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GENETIC VARIABILITY, CHARACTER ASSOCIATION AND PATH ANALYSIS IN SAFED MUSLI (*CHLOROPHYTUM BORIVILIANUM*, SANTAPAU)

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ABSTRACT

Seven germplasm lines of Safed Musli (*Chlorphytum borivilianum* L) were grown in RBD in three environments at Herbal Park, Rajasthan College of Agriculture, MPUAT, Udaipur (Raj.) during 2011-14. The magnitude of phenotypic coefficient of variation (PCV) was generally higher than genotypic coefficient of variation (GCV) for all seven quantitative traits. In addition, the high magnitude (> 20%) of PCV along with GCV was observed for length of middle leaves for each location separately and over pooled basis; number of leaves per plant in E_2, E_3; number of fasciculated root per bunch in E_3 and pooled basis. High heritability coupled with high expected genetic advance as percent of mean indicating that the presence of more additive gene effects so these characters could be improved through selection. Fasciculated root yield exhibited positive significant genotypic correlation with number of fasciculated root per bunch in all location and pooled basis, Length of main fasciculated root in all the environment including pooled except E_3; number of leaves per plant in E_2 and E_3; and width of middle leaves in E_2 and E_3. Number of fasciculated root per bunch in all location and pooled basis also exhibit positive significant phenotypic association with fasciculated root yield.

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INTRODUCTION

Chlorophytum borivilianum L. is an herbaceous medicinal plant commonly known as safedmusli, used in many Ayurvedic vital tonics and aphrodisiac formulations. It is belonging to the family Liliaceae. Seventeen species of *Chlorophytum*had been reported in India (Bordia *et al*., 1995). Among all the species of *Chlorophytum* present in India, *C. borivilianum*is cultivated on largescale in many parts of the county and produces the highest yield of roots and has the highest saponin content (Singh and Samuel, 2001). It is widely distributed in India mainly in Southern Rajasthan, Western Madhya Pradesh, North Gujarat and few parts of Karnataka (Kothari and Singh, 2003). The roots (tubers) are rich in alkaloids, vitamins, minerals, proteins, carbohydrates, saponins, root fibers, polysaccharides and steroids (Tandon and Shukla, 1993). It has various therapeutic values as total rejuvenator, antioxidant and Immuno modulator. It is beingused as an anti arthritic and anticancer drug. Fasiculated roots of *Chlorophytum borivilianum* are used as tonic and important ingredient of 20 ayurvedic and unnani preparations (Oudhia, 2001).

As it has incredible medicinal properties which can be explored for health advancement of human beings, steps should be taken for cultivation of *Chlorophytum borivilianum* and isolation of different phytoconstituents specially saponin, so that true medicinal value of our indigenous medicinal plant can be explored. There is need for commercial cultivation of this species. Thus, subsequently attempts were made to categorize superior germplasm and to develop the cultivation practices (Oudhia, 2001). A successful selection depends upon the information on the association of morpho-agronomic traits with seed yield (Kumar *et al*., 2013).

Keeping the above fact in mind, the present experiment was carried out to evaluate the genetic variability in different *Chlorophytum borivilianum* genotypes components to select a more desired trait that may contribute for the improvement of safed musli and estimates the extent of inter-relationship between different pairs of traits to develop the suitable selection criteria for breeding the desirable high root yielding genotypes.

MATERIALS AND METHODS

The present investigation was carried out on Safed musli germplasm at Herbal Park, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan). The experiment was laid in randomized block design in three environmental conditions during year 2011-12 to 2013-14 with seven test genotypes of Safed musli. These genotypes exhibited wide spectrum of variation for various agronomical and morphological characters. The data were recorded from 5 randomly selected competitive plants from each plot on seven distinct morphological characters. The data on fasciculated root yield, number of fasciculate root per bunch, thickness of main fasciculate root, length of main fasciculated root, length of middle leaves, width of middle leaves and number of leaves per plant were recorded for statistical analysis.

