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PATH ANALYSIS IN DRY BEAN GERMPLASM

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ABSTRACT

The analysis of inter-relationship among the different characters in 91 germplasm lines of rajmash (*Phaseolus vulgaris* L.) during three growing seasons, showed that grain yield was positively correlated with number of nodules, number of pods and pod length, but was highly significant with plant height. The path coefficient analysis revealed that pod number was most important yield character. The metroglyphic analysis showed that race-1 and race-5 genotypes were higher yielder and revealed a direct relationship between plant height and crop duration, whereas inverse relationship between plant height and pod/grain degeneration was evident. These characters, therefore could be used as useful criteria for developing high yielding rajmash varieties suitable for different growing seasons.

Key words: *Phaseolus vulgaris*, dry bean, rajmash, metroglyph, correlations, path coefficient.

Rajmash (*Phaseolus vulgaris* L.) has been cultivated in India for a long time. It is grown during different seasons and for different purposes in different parts of the country. In the north and northwestern part, it is grown as a pulse, whereas in northeastern part it is grown generally as vegetable. Depending on the climatic conditions and uses, determinate types are suitable for grain and indeterminate types for vegetable purposes.

MATERIALS AND METHODS

Experimental material consisted of 91 germplasm lines of rajmash belonging to different races of determinate and indeterminate types (Table 1). The material was evaluated during spring (March–June), kharif (June–September), and autumn (August–November) at I.C.A.R. Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok during 1986–88. The material was sown in randomized block design with three replications in each season. The observations were recorded on five competitive plants per replication for 10 quantitative traits. The genotypes were grouped according to growth habit and other

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characters into five races [1]. The data were analysed for inter- and intrarace variations. The correlation and path analysis were done as suggested by Dewey and Lu [2]. The variation in different characters was scored while dividing with the least value as suggested by [3–6]. The scored data were utilized for metroglyphic representation with respect to important characters affecting yield.

RESULTS AND DISCUSSION

The germplasm collections of rajmash (*Phaseolus vulgaris* L.) have been grouped into five races, viz indeterminate climbers, indeterminate semiclimbers, determinate climbers, indeterminate bush, and determinate bush [1, 7]. The genotypes showed inter- and intraracial variation (Table 2) with respect to plant and seed characters. The races differed significantly for mean plant height, number of nodules and pods per plant, 100-seed weight, seed yield per m^2 and pod/seed degeneration. Intrarace variations were also significant except for pod length and seeds per pod. The magnitude of variation was more for plant height (48.5–189.9 cm), number of nodules per plant (18.4–60.8), pods per plant (12.4–24.0), and pod/seed degeneration (3.4–50.6%). Pod/seed degeneration was maximum during kharif season in the bushy varieties. Grain yield did not show any race-specific trend but it was high in the indeterminate climbers and determinate bush types. Earlier studies have reported that genetic variability in this species has been revealed through plant and seed characters [1, 8, 9]. The genotypic suitability with respect to growth habit exclusively

Table 1. Morphological classification of dry bean germplasm

Race	Habit	Leaf size	Genotypes
1	Indeterminate climber	Small Large	Him-12, Him-13, Him-11, Him-14-1, Him-14-2, Him-14-3, JK-1, JK-2, JK-3, JK-3-1, JK-4, JK-5, JK-6, JK-7,
2	Indeterminate semiclimber	Small	JK-8, JK-9, RC-white, Him-1, Him-2, Him-local, Him-local-2, RCR-35, RCR-2, CRJ-201, CRJ-202, CRJ-203, CRJ-204, CRJ-205, CRJ-206, CRJ-207, CRJ-208, RCR-90.
3	Indeterminate bush	Small	RCR-15, CRJ-302
4	Determinate climber	Small	HUR-91, Raj-12-1, RCR-85, RCR-12, CRJ-301, CRJ-303, CRJ-304, CRJ-305, CRJ-306, CRJ-307, CRJ-112, CRJ-113.
5	Determinate bush	Large	PDR-5, PDR-9, PDR-5(sel), PDR-5-2, PDR-5-1, PDR-9-1, PDR-14, , PDR-14-1, HUR-15, HUR-15-1-1, HUR-15-1-2, HUR-15-1, PDR-20, PDR-20-1, PDR-22, PDR-23, PDR-24, HUR-120, HUR-136, HUR-137, HUR-138, Kim-1, Kin-2, Kin-3, Kin-3-1, VL-63, Raj-12, Raj-12-2, RCR-11, RCR-14, RCR-8, RCR-7, RCR-68, RCR-86, Jowale, CRJ-107 CRJ-108, CRJ-109, CRJ-110, CRJ-111, CRJ-114, CRJ-115

