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Breeding French bean (*Phaseolus vulgaris* L.) for resistance to rust (*Uromyces phaseoli* Reben Wint.)

T. S. Aghora, N. Mohan, R. G. Somkuwar[1] and Girija Ganeshan
Division of Vegetable drops
Indian Institute of Horticultural Research
Hessaraghatta Lake Post, Bangalore-560089, India
E-mail: aghor@iihr.ernet.in

ABSTRACT

French bean is an important legume vegetable grown for its tender, green pods for both fresh consumption and processing. Rust, caused by *Uromyces phaseoli,* limits successful cultivation of this crop. Popular varieties like Contender, Pant Anupama, Pusa Parvathi, Arka Komal, Arka Suvidha, etc., are susceptible to this disease. The french bean variety, Arka Bold, having resistance to rust was used in hybridization with Arka Komal, a popular bush variety with high yield and slender, long green pods but susceptible to rust. Inheritance studies indicated that resistance to rust was controlled by a single, dominant gene. Pedigree method of breeding was followed for incorporating rust resistance in to commercially cultivated varieties. Breeding lines with resistance to rust were selected to F_2 generation onwards. These were advanced up to F_7, wherein, a promising line, (Arka Bold x Arka Komal) 99-17-2-1-4-12-3, with resistance to rust with high pod yield and good pod quality was selected and named Arka Anoop and released for commercial cultivation.

Keywords: French bean, rust resistance,

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is one of the most important legume vegetables grown for its tender green pods. Globally it is grown in an area of 0.68 million ha with total production of 4.7 million metric tonnes and productivity is 6.91 tonnes / ha. In India, it is grown in an area of 0.15 million ha with annual production of 0.42 million metric tonnes (Anonymous, 2006). The crop is susceptible to various biotic and abiotic stresses. Among the various biotic stresses, rust caused by *Uromyces phaseoli* (Reben Wint) has become endemic in bean producing areas. The yield loss due to this disease is 78 to 90 % (Grafton *et al,* 1985) and it is serious during *rabi*. The disease incidence will be less during *kharif* season. The disease is more severe in tropics than in the temperate region and the pathogen will be more active under moderate temperature of 17 to 27^0 C and relative humidity of more than 95 %. The popular varieties like Contender, Pant Anupama, Pusa Parvathi, Arka Komal, Arka Suvidha etc., are susceptible to rust disease. Although chemical control using sulphur fungicides and propioconozole are recommended, the induction of genetic resistance will have the greater merit over the chemical control. Hence, the present study was taken up with the objective of developing a french bean variety with resistance to rust disease along with high yield and good pod quality and also to study the genetics of disease resistance.

MATERIAL AND METHODS

The source of resistance to rust was found in Arka Bold (Mohan *et al,* 1997). The hybridization was done between Arka Bold and Arka Komal (a bushy variety with high yield and slender long pods) in both combinations during 1999 at IIHR, Bangalore. Subsequently, F_1, F_2, B_1 and B_2 populations were raised and evaluated for resistance to rust. Artificial screening for rust was done by spraying uredospore suspension uniformly on both sides of the leaves. The concentration of spore suspension was maintained at 10^7 spores / ml. Percent disease index (PDI) was calculated as per the method given by Stavely (1983). The disease scoring was done on a 0- 9 scale where 0 = no pustules; 1 = small brown pustules covering less than 1% of leaf area; 3 = typical pustules covering 1-10 % of leaf area; 5= typical pustules covering 11- 25 % of leaf area; 7= typical pustules covering

[1]Present address:National Research Center for Grapes, Pune, Maharashtra

26 - 50 % of leaf area and 9= typical pustules covering more than 51 % of leaf area combined with withering of leaves. Per cent disease index (PDI) was calculated by using the formula given by Wheeler (1969),

$$PDI = \frac{0\ (\chi_0)+1\ (\chi_1)+3\ (\chi_3)+5\ (\chi_5)..... \times 100}{\chi_0+\chi_1+\chi_3+\chi_5....+\chi_n \times \max.scale\ (9)}$$