The mean value of the recorded data was subjected to analysis of variance (ANOVA)

for each environment and on pooled basis, using the statistical analysis procedures of Panse and Sukhatme, (1985). The phenotypic and genotypic variances were estimated according to the method suggested by Burton and De Vane (1953). Heritability (h^2) in broad sense and Genetic gain for each character was computed using the formula suggested by Hanson *et al*. (1956) and Johnson *et al*. (1955), respectively. The correlations between yield and its contributing traits were estimated using the method described by Searle (1961) and the estimates of direct and indirect contribution of various characteristics to seed yield were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Estimates of variance components

The analysis of variance revealed significant differences among the genotypes for different characters indicating presence of sufficient variability in the material in each location. Genotypic and phenotypic coefficient of variation, heritability (broad sense) and genetic gain were analyzed separately for each location and over pooled basis are shown in Table 1.

Phenotypic coefficient of variability (PCV) values ranged from 7.29% for fasciculated root yield in E_2 to 42.91% for number of leaves /plant in E_2, whereas the genotypic coefficient of variability (GCV) ranged from 4.77% for thickness of main fasciculated root in E_3 to 42.72% for number of leaves /plant in E_2. In addition, Phenotypic coefficient of variation (PCV) estimated was higher than genotypic coefficient of variation (GCV) for all the characters at all the locations indicated that the variability was not only due to genotypes but also due to the influence of environment. Selection for such traits sometimes may be misleading which is partly contrary to the finding of Kumar *at al*. (2007).

According to Deshmukh*et al*. (1986), PCV and GCV values roughly more than 20% are regarded as high, whereas values less than 10% are considered to be low and values between 10 and 20% to be medium. Based on this delineation, the high magnitude (> 20%) of PCV was observed for length of middle leaves for each location separately and over pooled basis, number of leaves per plant in E_2, E_3 and pooled basis, number of fasciculated root per bunch in E3 and pooled basis, and fasciculated root yield in E_3. Moderate estimate (10-20%) of PCV was recorded for fasciculated root yield in E_3, number of leaves per plant in E_1, thickness of main fasciculated root in E_2, number of fasciculated root per bunch in E_1 and E_2, length of main fasciculated root in E_1, E_3 and pooled basis, and width of middle leaves for each location separately and over pooled basis.While the low estimate of PCV were recoreded for characters studied in remaining location.

High estimate GCV was observed for number of fasciculated root per bunch in E_3, number of leaves per plant in E_2 and E_3, and length of middle leaves for each location separately and over pooled basis. Moderate estimate (10-20%) of GCV was recorded for number of fasciculated root per bunch in E_2, E_3 and pooled basis, number of leaves per plant in E_1 and pooled basis. Length of main fasciculated root and width of middle

Table 1: Estimates of phenotypic (PCV), genotypic (GCV), environmental (ECV) coefficients of variation, heritability (h^2), genetic advance (GA) and genetic gain (GG) of seven traits of Safed musli

S.N.	Characters	Env	GCV	PCV	ECV	h^2	GA	GG
1	Fasciculated root yield (Q/ha)	E_1	8.39	11.15	7.34	56.64	4.65	13.00
		E_2	6.26	7.29	3.73	73.82	3.76	11.08
		E_3	8.60	10.46	5.95	67.58	5.59	14.56
		Pool	7.77	9.89	5.93	61.70	4.53	12.57
2	No. of fasciculated root/bunch	E_1	14.13	17.27	9.93	66.97	3.14	23.82
		E_2	13.23	17.03	10.73	60.34	2.50	21.17
		E_3	29.12	29.89	6.76	94.89	7.76	58.43
		Pool	18.86	22.62	9.19	69.53	4.13	32.40
3	Thickness of main fasciculated root (mm)	E_1	8.50	9.62	4.51	78.03	1.16	15.47
		E_2	9.76	10.74	4.48	82.61	1.39	18.28
		E_3	4.77	7.58	5.89	39.69	0.48	6.20
		Pool	7.64	9.38	5.02	66.41	0.98	12.83
4	Length of main fasciculated root (cm)	E_1	17.64	19.59	8.53	81.06	3.66	32.71
		E_2	19.11	20.19	6.53	89.53	4.17	37.25
		E_3	12.03	12.60	3.75	91.14	2.91	23.66
		Pool	16.17	17.53	6.43	85.01	3.55	30.70
5	Length of middle leaves (cm)	E_1	24.41	25.07	5.72	94.79	10.69	48.96
		E_2	25.68	25.99	4.01	97.62	11.11	52.26
		E_3	21.15	21.69	4.85	95.00	9.37	42.46
		Pool	23.65	24.28	4.92	94.93	10.31	47.47
6	Width of middle leaves (cm)	E_1	13.97	14.64	4.37	91.10	4.60	27.48
		E_2	15.53	15.88	3.30	95.67	5.14	31.29
		E_3	14.28	15.02	4.66	90.36	4.63	27.97
		Pool	14.33	15.18	4.16	89.06	4.62	27.85
7	No of leaves /plant	E_1	13.97	14.64	4.37	91.10	4.60	27.48
		E_2	42.72	42.91	3.96	99.15	13.67	87.63
		E_3	36.54	37.22	7.08	96.38	12.22	73.91
		Pool	14.26	33.37	5.36	18.26	2.05	12.55

