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Bruchid Resistant Studies using Stabilized Derivatives (F_7 Families) of Interspecific Cross Cowpea × Rice Bean

Venkatesh Bondade, Sanjeev K. Deshpande

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Abstract

Bruchid (*Callosobruchus maculatus* F.) is the main constraint in cowpea production. It can be controlled by chemical application but it is hazardous and not eco-friendly, hence attempt has been made to derive bruchid resistant lines by screening 100 stabilized lines from interspecific cross between cowpea and rice bean. In this experiment, screening of 100 F_7 segregants of cross DC615 (susceptible) × Dharwad local (resistant) along with checks (DC15, DCS47-1, RBHP-38 and IC18563) was carried out against bruchid through artificial infestation at the Department of Genetics and plant Breeding, University of Agricultural Sciences, Dharwad. Out of 100 segregants screened, 7 were highly resistant, 52 were moderately resistant, 21 were least susceptible, 12 were moderately susceptible and 8 were highly susceptible. The segregant F_7:78-1-1 registered least values for bruchid infestation, seed damage at 30, 45 and 75 days, loss of vigour and seed viability loss.

Key words: Bruchid, Cowpea, Resistance.

Introduction

Cowpea, [*Vigna unguiculata* (L.) Walp.] is one among the ancient crops known to human. Its origin and domestication can be seen in Africa near Ethiopia. It is a member of the family Papilionaceae, with 22 number of chromosomes (2n=2x=22) (Darlington and Wylie, 1955). It is a chief source of protein in vegetarian dominated diet. It is being rich in protein and contain many other nutrients, it is known as vegetable meat (Avisha *et al.,* 2018).

Crop loss in cowpea is mainly because of insect pests. If the crop is not sprayed with insecticide, the grain yield can be nearly reduced to zero. The beetles of the family Bruchidae (*Callosobruchus maculatus*) damage complete seed storage tissue. Under storage condition, *Callosobruchus maculatus* commonly known as cowpea beetle, cowpea weevil or bruchid is regarded as most destructive and notorious pest (Jackai and Daoust, 1986). It is estimated to cause 90-100% of storage loss, where it is a loss of both quantity and quality of stored seeds (Umeozor, 2005). The insects make perforated holes on the surface of the seeds, due to these perforations, seed loses its usefulness and its cooking value and ultimately unfit for human consumption (Ali *et al.,* 2004).

All vigna crops except rice bean are susceptible to bruchids. Rice bean is one crop under vigna genus which is completely resistant to bruchids. Deshpande and Umesh (2018), evaluated the F_4 generation of inter-specific crosses between cowpea and rice bean for yield *per se* and bruchid resistance under artificial inoculated conditions. The families with high yield *per se* and improved tolerance to bruchids were advanced till F_6. So in the present study an attempt was made to evaluate 440 F_6 families under field condition for yield traits and based on yield *per se* 100 best F_7 families were screened for resistance under artificial infestation of cowpea weevil or cowpea seed beetle [*Callosobruchus maculatus* (L.)] in laboratory. These storage pests are also called as bruchids commonly.

Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.

Corresponding Author: Sanjeev K. Deshpande, Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India. Email: sanjeevgpb@gmail.com

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Materials and Methods

The experiment was conducted during *kharif* 2018 at Botanical Garden, Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad. The F_6 population generated earlier between cross DC 615 (Susceptible) × Rice bean (Resistant) was used for the present study. About 440 F_6 families were selfed and advanced to F_7 generation. Based on yield *per se* top 100 F_7 progenies were selected and used in the present study. Two checks of cowpea such as DC 15 (Moderately resistant check) and DCS 47-1 (susceptible check) and two rice bean germplasm (RBHP-38 and IC18563) were also used as check (Fig 2).

