MC	5	Tamil Nadu
256114	Bl, Cr, DB, G, LB, MC, W	7	Kerala
264704	Cr, DB, G, LB, MC, W	6	Kerala
320010	Cr, G, LB, MC, MGC	5	Tamil Nadu
320017	Ch, DB, LB	3	Tamil Nadu
010934B	Bl, Ch, Cr, DB, G, LB, W	7	Karnataka
026132A	Bl, Cr, DB, LB, MC, W	6	Karnataka
044021A	Cr, DB, G, LB, MC, W	6	Karnataka
071793A	MBr, MC	2	Tamil Nadu

Seed colours: Cr- Cream, IBr – Intermediate brown, LB - Light brown
DB – Dark brown G - Grey, MG - Mottled grey, MB - Mottled brown
MC - Mottled cream, GB - Greenish brown, Ch - Chocolate
Bl - Black, MGC - Mottled greyish cream, W – White

Table. 5: Colour wise mean of various seed characters in 50 accessions of horse gram studied.

Sl. No.	Colour	No. of acc	L (mm)	B (mm)	T (mm)	100 seed wt. (g)	SL(cm)	RL (cm)
1	Bl	18	5.65	3.59	1.95	2.87	4.21	4.10
2	Br	2	5.45	3.00	1.95	2.00	1.88	2.49
3	Ch	12	5.45	3.63	1.78	2.51	3.67	3.58
4	Cr	42	5.27	3.51	1.99	2.97	4.23	4.12
5	DB	33	5.45	3.60	1.94	2.56	3.99	4.00
6	G	18	5.41	3.37	1.98	2.91	4.22	4.10
7	IBr.	2	5.93	3.60	2.27	3.28	3.70	2.72
8	LBr	46	5.42	3.64	2.02	2.85	4.23	4.21
9	MB	3	4.95	3.38	2.06	2.90	3.59	4.07
10	MC	44	5.39	3.47	1.98	2.90	4.28	4.30
11	MGC	1	5.70	3.80	2.21	2.98	4.28	4.24
12	MG	2	5.35	3.25	1.97	2.85	3.75	4.10
13	W	23	5.22	3.55	1.88	2.60	4.38	4.48

Seed colours: Cr- Cream, IBr – Intermediate brown, LB - Light brown
DB – Dark brown G - Grey, MG - Mottled grey, MB - Mottled brown
MC - Mottled cream, GB - Greenish brown, Ch - Chocolate
Bl - Black, MGC - Mottled greyish cream, W – White

Table. 6: Pearson Correlation Matrix between different seed characters in 50 horsegram accessions.

	Length (L) (mm)	Breadth (B) (mm)	Thickness (T) (mm)	Seed volume (mm^3)	Hundred seed wt (g)	Germ Percentage (%)	Plumule Length (PL) (cm)	Radicle Length (RL) (cm)	Vigour Index	No. of seed coat colours
Length (L) (mm)	1									
Breadth (B) (mm)	0.645^{**}	1								
Thickness (T) (mm)	0.153^{NS}	0.296^{*}	1							
Seed volume (mm^3)	0.787^{**}	0.898^{**}	0.572^{**}	1						
Hundred seed wt (g)	0.300^{*}	0.343^{*}	0.327^{*}	0.433^{**}	1					
Germ Percentage (%)	-0.137^{NS}	0.058^{NS}	0.156^{NS}	0.033^{NS}	0.470^{**}	1				
Plumule Length (PL) (cm)	-0.134^{NS}	-0.155^{NS}	-0.013^{NS}	-0.132^{NS}	0.136^{NS}	0.539^{**}	1			
Radicle Length (RL) (cm)	-0.204^{NS}	-0.187^{NS}	-0.141^{NS}	-0.238^{NS}	0.073^{NS}	0.630^{**}	0.772^{**}	1		
Vigour Index	-0.156^{NS}	-0.155^{NS}	-0.062^{NS}	-0.169^{NS}	0.166^{NS}	0.737^{**}	0.896^{**}	0.941^{**}	1	
No. of seed coat colours	0.294^{*}	0.290^{*}	-0.101^{NS}	0.222^{NS}	-0.083^{NS}	-0.197^{NS}	-0.166^{NS}	-0.314^{*}	-0.298^{*}	1