Table 2: Genotypic and phenotypic correlation coefficients between different characters in safed musli

Character	Environments	Fasciculated root yield (Q/ha)		No. of fasciculated root/bunch		Thickness of main fasciculated root (mm)		Length of main fasciculated root (cm)		Length of middle leaves (cm)		Width of middle leaves (cm)		No. of leaves /plant	
		G	P	G	P	G	P	G	P	G	P	G	P	G	P
Fasciculated root yield(Q/ha)	E_1	-	-	0.96**	0.76*	0.44	0.26	0.97**	0.64	0.30	0.22	-0.40	-0.26	-0.40	-0.26
	E_2	-	-	1.00**	0.67	0.05	0.07	0.70	0.59	0.66	0.58	-0.76*	-0.61	0.83*	0.71
	E_3			0.99**	0.82*	0.06	0.19	0.79*	0.66	0.73	0.52	-0.76*	-0.62	0.85*	0.69
	P			0.94**	0.75	0.15	0.18	0.82*	0.60	0.55	0.43	-0.69	-0.47	1.23	0.45
No. of fasciculated root/bunch	E_1					0.23	0.22	0.91**	0.62	0.59	0.48	-0.40	-0.28	-0.40	-0.28
	E_2					-0.22	-0.09	0.91**	0.61	0.51	0.41	-0.62	-0.44	0.80*	0.60
	E_3					0.03	0.09	0.72	0.65	0.65	0.63	-0.55	-0.52	0.72	0.68
	P					0.02	0.07	0.78*	0.56	0.61	0.49	-0.52	-0.41	1.16	0.49
Thickness of main fasciculated root (mm)	E_1							-0.06	0.02	0.59	0.49	-0.34	-0.35	-0.34	-0.35
	E_2							-0.28	-0.21	0.29	0.29	-0.26	-0.19	0.33	0.28
	E_3							-0.50	-0.18	0.66	0.33	-0.28	-0.13	0.52	0.30
	P							-0.26	-0.12	0.49	0.37	-0.31	-0.22	0.84*	0.17
Length of main fasciculated root (cm)	E_1									0.22	0.22	-0.61	-0.53	-0.61	-0.53
	E_2									0.14	0.61	-0.64	-0.59	0.67	0.63
	E_3									0.37	0.31	-0.84*	-0.73	0.70	0.67
	P									0.23	0.21	-0.72	-0.59	1.07	0.40
Length of middle leaves (cm)	E_1											-0.61	-0.56	-0.61	-0.56
	E_2											-0.73	-0.70	0.79*	0.77*
	E_3											-0.61	-0.58	0.81*	0.75
	P											-0.66	-0.62	1.24	0.50
Width of middle leaves (cm)	E_1													1.00	1.00
	E_2													-0.91**	-0.89**
	E_3													-0.96**	-0.87*
	P													-1.27	-0.56
No. of leaves /plant	E_1														
	E_2														
	E_3														
	P														

* Significant at 5 % probability level, ** Significant at 1 %probability level.