Initial culture of *Callosobruchus maculatus* was obtained from the infected grains of cowpea from the farm stores. They were reared and maintained on cowpea by releasing ten pairs of adults (males and females) in stem jars. The mouth of the jar was covered with muslin cloth secured by rubber band. The artificial screening of the cowpea seeds against bruchids was undertaken according to the procedure followed by Basavaraj (2010). Seeds of each progeny weighing 50 g were kept in a plastic glass of 100 ml capacity, five pairs of adults (males and females) were introduced in each plastic glass and tops were kept covered with muslin cloth and tightly concealed by rubber bands and were kept under normal room temperature and humidity for a period of 75 days (Fig 1). The seed damage per cent was calculated at different intervals *viz*., 30, 45 and 75 days after bruchid infestation (DAI). (Neenu, 2018) It was worked out by the formula given below.

Damage (%) =

$$\frac{\text{Initial weight - Weight of undamaged seeds}}{\text{Initial weight}} \times 100$$

After the specified period of 45 days each bottle was examined for loss of weight in terms of actual weight loss and apparent weight loss was determined. Actual weight loss was calculated by using the following formula (Adams and Schulten, 1978).

$$\text{Actual weight loss (\%)} = \frac{U\,(Nd) - D\,(Nu)}{U\,(Nu + Nd)} \times 100$$

Where;

(Nd) = Number of damaged seeds [seeds showing emergent holes].

(Nu) = Number of undamaged seeds.

(D) = Weight of damaged seeds.

(U) = Weight of undamaged seeds.

(Nd + Nu) = Total number of seeds in 50 g.

Apparent weight loss was worked out using the following formula (Girish *et al.,* 1975).

Apparent weight loss (%) =

$$\frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

In general,

$$\text{Apparent weight loss (\%)} = (W_i - W_n) / W_i \times 100$$

Where,

W_i = Initial weight of seeds at the beginning experiment.

W_n = Weight of seeds after 'n' days (45 days).

The moisture content of seeds was determined by the oven dry (103 ± 1°C for 17±1 hours) method as per ISTA rules. The moisture content on wet basis was determined and expressed in percentage using the following formula:

$$\text{Moisture content (\%)} = \frac{(M_2 - M_3)}{(M_2 - M_1)} \times 100$$

Where,

M_1 - Weight of the empty metal box (g).

M_2 - Weight of metal box with seed sample before drying (g).

M_3 - Weight of metal box with seed sample after drying (g).

The percentage infestation was calculated by using following formula:

Infestation (%) =

$$\frac{\text{Number of seeds with emergent holes}}{\text{Total number of seeds observed}} \times 100$$

Based on per cent bruchid infestation, cowpea genotypes were classified according to Nagaraj (2006) (Table 1).

Similarly germination percentage was also worked out before and after infestation according to paper towel germination test and reduction in germination was calculated and genotypes were compared based on these results.

Germination (%) =

$$\frac{\text{Number of normal seedlings obtained after germination}}{\text{Total number of seeds put for germination}} \times 100$$

From the germination test, ten random seedlings from each of the genotype were carefully used for measuring seedling length. The seedling length from tip of shoot to tip of root was measured and the average length of the seedling was noted down. From the germination percentage and seedling length, seedling vigor index was calculated by following formula as per Abdulbaki and Anderson (1973).

Seedling vigour index =

$$\text{Germination (\%)} \times \text{Seedling length (cm)}$$

RESULTS AND DISCUSSION

Based on per cent bruchid infestation the F_7 segregants were classified as highly resistant, moderately resistant, least susceptible, moderately susceptible and highly susceptible, as presented in the Table 2. As shown in Table 2, the per cent bruchid infestation varied much among the different classes, the highly resistant (HR) class recorded 16.09 per cent bruchid infestation and moderately resistant (MR), least susceptible (LS), moderately susceptible (MS), highly susceptible (HS) classes recorded 29.75 per cent, 48.49 per cent, 69.59 per cent and 83.06 per cent bruchid infestation respectively. Accordingly, top 15 resistant F_7 segregants are given in the Table 3. The results revealed that, F_7: 78-1-1 segregant recorded least per cent bruchid infestation (12.24%). Among the rice bean resistant germplasm lines RBHP-38 and IC18563 recorded zero per cent infestation, the variety DC 15 exhibited infestation of 26.53 per cent and considered as moderately resistant and

Table 1: Bruchid resistance classification by Nagaraj (2006).