Where χ represents the diseased leaves within the sample plants in the respective class such as 0, 1, 3, …9. Data obtained from the two crosses and two testcrosses were subjected to χ^2 analysis. Based on the disease reaction in F_1, F_2, B_1 and B_2 population, the inheritance of resistance to rust was worked out. The plants with PDI less than 5 % were considered as resistant and those showing PDI more than 5 % as susceptible for formation of classes for test. Data of two crosses and two testcrosses were subjected to analysis to test the goodness of fit against assumed phenotypic ratio of 3:1(resistant and susceptible respectively) for single dominant gene controlling rust resistance. Pedigree method of selection was followed up to F_7 generation. Replicated yield trials were conducted for selected breeding lines.

RESULTS AND DISCUSSION

All the F_1 plants in the cross Arka Bold (R) and Arka Komal (S) and its reciprocal were resistant indicating the dominance over susceptibility and had shown that cytoplasmic genes are not involved in resistance. In F_2 population of 196 plants, observed segregation ratio for resistance to susceptibility, was 146: 50 as against expected ratio of 147:49 (Table 1). In the reciprocal cross, 216 plants were resistant and 68 were susceptible as against expected ratio of 213:71 respectively. Further, the test cross progeny of Arka Bold (R) and Arka Komal (S) segregated in the ratio of 55 resistant to 50 susceptible plants as against the expected ratio of 53: 53 respectively out of 106 test cross plants. In another test cross progeny of Arka Komal (S) and Arka Bold (R), the ratio was 54:48 as against 51:51. The calculated χ^2 value for both the F_2 and testcrosses were non significant with high probability of 0.87 to 0.89 and 0.55 to 0.63, respectively. F_2 population of both the crosses showed a good fit of 3:1 between resistant and susceptible and test cross progeny indicated the segregation in 1:1 ratio (Table 2). The cross, Arka Bold x Arka Komal indicated dominance of resistance to rust over susceptibility in F_1 progeny. This was similar in the reciprocal cross also. The pattern of segregation in F_2 population along with the two test cross generations followed Mendelian ratio of dominance and application of χ^2 test for F_2 and test cross generations indicated that resistance to rust was inherited as a single dominant gene in french bean variety, Arka Bold. These findings are in conformity with Augustin *et al*, (1972a, b), Stavely (1984), Stavely and Grafton (1985), Grafton *et al*, (1985), Finke *et al*, (1986), Sayler *et al*, (1995) and Yuebin (1995) who reported that the resistance to rust is monogenically controlled.

Further, Pedigree method of breeding was followed and segregants with resistance to rust were selected from F_2 generation onwards and were advanced up to F_7 generation, wherein, a promising line (Arka Bold x Arka Komal)-99-17-2-1-4-12-3 possessing resistance to rust with high yield and good pod quality was selected and named as

Table 1. Frequency of resistant and susceptible plants in parents and F_1's

Sl No.	Crosses	First parent		Second parent		F_1		F_2		Test Cross		BC with R Parent.	
		R	S	R	S	R	S	R	S	R	S	R	S
1	B x A	87	0	0	89	78	0	147	49	55	50	91	0
2	A x B	0	89	87	0	85	0	216	68	54	48	105	0

R=Resistant, S=Susceptible, A=Arka Komal, B=Arka Bold, BC=Back cross.

Table 2. Frequencies of F_2 and test cross progenies with their χ^2 estimates

Sl No	Crosses	Observed ratio		Expected ratio		Total	Chi Square	Probability
		R	S	R	S			
1	B x A	146	50	147	49	196	0.03	0.87
2	A x B	216	68	213	71	284	0.02	0.89
	Pooled	350	120	360	110	470	0.18	0.68
	Test crosses							
1	(B x A) x A	55	51	53	53	106	0.24	0.63
2	(A x B) x A	54	48	51	51	102	0.35	0.55
	Pooled	109	99	104	104	208	0.96	0.33
	Table χ^2 @ 1df.						3.84	

R=Resistant, S=Susceptible, C=Contender, A=Arka Komal, B=Arka Bold, K=KPV-1, BC=Back cross.