Table 3: Path analysis showing direct& indirect effects of six characters on root yield per plant in Safedmusli for three environments and over pooled basis (P)

Character	Environment	Direct effect	No. of fasciculated root/bunch	Thickness of main fasciculated root (mm)	Length of main fasciculated root (cm)	Length of middle leaves (cm)	Width of middle leaves (cm)	No of leaves /plant	r
No. of fasciculated root/bunch	E_1	0.87	-	0.16	0.32	-0.41	0.00	0.01	0.96**
	E_2	-0.04	-	-0.69	5.81	2.30	-0.51	-5.88	1.00**
	E_3	0.56	-	0.00	0.26	0.01	-0.18	0.33	0.99**
	P	0.45	-	0.00	0.35	0.00	-0.00	0.08	0.94**
Thickness of main fasciculated root (mm)	E_1	0.66	0.20	-	-0.02	-0.41	0.00	0.01	0.44
	E_2	3.16	0.01	-	-1.79	1.34	-0.21	-2.46	0.05
	E_3	0.06	0.02	-	-0.18	0.01	-0.09	0.24	0.06
	P	0.20	0.01	-	-0.11	0.00	-0.00	0.06	0.15
Length of main fasciculated root (cm)	E_1	0.37	0.79	-0.04	-	-0.16	0.00	0.01	0.97**
	E_2	6.42	-0.03	-0.88	-	0.66	-0.53	-4.94	0.70
	E_3	0.36	0.40	-0.03	-	0.01	-0.27	0.32	0.79*
	P	0.45	0.35	-0.05	-	0.00	-0.00	0.07	0.82*
Length of middle leaves (cm)	E_1	-0.70	0.51	0.39	0.08	-	0.00	0.01	0.30
	E_2	4.54	-0.02	0.93	0.93	-	-0.60	-5.83	0.66
	E_3	0.02	0.36	0.04	0.13	-	-0.19	0.37	0.73
	P	0.00	0.27	0.10	0.10	-	-0.00	0.08	0.55
Width of middle leaves (cm)	E_1	-0.00	-0.35	-0.22	-0.22	0.42	-	-0.02	-0.40
	E_2	0.82	0.02	-0.82	-4.12	-3.33	-	6.66	-0.76*
	E_3	0.32	-0.31	-0.02	-0.30	-0.01	-	-0.44	-0.76*
	P	0.00	-0.23	-0.06	-0.32	-0.00	-	-0.08	-0.69
No of leaves /plant	E_1	-0.02	-0.35	-0.22	-0.22	0.42	-0.00	-	-0.40
	E_2	-7.36	-0.03	1.06	4.31	3.59	-0.74	-	0.83*
	E_3	0.46	0.40	0.03	0.25	0.02	-0.31	-	0.85*
	P	0.07	0.52	0.17	0.48	0.00	-0.00		1.23

leaves showed moderate estimate of GCV for each location separately and over pooled basis. While the low estimate of GCV were recoreded for remaining characters. While the low estimate of GCV were recoreded for characters studied in remaining location. The high GCV values of these characters suggest that the possibility of improving these trait through selection.

The difference between PCV and GCV values was high in location E_1 for fasciculated root yield, number of fasciculated root per bunch and length of main fasciculated root, location E_2 for fasciculated root yield and number of fasciculated root per bunch, location E_3 for fasciculated root yield, and over pooled basis for fasciculated root yield, number of fasciculated root per bunch and number of leaves per plant. However, this difference was low in location E_2 for number of leaves per plant amd width of middle leaves and in location E_3 for number of fasciculated root per bunch, length of main fasciculated root and length of middle leaves suggesting minimal influence of environment on the expression of the characters.