Table 2. Mean, range and score for different characters in dry bean

Race	Habit	Parameter	Plant height (cm)	No. of nodules per plant	No. of pods per plant	Pod length	No. of seeds per pod	100-grain weight (g)	Seed yield per m^2 (g)	Pod/seed degeneration (%)		
										spring	kharif	autumn
1	Indeterminate climber	Mean	189.9	60.6	24.0	14.4	5.6	40.5	34	5.0	6.0	3.4
		Range	150–240	24–105	14–40	8–18	3–7	21.8–57.9	210–390	2–8	4–10	1–8
		Score	3.9	3.3	1.9	1.2	1.2	1.3	2.1	1.0	1.0	1.3
2	Indeterminate semiclimber	Mean	165.4	58.6	22.4	14.2	6.4	31.2	195	5.0	8.0	2.6
		Range	125–200	22–98	12–34	6–16	5–7	23.1–39.2	140–310	3–9	6–14	1–8
		Score	3.4	3.2	1.8	12	1.3	1.0	1.2	1.0	1.3	1.0
3	Indeterminate bush	Mean	105.8	28.0	16.7	12.0	6.0	33.5	180	10.0	15.0	4.8
		Range	98–125	15–46	8–24	8–14	4–7	24.2–41.7	130–290	6–15	12–20	3–12
		Score	2.2	1.5	1.3	1.0	1.2	1.2	1.1	2.0	2.5	1.8
4	Determinate	Mean	94.7	20.0	14.6	12.2	6.8	40.0	160	150.0	30.4	8.7
		Range	82–115	4–40	4–20	8–13	6–8	35.1–52.9	100–240	8–20	20–60	6–17
		Score	1.9	1.1	1.2	1.0	1.4	1.3	1.0	3.0	5.1	3.3
5	Determinate bush	Mean	48.5	18.4	12.4	13.7	4.8	43.1	280	18.0	50.6	6.8
		Range	37–70	0–30	6–15	6–18	3–5	30.7–60.5	150–340	10–30	20–70	4–18
		Score	1.0	1.0	1.0	1.1	1.0	1.4	1.7	3.6	8.4	2.6

depended on the climatic conditions and their use [7]. Indeterminate climbers and semiclimbers (race-1 and race-2) were more suited for vegetable purpose and were found to be better yielders in kharif season. The indeterminate bush and other determinate types were better as grain types and are more suitable for cultivation in spring and autumn. The pod/seed degeneration was highly significant in determining the genotypic suitability for different growing seasons. The genotypes belonging to first three races (1, 2 and 3), which were generally pole type, showed minimum pod/seed degeneration over all the three growing seasons. The race-4 and race-5 genotypes were more prone to pod/seed degeneration, which was significantly higher in kharif. In case of spring sowing, when maturity overlapped with high rainfall, pod/seed degeneration was equally high. The observations indicated that the pod of determinate types came in contact with the ground, leading to pod degeneration, and ultimately reduced grain yield.

The variation expressed in the form of metroglyphs, indicated that crop duration was directly related with plant height, showing that most of the indeterminate types were had late maturity (Fig. 1). Also, correlation of plant height with grain yield revealed that race-1 and race-5 were better yielder as compared to other races of indeterminate plant height (Fig. 2). The third metroglyph (Fig. 3) between plant height and pod/seed degeneration showed lowest yield losses due to pod/seed degeneration in race-1 and race-2 over all the seasons, whereas race-4 and race-5 showed more losses in all the seasons, maximum being in kharif.