Class	Bruchid infestation (%)
Highly resistant	00-20
Moderately resistant	21-40
Least susceptible	41-60
Moderately susceptible	61-80
Highly susceptible	81-100

DCS 47-1 reported 68.98 per cent infestation, regarded as moderately susceptible.

The results pertaining to number of adults emerged out of different classes of stabilized F_7 lines are depicted in Table 2. High degree of variation was observed among the different stabilized F_7 lines. The highly resistant (HR) class reported 13.43 number of bruchids emerged, while moderately resistant (MR), least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS) classes reported 32.21, 47.38, 52.83 and 56.25 number of bruchids emerged respectively. Considerably least number of bruchids were emerged in F_7 lines namely, F_7:78-1-1 (Table 3). As far as checks are concerned, checks RBHP-38 and IC18563 had zero number of bruchids emergence whereas, DC 15 and DCS 471 showed 21.0 and 34.0 adults respectively. The reason for resistance may be due to oviposition and antibiosis to egg and larva. Adult recovery is hampered by unpalatable physicochemical characteristics of grains.

The seed moisture content of different classes of F_7 progenies are presented in Table 4. The highly resistant (HR) class reported 7.57 per cent moisture content. While, moderately resistant (MR), least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS) classes reported 8.09, 8.20, 8.81 and 9.09 per cent moisture content respectively, indicates the presence of considerable variability among different classes for seed moisture content. Similarly, seed moisture (%) of top 15 resistant F_7 progenies is presented in Table 5. The progeny, F_7: 78-1-1 contained minimum moisture (6.49%) followed by F_7: 59-3-1 (6.70%). Since there is difference among different classes, this clearly indicates that seed moisture content of genotypes influence the resistance or susceptibility against bruchids attack. While, the moderately resistant check DC 15 (MR) recorded 8.25 per cent moisture, moderately susceptible check DCS 47-1 (MS) recorded 9.10 per cent moisture. Highly resistant rice bean checks RBHP-38 and IC18563 have 8.01 and 8.06

Fig 1: Experimental set-up laid out for artificial infestation of 100 F_7 progeny lines for bruchid infestation.

a. DC15 b. DCS 47-1 c. RBHP-38 d. IC18563

Fig 2: Checks used in the present study.

Table 2: Classification of F_7 segregants in terms of resistance to bruchid based on mean percent bruchid infestation at 45 days after infestation (DAI) and average number of bruchids emerged.

Class	Range	Average bruchid infestation %	No. of segregants	Average number of bruchids emerged
Highly resistant	0-20	16.09	7	13.43
Moderately resistant	21-40	29.75	52	32.21
Least susceptible	41-60	48.49	21	47.38
Moderately susceptible	61-80	69.59	12	52.83
Highly susceptible	81-100	83.06	8	56.25

per cent moisture respectively, So less moisture is associated with the resistant nature of the cowpea seeds.

In Table 4, results indicates the apparent weight loss (%) of different classes of F_7 families due to infestation of bruchids was minimum in the highly resistant (HR) class with 3.75 per cent apparent weight loss, while moderately resistant (MR), least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS) classes reported 6.41, 8.87, 9.07 and 10.65 per cent apparent weight loss respectively. Among top 15 resistant lines mentioned in Table 5, the segregant F_7: 78-1-1 have less apparent weight loss with 2.48 per cent where it has values 6.36 and 8.24, in moderately resistant and susceptible checks such as DC15, DC S47-1 and 1.48 and 3.24 percent in resistant checks of ricebean namely RBHP-38 and IC18563 respectively. These results are in agreement with findings of Divya *et al.* (2012) who stated that entries which were least favoured by bruchids for oviposition, adult emergence and insect recorded less percent weight loss are resistant to bruchids.