Estimation of heritabilityin broad sense and genetic advance

Estimates of heritability in broad sense (h^2) ranged from 18.26 to 99.26%for number of leaves per plant over pooled basis and location E_2, respectively (Table 1). Heritability estimate was high (>80%) for length of main fasciculated root, length of middle leaves and width of middle leaves for each location separately and over pooled basis. In addition, number of leaves per plant in each location except pooled basis, thickness of main fasciculated root in E_2 and number of fasciculated root per bunch in E_3 also showes high magnitude of heritability, indicated that selection for such characters could be fairly easy. This is because there would be a close correspondence between the genotype and the phenotype due to the relative small contribution of the environment to the phenotype. It was low (less than 40%) for the thickness of main fasciculated root in E_3 and number of leaves per plant over pooled basis, suggesting that selection may be considerably difficult or virtually impractical due to the masking effect of environment.

Genetic advance under selection (GA) refers to the improvement of characters in genotypic value for the new population compared with the base population under one cycle of selection at a given selection intensity (Singh, 2001). Maximum genetic gain (GG) at 5% selection intensity was recorded for number of leaves per plant in E_2 and E_3, followed by number of fasciculated root per bunch in E3.According to Johnson et al. (1955), high heritability estimates along with the high genetic gain is usually more helpful in predicting gain under selection than heritability estimates alone. The present study reveals high heritability coupled with high expected genetic gain fornumber of leaves per plant in E_2 and E_3, number of fasciculated root per bunch in E_3 etc.

Correlation

The phenotypic and genotypic correlation coefficients were worked out based on the data for three environment and also based on pooled data on pooled environments in the present investigation (Table 2). This type of study over environment is needed to confirm the character association with fasciculated

root yield so as to fix some of the positively associated characters with fasciculated root yield as selection criteria for the improvement of root yield.

In the present investigation, mostly the genotypic correlation coefficients were slightly higher than the phenotypic correlation coefficients. This may be due to effect of environment in modifying the total expression of genotypes, thus altering the phenotypic expression. This was confirmed by the previous findings of Bhagat and Jadeja (2003). Fasciculated root yield exhibited positive significant genotypic correlation with number of fasciculated root per bunch in all location and pooled basis, Length of main fasciculated root in all the environment including pooled except E_3; number of leaves per plant in E_2 and E_3; and width of middle leaves in E_2 and E_3. In addition to above, number of fasciculated root per bunch in all location and pooled basis also exhibit positive significant phenotypic association with fasciculated root yield. This was confirmed by the previous findings of Kumar *at al*. (2007).

Width of middle leaves exhibited positive significant genotypic and phenotypic correlation with number of leaves per plant in E_2, E_3 test environment. Similarly, length of middle leaves exhibited positive significant genotypic and phenotypic correlation with number of leaves per plant in E_2 test environment. In addition, number of leaves per plant in E_3 also positively associated with length of middle leaves at genotypic level. Number of fasiculated root per bunch exhibited positive significant correlation with number of leaves per plant in all the test environment except E_3, including pooled. Studies on correlation provide an opportunity for critically assessing the relationship of these characters with root yield. Identification of important yield components and information about their interrelationship with yield and also each other will be very useful in developing high yielding variety. From this point of view, the information on correlation of root yield with related traits is the prerequisite to form an effective selection strategy aimed at its improvement.

Path coefficient

The direct and indirect effects of six characters on root yield per plant estimated under path coefficient analysis using correlations are given in Table 3. It can be noticed from Table 3 that the highest positive direct effect on root yield per plant exerted by length of main fasciculated root (6.42) in E_2 followed by length of middle leaves (4.54) in E_2 and thickness of main fasciculated root (3.16) in E_2. It means a slight increase in any one of the above traits may directly contribute towards root yield per plant. High positive indirect effect on root yield per plant exerted by width of middle leaves (E_2) *via* number of leaves per plant followed by number of fasciculated root per bunch (E_2) *via* length of main fasciculated root. This suggests that width of middle leaves and number of fasciculated root per bunch were the most important indirect contributors to root yield per plant *via* number of leaves per plant and length of main fasciculated root, respectively. Some of the earlier reports have also identified such characters as important indirect contributors towards expression of root yield in safed musli (Kumar et *al*. 2007). The characters identified above as important direct and indirect contributors on root yield are helpful for consideration in formulating selection strategy in safed musli for developing high yielding varieties.

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