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Studies on variability, correlation and path coefficient analysis for seed yield in buckwheat (*Fagopyrum esculentum* Moench) germplasm

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Abstract
A study was undertaken to estimate the genetic variability, correlation and path coefficient analysis of yield and yield contributing traits in thirty diverse germplasm line of buckwheat including four check varieties *i.e.* PRB-1, Himpriya, VL-7 and Shimla-B1 grown in Randomized Block Design with three replications at Research Farm of Department of Crop Improvement, V.C.S.G. Uttarakhand University of Horticulture and Forestry, College of Forestry, Ranichauri, Tehri Garhwal, Uttarakhand, during *kharif* season 2013. The analysis of variance indicated that the treatments were highly significant for all the traits. Genotypic and phenotypic variance was high in plant height ensued by days to 50% flowering. Large value of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were found for 100-seed weight. The maximum heritability in broad sense was realized for days to 50% flowering and high value of genetic advance mean recorded for seed yield per plant. The genotypic correlation was generally similar in nature and higher in magnitude than corresponding phenotypic correlation coefficient. Seed yield per plant was positively correlated with days to maturity, plant height, number of primary branches per plant and 100-seed weight. Path coefficient analysis indicated that days to maturity, plant height, number of primary branches per plant and 100-seed weight showed positive direct effect to seed yield per plant. It is suggested that these characters can be considered as selection criteria in improving the seed yield of buckwheat germplasm.

Keywords: Buckwheat, Correlation, Path Coefficient, Seed Yield, Variability.

Introduction

Common buckwheat (*Fagopyrum esculentum* Moench) is herbaceous erect annual plant with diploid chromosome number (2n=16) it belongs to the family Polygonaceae. Buckwheat is one of the most important pseudo cereal crop of the mountain region widely cultivated in the middle and higher Himalayas between 1800 m and 4500 m asl in kharif season. Buckwheat is originated in temperate Central Asia. In India this crop is grown on large scale in Jammu and Kashmir, Himanchal Pradesh and Uttarakhand and to some extent in Northern states *i.e.* Sikkim, Assam, Arunanchal Pradesh, Nagaland, and Manipur. It is also sporadically cultivated in the Niligiris and Palni hills in Southern India (Joshi, 1999).

Genetic variability plays an important role in a crop for best selecting of genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programmes. This crop having a greater genetic variation in seed yield and yield components. Heritability is an index for calculating the relative influence of environment on expression of genotypes. It becomes very difficult to judge how much of the variability is heritable and how much is non-heritable. Genetic advance under selection measures the role of genetic progress as the deviation between the mean genotypic value of the selected families and the mean genotypic value of the base population due to selection. Correlation coefficients are worked out to describe the degree of association between independent and dependent variables. Path coefficient analysis measures the direct influence of one variable upon another and permits the separation of correlation coefficients into components of direct and indirect effects. This gives clear picture of direct and indirect effects of the various traits on seed yield of plant.

Materials and Methods

A study was undertaken to estimate the genetic variability, correlation and path coefficient analysis of yield and yield contributing traits in thirty diverse germplasm line *viz.*, IC-13507, IC-294344, IC-412733, IC-412762, IC-13446, IC-13454, IC-13458, IC-13533, IC-13544, RSR/SKS-71, RSR/SKS-84, RSR/SKS-104, RSR/SKS-106, IC-26598, IC-26599, IC-36805, IC-36914, IC-37265, IC-42426, IC-107988, IC-108516, IC-109309, IC-204020, IC-329200, IC-341661, IC-276627 of buckwheat including four check varieties *i.e.* PRB-1, Himpriya, VL-7 and Shimla-B1 grown in Randomized Block Design with three replications at Research Farm of Department of Crop Improvement, V.C.S.G. Uttarakhand University of Horticulture and Forestry, College of Forestry, Ranichauri, Tehri Garhwal, Uttarakhand, during *kharif* season 2013. The seed material of 26 germplasm and four check varieties used in the study was procured from Project Coordinator Unit of All India Coordinated Research Project on Under Utilized crop, NBPGR, regional station Shimla.

Observation was recorded on Days to 50% flowering, Days to maturity, Plant height at maturity (cm), Number of primary branches per plant, Number of secondary branches per plant, Number of internodes per plant, Number of leaves per plant, Leaf length (cm), 100-seed weight (g), Seed yield per plant (g).

The correlation between all characters under study, at genotypic, phenotypic and environmental levels was estimated as per the method described by Robinson *et al.* (1951) [16] and Searle (1961) [17]. Parameters of variability were estimated as per formula given by Burton and De vane (1953) [2]. Heritability in broad sense was calculated as per formula given by Burton and De vane (1953) [2] and Allard (1960) [1]. The expected genetic advance resulting from selection of five per cent superior individuals were worked out by Burton and De vane (1953) [2] and Johnson *et al.* (1955) [9]. Path coefficient was obtained according to the procedure as suggested by Wright (1921) [18] and as elaborated by Dewey and Lu (1959) [5].