Table 3: Bruchid infestation and average number of bruchids emerged among the top 15 resistant and stabilized F_7 lines derived from cowpea × rice bean crosses.

Sl. no.	Segregants	Per cent bruchid infestation	Number of bruchids emerged
1	78-1-1	12.24	12
2	59-3-1	14.29	14
3	27-1-2	14.29	14
4	247-2-1	16.73	14
5	71-2-1	18.37	12
6	30-2-2	18.37	13
7	16-2-2	18.37	15
8	14-1-2	20.41	16
9	41-1-2	20.41	12
10	27-1-1	20.41	13
11	33-1-2	20.41	14
12	127-2-2	22.45	16
13	17-1-2	22.45	17
14	63-4-1	22.45	19
15	41-3-2	22.45	19
		Checks	
1	DC15	26.53	21.00
2	DCS47-1	68.98	34.00
3	RBHP-38	0.00	0.00
4	IC18563	0.00	0.00

The results pertaining to the per cent actual weight loss in different groups of F_7 lines after infestation are presented in Table 5. There was a variability existed among the different F_7 lines. The highly resistant (HR) group showed 2.63 per cent actual weight loss, while moderately resistant (MR), least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS) groups showed 5.29, 7.75, 7.95 and 9.53 per cent actual weight loss respectively. The actual weight loss (%) of top 15 resistant lines is given in Table 5. The results showed that the progeny F_7: 78-1-1 recorded least actual weight loss of 1.36 per cent respectively. Among the checks RBHP-38 exhibited minimum weight loss (1.10%), while IC-18563, DCS 47-1 and DC 15 exhibited 2.89 per cent, 6.34 per cent and 4.92 per cent actual weight loss respectively. The minimum actual weight loss is attributed to minimum adult emergence and less seed damage.

The seed germination (%) at initial and 45 days after release of bruchids was recorded (Table 10). The results show that the minimum reduction in germination percentage was seen in highly resistant class with 4.71% and it was followed by moderately resistant (MR), least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS) classes reported 20.35, 38.71, 59.92 and 71.63 per cent reduction respectively. While among top 15 resistant lines (Table 11), F_7: 78-1-1 (Fig 3) have least reduction in germination per centage with value of 3.0 and F_7: 223-1-1 have maximum reduction in germination per centage with value of 92 (Fig 4) among checks lowest reduction was observed for check RBHP-38 (1.0%) and it was followed by IC-18563, DC 15 and DCS 47-1 with values 2.0, 3.0 and 4.0 respectively. (Tomaz *et al.,* 2007) found in some cases larval feeding effectively kills the embryo or feeds on the endosperm so that that the seed cannot be germinated.

The results considering seed damage per cent at 30, 45 and 75 days after release (DAR) of bruchids was minimum in highly resistant class, showing 18.16, 38.61 and 49.71% respectively (Table 6). In moderately resistant genotypes 25.99, 43.74 and 56.11 % at 30, 45 and 75 DAR, respectively. Least susceptible genotypes shown 28.78, 45.86 and 59.65% of damage at 30, 45 and 75 DAR respectively. Whereas moderately susceptible genotypes shown 30.30, 45.63 and 61.59% of seed damage at 30, 45 and 75 DAR respectively. Highly susceptible genotypes exhibited more seed damage of 35.77, 47.83 and 65.68 % at 30, 45 and 75 DAR respectively. Among top 15 resistant F_7 segregants of stabilized lines (Table 7), F_7: 78-1-1 exhibited less seed damage of 13.41, 30.10 and 38.42% at 30, 45

Table 4: Mean moisture per cent, apparent weight loss, actual weight loss, among bruchid resistance classes of F_7 segregants.