Fig 1. Arka Anoop a new french bean variety

Fig 2. French bean var. Arka Anoop (on either side) showing resistance to rust with susceptible check in the middle

Arka Anoop (Fig 1 and 2). Replicated yield trials conducted at IIHR, Hessaraghatta for three years from 2003 to 2005) during *rabi* season showed that the new variety, Arka Anoop had a significantly higher number of pods per plant (42.50) as compared to check (Table 3). It also recorded an average pod yield of 19.78 t /ha, as against a yield of 14.29 and 8.24 t/ha in the check varieties Arka Komal and Contender, respectively. The percent yield increase in Arka Anoop over check varieties Arka Komal and Contender was 38.42 and 140.05 respectively. Arka Anoop was completely resistant

Table 3. Average plant and pod characters of french bean var. Arka Anoop compared with parents and checks

Sl. No.	Characters	Arka Anoop	Arka Komal	Arka Bold	Contender	*P=0.05*	CV %
1	Days to 50 % flowering	32.50	32.00	33.0	32.50	1.41	2.05
2	Days to pod maturity	45.00	45.50	47.0	43.50	1.45	1.97
3	Plant height	58.50	57.50	55.0	52.50	2.33	4.72
4	Pod length (cm)	17.60	15.75	14.5	14.25	1.03	2.93
5	Pod width (cm)	1.00	1.05	1.55	1.00	0.11	4.24
6	Number of pods per plant	42.50	31.58	22.5	15.50	2.35	6.98
7	Ten pod weight (g)	88.50	56.00	75.0	51.00	11.00	5.79

Table 4. Average pod yield (t/ha) and rust index (PDI) of french bean var. Arka Anoop between 2003-2005 during *rabi*

Sl. No.	Varieties	Pod yield (t/ha)			Average	Rust PDI			Average	% Yield increase over Arka Komal	% Yield increase over Contender
		2003	**2004**	**2005**		**2003**	**2004**	**2005**			
1	Arka Bold (res. parent)	14.50	15.20	14.80	14.83	2.15	1.86	2.64	2.22	-	-
2	Arka Komal (Susc. Parent)	17.11	16.10	9.67	14.29	27.90	36.45	56.84	40.40	-	-
3	Arka Anoop	18.71	19.38	21.24	19.78	2.35	1.79	1.58	1.91	38.42	140.05
4	Contender (susc. check)	9.92	8.70	6.10	8.24	45.36	51.30	74.36	57.01	-	-
	CD *(P=0.05)*	2.43	1.92	1.76	-	5.79	2.83	4.85	-	-	-
	CV %	14.04	5.92	5.20	-	7.66	11.26	9.53	-	-	-

Table 5. Average pod yield (t/ha) of Arka Anoop during *Kharif* season

Sl. No.	Varieties	2003	2004	2005	Average	% increase over Arka Komal	increaseover % Contender
1	Arka Bold (res. parent)	15.50	14.30	14.90	14.90	-	-
2	Arka Komal (Susc. Parent)	18.00	18.50	17.22	17.90	-	-
3	Arka Anoop	18.83	21.13	19.90	19.95	15.85	69.00
4	Contender (susc. check)	10.50	12.25	12.69	11.81	-	-
	CD*(P=0.05)*	0.71	2.82	3.59	-	-	-
	CV %	4.22	7.85	15.00	-	-	-

to rust with very low PDI of 1.91 whereas, the check varieties, Arka Komal and Contender were susceptible (Table 4). Yield trials were also conducted during *kharif* seasons for three years from 2003 to 2005 wherein, Arka Anoop gave an average green pod yield of 19.95 t /ha, while in parents Arka Bold and Arka Komal, the yields were 14.9 and 17.9 t/ha, respectively (Table 5). The per cent yield increase in Arka Anoop over check varieties Arka Komal and Contender was 15.85 and 69.00 in that order (Table 5). The yields in the check varieties were comparatively better during *kharif* due to low or no incidence of rust.

The study confirmed that the resistance to rust in french bean variety, Arka Bold was controlled by single dominant gene. Further, it also revealed that the selected breeding line, Arka Anoop was resistant to rust with average yield potential of 19.8 t/ha.

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