Coefficients of correlation were worked out between different plant and seed characters (Table 3). Plant height was significantly and positively associated with number of nodules

Table 3. Phenotypic coefficients of correlation among different characters in dry bean

Characters	No. of nodules	No. of pods	Pod length	Seeds per pod	100-seed weight	Crop duration	Pod or seed degeneration	Seed yield
Plant height	+0.91*	+0.99*	+0.54	+0.32	−0.42	+0.93*	−0.92*	+0.92*
No. of nodules		+0.98*	+0.74	+0.12	−0.41	+0.80	−0.94*	+0.43
No. of pods			+0.62	+0.22	−0.44	+0.89	−0.95*	+0.35
Pod length				−0.41	+0.10	+0.25	−0.52	+0.73
Seeds per pod					−0.54	+0.39	−0.15	−0.74
100-seed weight						−0.42	+0.60	+0.56
Crop duration							−0.87	+0.21
Pod/seed degeneration								−0.27

and pods, crop duration and grain yield, but the degree of association with pod length and grains/pod was low. Plant height showed significant negative association with pod/seed degeneration. Number of nodules per plant also showed significant positive association with plant height and number of pods, but significantly negative with pod/seed degeneration. It also showed positive association with pod length, number of seeds, crop duration and grain yield, but negative association with 100-seed weight. Pod length, number of seeds and 100-seed weight did not show significant correlation coefficients with any of the characters studied. Pod/seed degeneration had significant negative correlation with plant height, number of nodules and pods per plant. Although yield was affected by all the characters, plant height affects yield realization more in the kharif season. Similar correlation studies earlier showed a significant effect of plant height and number of pods per plant on seed yield [10–14].

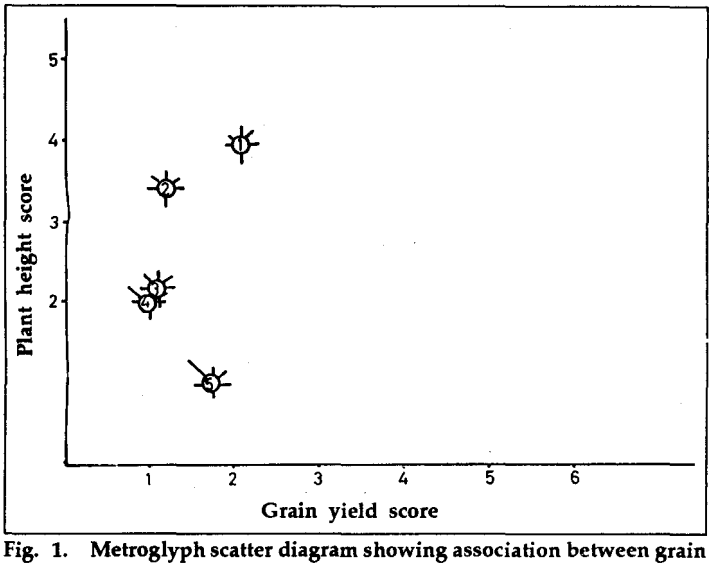

Fig. 1. Metroglyph scatter diagram showing association between grain yield and plant height in dry bean.

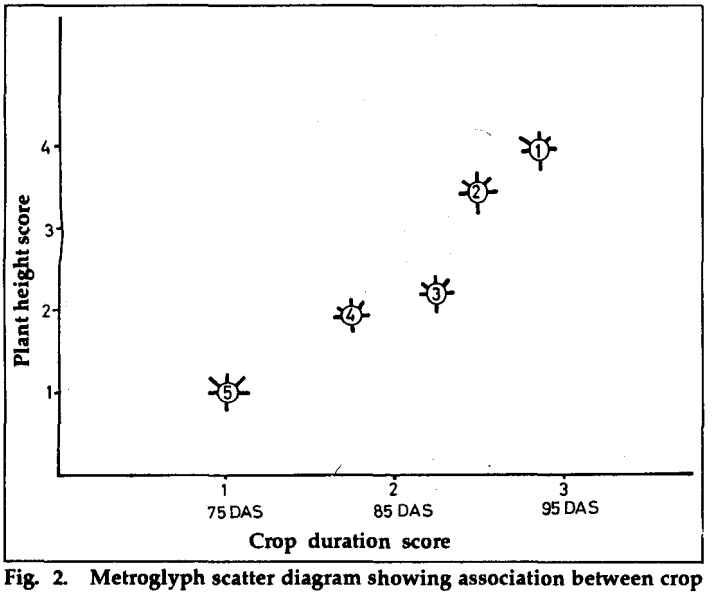

Fig. 2. Metroglyph scatter diagram showing association between crop duration and plant height in dry bean.