Class	Range	No. of segregants	Average moisture %	Average apparent weight loss %	Average actual weight loss %
Highly resistant	0-20	7	7.57	3.75	2.63
Moderately resistant	21-40	52	8.09	6.41	5.29
Least susceptible	41-60	21	8.20	8.87	7.75
Moderately susceptible	61-80	12	8.81	9.07	7.95
Highly susceptible	81-100	8	9.09	10.65	9.53

Table 5: Moisture per cent, apparent weight loss and actual weight loss among top 15 bruchid resistance classes of F_7 segregants.

Sl. no.	Segregants	Moisture content %	Apparent weight loss %	Actual weight loss %
1	78-1-1	6.49	2.48	1.36
2	59-3-1	6.70	3.02	2.30
3	27-1-2	7.42	4.20	3.08
4	247-2-1	8.08	3.36	2.24
5	71-2-1	8.09	4.40	3.28
6	30-2-2	8.11	3.44	2.32
7	16-2-2	8.12	4.44	3.32
8	14-1-2	8.10	4.23	3.11
9	41-1-2	8.11	3.84	2.72
10	27-1-1	8.22	4.36	3.24
11	33-1-2	8.10	4.12	3.00
12	127-2-2	8.21	4.78	3.66
13	17-1-2	8.29	5.26	4.14
14	63-4-1	8.31	5.23	4.11
15	41-3-2	8.33	5.94	4.82
		Checks		
1	DC15	8.25	6.36	4.92
2	DCS47-1	9.10	8.24	6.34
3	RBHP-38	8.01	1.48	1.10
4	IC18563	8.06	3.24	2.89

and 75 DAR respectively (Fig 5) and F_7: 223-1-1 reported higher seed damage of 38.99, 52.71 and 64.42% at 30, 45 and 75 DAR (Fig 6). Among the checks, DC 15 shown moderate seed damage of 13.28, 24.01 and 28.56% at 30, 45 and 75 DAR respectively, whereas susceptible DCS47-1 registered 25.24, 64.04 and 73.72 % of seed damage at 30, 45 and 75 DAR respectively. Two rice bean checks (IC18563 and RBHP-38) registered minimum seed damage per cent, among these two IC18563 shown 3.48, 3.86 and 5.32% of damage at 30, 45 and 75 DAR respectively. Whereas, RBHP-38 registered 1.24, 3.73 and 6.40% of seed damage at 30, 45 and 75 DAR respectively and remained as minimum seed damaged check variety.

The results pertaining to the seed moisture reduction per cent (Table 10), the highly resistant class registered minimum seed moisture reduction of 1.72%, followed by moderately resistant (MR), least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS) classes reported 2.86, 5.02, 5.32 and 6.17 per cent reduction respectively. While among the top 15 resistant lines (Table 11), F_7: 78-1-1 have least reduction in moisture per cent with value of 1.33 per cent and among checks lowest reduction was observed for check RBHP-38 (0.64%) and it was followed by DC 15, IC-18563and DCS 47-1 with values 1.10, 1.13 and 1.99 per cent respectively.

Table 6: Average seed damage per cent at 30, 45 and 75 days after infestation (DAI) among bruchid resistance classes of F_7 segregants.

Class	Range	No. of segregants	Average infestation %	Average seed damage %		
				30 DAI	45 DAI	75 DAI
Highly resistant	0-20	7	16.09	18.16	38.61	49.71
Moderately resistant	21-40	52	29.75	25.99	43.74	56.11
Least susceptible	41-60	21	48.49	28.78	45.86	59.65
Moderately susceptible	61-80	12	69.59	30.30	46.63	61.59
Highly susceptible	81-100	8	83.06	35.77	47.83	65.68

Fig 3: Highly resistant F_7: 78-1-1 genotype before and after 45 days after infestation

Fig 4: Highly susceptible F_7: 223-1-1 genotype before and after 45 days after infestation.

e. f. g.