Results and Discussion

1 Genetic variability, heritability and genetic advance

Genotypic and phenotypic variances were highest for plant height (179.81 cm and 190.84 cm) followed by days to 50% flowering (66.02 and 70.05). It is evident that estimated PCV were larger than GCV for all the characters under study. Comparative study of coefficient of variation on various characters revealed relatively high contribution of genotypic variation in determining the total phenotypic variation for most of the characters. Seed yield per plant exhibited highest GCV (15.11%) followed by 100-seed weight (15.08%), where 100-seed weight was observed highest PCV (16.54%) followed by seed yield per plant (15.63%) (Table-1). The result of present investigation were found similar to Rana (1998) [15]; Rana and Sharma (2000) [14]; Kapila *et al.* (2006) and Dutta *et al.* (2008) [6] in common buckwheat. Highest heritability (broad sense) value was obtained for days to 50% flowering (94%) followed by plant height (93%). Heritability is an index for calculating the relative influence of environment on expression of genotypes. High heritability for different traits showed that large proportion of phenotypic variance was choiceness to genotypic variance. Selection could be made for these traits on the basis of phenotypic expression. These results are agreement with the finding of Rana (1998) [15]; Rana and Sharma (2000) [14] and Dutta *et al.* (2008) [6] in common buckwheat. The genetic advance varied from 0.37 for number of primary branches per plant to 26.72 for plant height. High genetic advance has also been reported by Dutta *et al.* (2008) [6] for number of secondary branches, seed yield, number of leaves, number of primary branches per plant and basal girth in common buckwheat.

Table 1: Estimates of variance and genetic parameters of different characters in buckwheat germplasm

S.N.	Characters	General mean	Variance		Coefficient of variation (%)		Heritability h^2% (broad sense)	Genetic advance (GA)	Genetic advance as percentage of mean (%)
			Genotypic σ^2g	Phenotypic σ^2p	Genotypic (GCV)	Phenotypic (PCV)			
1	Days to 50% flowering	55.67	66.02	70.05	14.59	15.03	94	16.24	29.17
2	Days to maturity	118.75	14.49	17.03	3.20	3.47	85	7.23	6.08
3	Plant height at maturity (cm)	98.63	179.81	190.84	13.57	14.00	93	26.72	27.09
4	No. of primary branches per plant	3.36	0.07	0.15	7.86	11.55	46	0.37	11.01
5	No. of secondary branches per plant	10.37	0.48	0.60	6.68	7.47	80	1.27	12.24
6	No. of internodes per plant	10.25	1.98	2.33	13.74	14.90	85	2.67	26.04
7	No. of leaves per plant	23.93	8.35	8.89	12.07	12.46	93	5.77	24.11
8	Leaf length (cm)	5.77	0.19	0.66	7.71	14.10	29	0.50	8.66
9	100-seed weight (g)	1.66	0.06	0.07	15.08	16.54	83	0.47	28.31
10	Seed yield per plant (g)	2.79	0.17	0.19	15.11	15.63	93	0.84	30.10

2 Correlation Coefficient

The genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficient for most of the character pairs, indicating a strong inherent association between the characters in buckwheat (Joshi and Rana, 1995 [10]; Rana, 1998 [15]; Rana and Sharma, 2000 [14]; Joshi, 2005 [12]; Debnath *et al*., 2008 [4] and Dutta *et al.*, 2008 [6]). Results indicated that negative and significant phenotypic correlation with days to 50% flowering (-0.2157), while number of leaves per plant was largely significant and positive phenotypic correlation with plant height (0.3536). While it showed 100-seed weight showed positive and highly significant phenotypic correlation with plant height (0.3349). The estimates of phenotypic correlation coefficient for rest of the characters pairs were positive or non-significant (Table-3).

The estimates of genotypic correlation coefficient between different characters showed close parallelism in direction with their corresponding phenotypic correlation (Table-2). The genotypic correlations were slightly higher in magnitude than corresponding correlation at phenotypic level. It is evident from correlation coefficient at genotypic and phenotypic levels that number of leaves per plant, plant height, days to 50% flowering, and 100-seed weight were principal yield contributing traits. They had positive and significant correlation with latter corresponding to the results of present investigation. Similar results on correlation have been also reported by Joshi and Rana, (1995) [19]; Rana, (1998) [15]; Rana and Sharma, (2000) [14]; Honda *et al.* (2003) [8]; Joshi, (2005) [12]; Debnath *et al*., (2008) [4] and Dutta *et al.*, (2008) [6]. They have also reported positive and significant association of seed yield per plant with days to flowering, days to maturity, length of main stem, number of internodes, number of leaves, branches per plant, leaf length, leaf width and 100-seed weight in buckwheat.