Colour-wise computation of character means depicted in Table 5, showed that Intermediate Light brown (IBr) seeds exhibited maximum values for seed length (5.93 mm), thickness (2.26 mm) and hundred seed weight (3.27 g). Interestingly, the least frequent colour Mottled Grey Cream (MGC) exhibited highest value for seed breadth (3.80mm) as well as all physiological parameters. Thus these colours can be given due preference while breeding for seed yield and yield contributing characters. [17, 18] also, found that seed colour enables determination of seed quality in horsegram by reporting that germination pattern, seedling emergence and 1000 seed weight which were better for grey and dark brown coloured seeds when compared to black seeded type. Similarly, the influence of seed coat colour variations on Bengal gram was studied by [1] and reported significant differences among the colour grades for germination, seed length, vigour index, protein content, a-amylose and dehydrogenase activity.

Correlation studies were done in order to analyze the relationship between the seed physical and physiological characters in horsegram accessions. Results (Table 6) showed positive significant correlation between length and breadth, length and volume, breadth and volume, thickness and volume, hundred seed weight and volume, hundred seed weight and germination percentage, germination percentage and seedling vigour (both plumule and radicle length), germination percentage and vigour index, plumule length with radicle length and vigour index, and between radicle length and vigour index (at 1 % level). Correlation was significant and positive at 5% level between thickness and breadth, hundred seed weight with length, breadth, and thickness and number of seed colours with length and breadth. Positive correlation between seed length and breadth was reported by [19] in castor seeds. All the physiological attributes showed non-significant correlation with the seed physical characters except for germination percentage which showed highly significant positive correlation with hundred seed weight, indicating a very close relationship between seed health and the germination process as expected usually in the case of orthodox seeds. Differences in germinability or seeding vigour associated with seed size or density have been noted in many species viz. cabbage and turnip [20], cotton [21] and rape seed [22]. The relationship of vigour parameters to the seed size is found not to be always linear with seed size. This was evident from the results obtained for soybean where seedlings emerge more rapidly from small or medium sized seeds than larger seeds [23], and in carrot (*Daucuscarota* L.) where embryo size rather than seed size is more closely associated with rate of seedling growth [24]. Differences in vigour associated with these causes are often explained on the basis of differences in composition of seed, particularly the food reserves or the efficiency of mobilization of nutrients. There may be other factors other than seed size and weight playing important role in the maintenance of vigour.

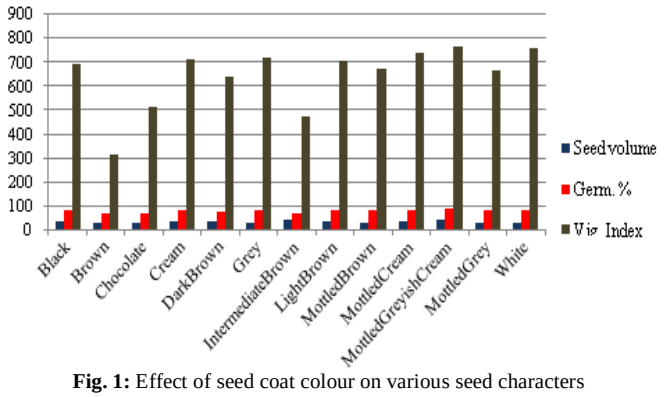

Fig. 1: Effect of seed coat colour on various seed characters

4. CONCLUSION

The results in general showed that there exists tremendous variability in horsegram seeds, which can be directly utilized in crop breeding programmes. The variability can be linked to their geographical origin of the collections so that spatial distribution can also be ascertained. The narrow difference between PCV and GCV revealed very less environmental influence on these characters providing scope for direct selection based on phenotype. The non-significant correlation of germination with all the seed physical characters except hundred seed weight suggested that the extent of seed polymorphism in terms of seed size and colour do not appear to be that detrimental or decisive in seed viability as the all the accessions except IC320017 and IC277610 maintained germination above 50%. Intermediate light brown and mottled grey cream could be the preferred colours for future yield improvement programmes.

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