Fig 5: Highly resistant F_7: 78-1-1 genotype at 30(e), 45(f) and 75(g) days after infestation.

h. i. j.

Fig 6: Highly susceptible F_7: 223-1-1 genotype at 30(h), 45(i) and 75(j) days after infestation.

Table 7: Seed damage per cent at 30, 45 and 75 days after infestation (DAI) among top 15 bruchid resistance classes of F_7 segregants.

Sl. no.	Segregants	Seed damage %		
		30 DAI	45 DAI	75 DAI
1	78-1-1	13.41	30.10	38.42
2	59-3-1	15.38	44.49	52.81
3	27-1-2	15.38	46.54	68.69
4	247-2-1	27.02	36.26	44.58
5	71-2-1	17.34	34.21	42.53
6	30-2-2	19.31	40.38	48.70
7	16-2-2	19.31	38.32	52.24
8	14-1-2	21.28	50.66	58.98
9	41-1-2	21.28	36.26	52.24
10	27-1-1	21.28	50.66	62.52
11	33-1-2	19.31	40.38	52.24
12	127-2-2	23.25	48.60	64.58
13	17-1-2	23.25	44.49	54.30
14	63-4-1	21.28	48.60	50.18
15	41-3-2	23.25	36.26	48.13
		Checks		
1	DC15	13.28	24.01	28.56
2	DCS47-1	25.24	64.04	73.72
3	RBHP-38	1.24	3.73	6.40
4	IC18563	3.48	3.86	5.32

The results on percent reduction in seedling length (Table 10) revealed that reduction is maximum in highly susceptible class with 17.74 per cent and it is followed with moderately susceptible, least susceptible, moderately resistant and highly resistant class with 13.54, 12.24, 5.18 and 1.31 per cent respectively. Among top 15 resistant lines (Table 11), the lowest per cent reduction was for the segregant F_7: 59-3-1 followed by F_7: 78-1-1. Among checks, RBHP-38, recorded minimum reduction in seedling length (0.54%) while checks, IC18563, DC 15 and DCS 47-1 shows1.12, 1.83 and 3.62 per cent reduction in seedling length respectively. The reduction in seedling length in highly susceptible plants is may be attributed to the depletion of cotyledon reserves due to the larval feeding of bruchid which later leads to the slower and reduced growth of the plants.

Table 8: Average yield among bruchid resistance classes of F_7 segregants.

Class	Range	No. of segregants	Average yield (grams/plant)
Highly resistant	0-20	7	22.86
Moderately resistant	21-40	52	21.97
Least susceptible	41-60	21	20.57
Moderately susceptible	61-80	12	18.62
Highly susceptible	81-100	8	17.23

Table 9: Average yield among top 15 bruchid resistance classes of F_7 segregants.

Sl. no.	Segregants	Average yield (g/plant)
1	78-1-1	24.75
2	59-3-1	25.17
3	27-1-2	17.95
4	247-2-1	21.47
5	71-2-1	24.50
6	30-2-2	19.25
7	16-2-2	24.91
8	14-1-2	18.36
9	41-1-2	20.24
10	27-1-1	23.10
11	33-1-2	23.39
12	127-2-2	18.94
13	17-1-2	24.53
14	63-4-1	23.04
15	41-3-2	20.65
	Checks	
1	DC15	26.18
2	DCS47-1	22.80
3	RBHP-38	15.05
4	IC18563	13.05

The results pertaining to seedling vigour index is shown in Table 10. In case of highly resistant varieties the reduction in seedling vigour index was less with value of 11.07 per cent compared to moderately resistant, least susceptible, moderately susceptible and highly susceptible types with values of 39.67, 73.28, 87.67 and 95.56 per cent reduction respectively. Among top 15 resistant F_7 stabilized lines (Table 11), F_7: 78-1-1 registered less reduction in seedling vigour index with the value of 8.28% and it was followed by F_7: 59-3-1 with 10.16%. Among the checks, the seedling vigour

Table 10: Mean seed germination (%), moisture per cent, seedling length (cm), seedling vigour index and viability among different classes.