The path analysis studies indicated that number of pods per plant was the most important character with maximum direct effect on seed yield, which was considerably counterbalanced by high magnitude of indirect effect via number of nodules per plant. Mean pod length also had high direct effect on

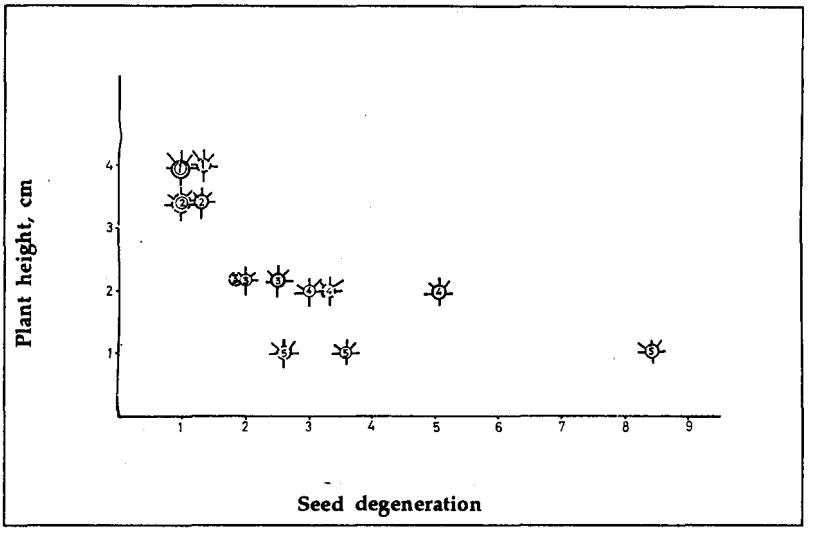

Fig. 3.
Metroglyph scatter diagramme showing association between seed degeneration and plant in dry bean.

- **Spring**
- **Kharif**
- **Autumn**
- **No. of nodules**
- **No. of pods**
- **Pod length**
- **No. of grain**
- **100-grain weight**
- **Grain yield**

seed yield coupled with positive indirect effect via number of pods and number of nodules (Table 4). Though plant height was significantly associated with seed yield, its direct effect was low and negative, which contributed toward increased seed yield through pods per plant, which was also evident from its indirect effect on pod number. Vaid et al. [14] reported

Table 4. Phenotypic path coefficient analysis of seed yield with other characters in dry bean

Character	Plant height	No. of nodules	No. of pods	Pod length	Seeds per pod	100-grain weight	Crop duration	Pod or seed degeneration	Genotypic correlation with seed yield
Plant height	**-0.77**	-11.76	+13.10	+1.23	+0.01	-0.32	-1.78	+1.11	+0.92
No. of nodules	-0.70	**-12.3**	+12.97	+1.68	+0.00	-0.30	-1.53	+1.14	+0.01
No. of pods	-0.76	-12.57	**+13.23**	+1.41	+0.01	-0.33	-1.70	+1.15	+0.44
Pod length	-0.42	-9.49	+8.21	**+2.28**	-0.12	+0.08	-0.48	+0.63	+0.78
Seeds per pod	-0.24	-1.54	+2.92	-0.93	**+0.04**	-0.41	-0.74	+0.18	-0.75
100-seed weight	-0.32	+5.26	-5.82	+0.23	-0.02	**+0.75**	+0.80	-0.73	+0.80
Crop duration	-0.72	-10.26	+11.78	+0.57	+0.01	-0.32	**-1.91**	+1.05	+0.21
Pod/seed degeneration	+0.70	+12.06	-12.57	-1.18	-0.01	+0.45	+1.66	**-1.67**	-0.09

Residual effect +1.5713.

Diagonal values (in bold) represent direct effect.

that number of pods per plant was the most important character in *Phaseolus vulgaris*. Plant height, number of nodules, pod length and seeds/pod were secondary yield characters as they expressed their effect via pod number. Natarajan and Arumugan [12] observed that number of pods exerted highest direct effect on seed yield, while plant height, number of branches and pod length affected yield indirectly via pod number. Durate and Adams [11] also observed that pods per plant had highest direct effect on yield in dry bean.

It may be concluded that determinate climbers and determinate bush types, which are prone to pod/seed degeneration, may not produce good economic yields during kharif particularly under high rainfall with prolonged rainy season in northeastern India. Hence race-1 and race-2 genotypes could be grown in kharif either for vegetable or grain purposes. Pods per plant is the most important yield component, followed by pod length, 100-grain weight and grains per pod, which could be exploited for developing high yielding varieties of rajmash for different agro-climatic conditions.

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