Table 2: Genotypic correlation coefficients among different yield contributing traits in buckwheat germplasm

Characters	Days to maturity	Plant height at maturity (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of internodes per plant	No. of leaves per plant	Leaf length (cm)	100-seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	0.1586	-0.1155	-0.1010	0.3635	-0.0626	-0.2232	-0.1390	-0.1465	-0.1147
Days to maturity		0.0382	0.0498	0.1754	0.0356	0.0815	0.1837	0.1690	0.1528
Plant height at maturity (cm)			0.2444	0.2903	0.0384	0.3702	0.0293	0.4001	0.1217
No. of primary branches per plant				0.1190	0.3660	-0.0677	0.0512	-0.1290	0.1166
No. of secondary branches per plant					-0.1457	0.1344	-0.0775	-0.1009	-0.1244
No. of internodes per plant						0.0138	-0.0406	0.1282	-0.1378
No. of leaves per plant							-0.3102	0.2769	-0.0132
Leaf length (cm)								0.1460	-0.3767
100-seed weight (g)									0.0828

*Significant at 5% level; ** Significant at 1% level

Table 3: Phenotypic correlation coefficient among different yield contributing traits in buckwheat germplasm

Characters	Days to maturity	Plant height at maturity (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of internodes per plant	No. of leaves per plant	Leaf length (cm)	100-seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	0.1581	-0.1170	-0.0784	0.3240**	-0.0396	-0.2157*	-0.0377	-0.1184	-0.1005
Days to maturity		0.0128	0.0262	0.1645	0.0276	0.0938	0.1125	0.1377	0.1487
Plant height at maturity (cm)			0.2133*	0.2553*	0.0062	0.3536**	-0.0456	0.3349**	0.1171
No. of primary branches per plant				0.0498	0.2207*	-0.0050	0.0701	-0.0603	0.0724
No. of secondary branches per plant					-0.0926	0.0944	-0.0114	-0.0634	-0.1098
No. of internodes per plant						-0.0106	0.0168	0.1246	-0.1248
No. of leaves per plant							-0.1956	0.2598*	-0.0186
Leaf length (cm)								0.0234	-0.2065
100-seed weight (g)									0.0516

*Significant at 5% level; ** Significant at 1% level

Path coefficient analysis

The direct and indirect effects of different characters on seed yield per plant at phenotypic level are presented in Table-4. The highest positive direct effect on seed yield per plant were exerted by days to maturity (0.2365) followed by plant height (0.1664), while highest negative direct effect on seed yield were exerted by leaf length (-0.2675), number of internodes per plant (-0.1701), number of leaves per plant (-0.1658), number of secondary branches per plant (-0.1621) and days to 50% flowering (-0.1098), while remaining characters were too low to be considered important. The rest of the estimates of indirect effects obtained in path analysis at phenotypic level were negligible. The residual effect of phenotypic path coefficient analysis was 91.10 % that indicated that almost 8.9% variability in seed yield per plant was explainable through the selected components. The estimate of residual factor obtained in phenotypic path analysis was 0.9110. The direct and indirect effects of different characters on seed yield per plant at genotypic level are presented in Table-5. The highest positive direct effect on seed yield per plant at genotypic level was recorded by days to maturity (0.3424) followed by plant height (0.2044). In contrast, high order negative direct effect on seed yield per plant were exerted by leaf length (-0.6488).

Positive indirect contribution on seed yield per plant was made by number of leaves per plant (0.1114) via leaf length. Leaf length (0.2013) exerted substantial positive indirect on seed yield per plant via number of leaves per plant while number of internodes (-0.1161) exerted substantial negative indirect effect on seed yield per plant via number of primary branches per plant. Number of leaves per plant (-0.1329) exerted substantial negative direct effect on seed yield per plant via plant height, while negative indirect effect on seed yield per plant via days to maturity were exhibited by leaf length (-0.1192). The rest of the estimates of indirect effects at genotypic level were too low to be considered important. The residual factor for genotypic path coefficient analysis in this study was obtained 0.7363, which indicate 26.37% of variability among genotypes for seed yield per plant was explainable through selected components and only 73.63% of variability for seed yield per plant had not been covered.

Evaluation of entire genotypic and phenotypic path analysis revealed that the characters, *viz.* days to maturity, plant height and number of primary branches per plant exhibited high positive direct effect on yield. These traits also had significant correlation with seed yield per plant both at genotypic and phenotypic levels. Hence, the relative information of these characters might be considered during the time of selection procedure for improving the seed yield in buckwheat. These character have also been identified as major direct contributors seed yield per plant by earlier worker Choi *et al.* (1995) [3]; Joshi and Rana (1995) [10]; Rana and Sharma (2000) [14]; Joshi (2005) [12]; Debnath *et al.* (2008) [4] and Dutta *et al.* (2008) [6] in buckwheat and Hasan *et al.* (2013) [7], Patial *et al.* (2014) [13] in amaranth.