Class	Germination %			Moisture %			Seedling length (cm)			Vigour index			Viability %		Loss in seed viability
	Initial	45 DAI	Reduction %	Initial	45 DAI	Reduction %	Initial	45 DAI	Reduction %	Initial	45 DAI	Reduction %	Initial	45 DAI	
Highly resistant	84.43	79.71	4.71	10.32	8.60	1.72	22.75	21.44	1.31	1920.90	1708.83	11.07	91.29	86.29	5.00
Moderately resistant	84.67	64.33	20.35	10.69	7.83	2.86	24.64	19.47	5.18	2095.58	1279.81	39.67	92.38	76.36	16.02
Least susceptible	85.62	46.90	38.71	10.74	5.71	5.02	25.39	13.15	12.24	2186.63	628.52	73.28	92.10	62.89	29.20
Moderately Susceptible	84.67	24.75	59.92	10.55	5.24	5.32	23.95	10.41	13.54	2027.08	255.77	87.67	92.50	55.36	37.14
Highly Susceptible	85.25	13.63	71.63	10.80	4.63	6.17	25.05	7.31	17.74	2127.66	94.30	95.56	92.63	45.50	47.13

Table 11: Effect of *Callosobruchus maculatus* on seed germination (%), moisture per cent, seedling length (cm), seedling vigour index and viability of top 15 resistant F_7 segregants in cowpea.

Sl. no.	Genotypes	Germination %			Moisture %			Seedling length (cm)			Vigour %			Viability %		Loss in seed viability
		Initial	Final	Reduction %	Initial	45 DAI	Reduction %	Initial	Final	Reduction	Initial	Final	Reduction %	Initial	Final	
1	78-1-1	84.0	81.0	3.0	10.54	9.21	1.33	23.56	22.41	1.15	1979.04	1815.21	8.28	92.0	89.0	3.00
2	59-3-1	86.0	82.0	4.0	10.32	8.83	1.49	21.88	20.87	1.01	1881.68	1690.47	10.16	92.0	89.0	3.00
3	27-1-2	84.0	79.0	5.0	9.91	7.87	2.04	20.56	19.34	1.22	1727.04	1547.20	10.41	91.0	87.0	4.00
4	247-2-1	82.0	77.0	5.0	10.11	8.26	1.85	20.26	19.25	1.01	1661.32	1482.25	10.78	91.0	87.0	4.00
5	71-2-1	92.0	87.0	5.0	11.44	9.54	1.90	23.60	22.25	1.35	2171.20	1935.75	10.84	92.0	88.0	4.00
6	30-2-2	80.0	75.0	5.0	10.11	8.68	1.43	25.28	23.91	1.37	2022.40	1793.25	11.33	91.0	86.0	5.00
7	16-2-2	83.0	77.0	6.0	9.81	7.79	2.02	24.14	22.64	1.50	2003.62	1743.28	12.99	90.0	84.0	6.00
8	14-1-2	90.0	83.0	7.0	10.84	8.83	2.01	30.06	27.94	2.12	2705.40	2319.02	14.28	96.0	90.0	6.00
9	41-1-2	86.0	79.0	7.0	12.20	10.19	2.01	29.28	27.16	2.12	2518.08	2145.64	14.79	92.0	85.0	7.00
10	27-1-1	80.0	72.0	8.0	10.21	8.20	2.01	21.04	18.93	2.11	1683.20	1362.96	19.03	90.0	83.0	7.00
11	33-1-2	86.0	77.0	9.0	10.01	7.98	2.03	19.54	17.18	2.36	1680.44	1322.86	21.28	92.0	84.0	8.00
12	127-2-2	76.0	66.0	10.0	10.21	8.18	2.03	13.04	11.85	1.19	991.04	782.10	21.08	96.0	86.0	10.00
13	17-1-2	89.0	78.0	11.0	11.11	9.10	2.01	28.28	25.81	2.47	2516.92	2013.18	20.01	92.0	81.0	11.00
14	63-4-1	90.0	78.0	12.0	11.44	9.34	2.10	21.90	19.32	2.58	1971.00	1506.96	23.54	90.0	79.0	11.00
15	41-3-2	90.0	77.0	13.0	11.01	8.99	2.02	28.08	25.39	2.69	2527.20	1955.03	22.64	92.0	80.0	12.00
								Checks								
1	DC15	89.00	86.00	3.00	10.40	9.30	1.10	29.01	27.18	1.83	2581.00	2191.84	15.08	88.00	74.00	14.00
2	DCS47-1	89.00	85.00	4.00	10.80	8.81	1.99	26.94	23.32	3.62	1975.66	1227.20	37.88	85.00	63.00	22.00
3	RBHP-38	87.00	86.00	1.00	10.74	10.10	0.64	26.46	25.92	0.54	2402.02	2359.04	1.79	85.00	84.00	1.00
4	IC18563	88.00	86.00	2.00	10.64	9.51	1.13	30.90	29.78	1.12	2895.20	2661.08	8.09	87.00	83.00	4.00

Fig 7: Top 5 resistant F_7 interspecific cross between cowpea and ricebean against bruchid (*Callosobruchus maculatus* F.) infestation.

index was more reduced in check DCS 47-1 with 37.88% and it was followed by DC15, IC18563 and RBHP-38 with 15.08, 8.09 and 1.79 per cent reduction respectively. The reduction in seedling vigour index is mainly attributed to lowest value in seedling germination per cent and less seedling length in susceptible varieties since vigour is calculated by using both parameters.

Seed viability test was done using tetrazolium method and results with respect to per cent reduction among different classes of F_7 generations are represented in Table 10. There was considerable variation observed among the F_7 progenies. Highly resistant class noticed 5.00 per cent loss in seed viability and moderately resistant, least susceptible, moderately susceptible, highly susceptible classes noticed 16.02, 29.20, 37.14 and 47.13 per cent loss in seed viability, respectively in F_7 generations. The results with respect to per cent reduction in seed viability among top 15 resistant lines were given in Table 11. The progeny, F_7: 78-1-1 and F_7: 59-3-1 recorded minimum (3.0%) loss in seed viability. Among the checks, rice bean accession RBHP-38 recorded least per cent loss (1.0%) in seed viability while, IC18563 recorded 4.0 % loss in seed viability. cowpea varieties DC 15 (MR), DCS 47-1 (MS), showed loss in seed viability of 14.0 and 22.0 per cent, respectively.

Yield is most important character and the genotypes showing minimum bruchid infestation and high yield *per se* are desirable. Some of the segregants from highly resistant class registered the high yield. Among different classes highly resistant class registered highest yield *per se* of 22.86 grams per plant, followed by moderately resistant class (21.97 grams per plant) (Table 8). Among top 15 resistant segregants F_7: 78-1-1 and F_7: 59-3-1 were proven to be high yielding segregants. Among checks the moderately resistant variety (DC 15) has shown 26.18 grams per plant and DCS 47-1 registered 22.80 grams per plant and both the rice bean checks RBHP-38 and IC18563 had registered 15.05 and 13.05 grams per plant respectively (Table 9).

CONCLUSION

So from this study we have identified the some of the stabilized F_7 lines (Fig 7) such as F_7:78-1-1 and F_7: 59-3-1 of interspecific cross between cowpea × ricebean to exhibit enhanced level of resistance to bruchids along with desirable seed characters. These stabilized F_7 segregants further will be evaluated for biochemical and artificial bruchid infestation studies and desirable transgressive segregants for bruchid resistance and favourable seed characteristics will be identified in future studies. Such new stabilized lines hold promise will be used to develop new bruchid resistant high yielding cowpea varieties or as parents in cowpea hybridization programs.

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