Table 4: Path coefficient analysis showing the direct and indirect effect of 10 parameters on seed yield per plant in buckwheat germplasm at phenotypic level

Characters	Days to 50% flowering	Days to maturity	Plant height at maturity (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of internodes per plant	No. of leaves per plant	Leaf length (cm)	100-seed weight (g)	Phenotypic correlation (r_p) with seed yield per plant
Days to 50% flowering	-0.1098	-0.0174	0.0128	0.0086	-0.0356	0.0044	0.0237	0.0041	0.0130	-0.1005
Days to maturity	0.0374	0.2365	0.0030	0.0062	0.0389	0.0065	0.0222	0.0266	0.0326	0.1484
Plant height at maturity (cm)	-0.0195	0.0021	0.1664	0.0355	0.0425	0.0010	0.0588	-0.0076	0.0557	0.1171
No. of primary branches per plant	-0.0068	0.0023	0.0185	0.0866	0.0043	0.0191	-0.0004	0.0061	-0.0052	0.0724
No. of secondary branches per plant	-0.0525	-0.0267	-0.0414	-0.0081	-0.1621	0.0150	-0.0153	0.0018	-0.0103	-0.1098
No. of internodes per plant	0.0067	-0.0047	-0.0011	-0.0375	0.0158	-0.1701	0.0018	-0.0029	-0.0212	-0.1248
No. of leaf per plant	0.0358	-0.0156	-0.0586	0.0008	-0.0157	0.0018	-0.1658	0.0324	-0.0431	-0.0186
Leaf length (cm)	0.0101	-0.0301	0.0122	-0.0188	0.0030	-0.0045	0.0523	-0.2675	-0.0063	-0.2065
100-seed weight (g)	-0.0019	0.0022	0.0053	-0.0010	-0.0010	0.0020	0.0041	0.0004	0.0157	0.0516

Residual factor = 0.9110 r_p = phenotypic correlation coefficient

Table 5: Path coefficient analysis showing the direct and indirect effect of 10 parameters on seed yield per plant in buckwheat germplasm at genotypic level

Characters	Days to 50% flowering	Days to maturity	Plant height at maturity (cm)	No. of primary branches	No. of secondary branches	No. of internodes	No. of leaves per plant	Leaf length (cm)	100-seed weight (g)	Genotypic correlation (r_g) with seed yield per plant
Days to 50% flowering	0.2123	-0.0337	0.0245	0.0214	-0.0772	0.0133	0.0474	0.0295	0.0311	-0.1147
Days to maturity	0.0543	0.3424	0.0131	0.0171	0.0600	0.0122	0.0279	0.0629	0.0579	0.1528
Plant height at maturity (cm)	-0.0236	0.0078	0.2044	0.0500	0.0593	0.0078	0.0757	0.0060	0.0818	0.1217
No. of primary	-0.0201	0.0099	0.0487	0.1991	0.0237	0.0729	-0.0135	0.0102	-0.0257	0.1166

branches										
No. of secondary branches	-0.0812	-0.0392	-0.0648	-0.0266	-0.2233	0.0325	-0.0300	0.0173	0.0225	-0.1244
No. of internodes	0.0199	-0.0113	-0.0122	-0.1161	0.0462	-0.3172	-0.0044	0.0129	-0.0407	-0.1378
No. of leaf per plant	0.0801	-0.0293	-0.1329	0.0243	-0.0483	-0.0050	-0.3591	0.1114	-0.0994	-0.0132
Leaf length (cm)	0.0902	-0.1192	-0.0190	-0.0332	0.0503	0.0264	0.2013	-0.6488	-0.0947	-0.3767
100-seed weight (g)	-0.0220	0.0253	0.0600	-0.0194	-0.0151	0.0192	0.0415	0.0219	0.1500	0.0828

Residual factor = 0.7368 r_g = genotypic correlation coefficient

Conclusion
From the present study it is concluded that genetic variability, correlation and path coefficient analysis of seed yield and yield contributing traits existence of large ranges of alteration for most of the characters among buckwheat germplasm and chances of the genetic gain through selection or hybridization. Phenotypic and genotypic correlation analysis showed the positive correlation of seed yield with important agro-morphological characters. Hence, improving one or more of the traits could result in high seed yield for buckwheat. Plant height, days to 50% flowering, 100-seed weight, number of primary branches per plant with seed yield per plant suggesting the possibility of improving seed yield through direct selection of these traits. So it is informed that these traits can be considered as selection criteria in enhancing the seed yield of buckwheat germplasm.

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