

Importance of aecial cups/pustule for selection for slow rusting in pea (*Pisum sativum*) against *Uromyces fabae**

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Pea rust caused by *Uromyces fabae* Pers de Bary, is gaining prominence in warm and humid areas of India. Losses in grain yield due to rust range from 56.8 to 100% (Upadhyay and Singh 1994). Aeciospores play key role in initiation and spread of the disease (Kushwaha *et al.* 2006). Rust resistance in pea is partial also known as slow rusting and, has been reported from different parts of the world (Xue and Warkentin 2002). Inoculum production plays an important role in polycyclic diseases, like rust as it determines the rate of epidemic build-up. Small pustule size limits the amount of inoculum available for subsequent infection cycles (Parlevliet 1979), which ultimately leads to lower disease severity.

Pustule size has been identified as an important component of slow rusting in pea (Chand *et al.* 2006). Unlike uredia, aecial pustules in pea rust are an aggregate of aecial cups that produces aeciospores independently. Therefore, inoculum producing ability of an aecial pustule is directly proportional to the number of aecial cups/pustule. However, information regarding number of aecial cups/pustule and its relation with other slow rusting components in pea is lacking. Therefore, studies were undertaken to characterize number of aecial cups/pustule in germplasm lines of pea and assess its importance as selection criterion in pea rust resistance improvement programmes.

Seeds of 50 diverse genotypes of pea (*Pisum sativum* L.) were obtained from the Department of Genetics and Plant Breeding, Banaras Hindu University, Varanasi and evaluated under field and polyhouse conditions for number of pustules/

leaf, pustule size (mm), number of aecial cups/pustule and AUDPC in 2003–04 and 2004–05.

The field experiment was laid according to randomized block design with 3 replications; standard agronomic practices were followed to raise a good crop. In each replication, every genotype was sown in a row of 5 m. Five randomly selected plants from each row were used for recording pustule size, number of aecial cups/pustule, number of pustules/leaf and area under disease progress curve (AUDPC). Mean of data recorded from 5 plants from each genotype was treated as a single replicate.

Fifty recombinant inbred lines (RILs) derived from the cross 'HUVF 1' and 'FC 1' were also evaluated for pustule size and number of aecial cups/pustule in the polyhouse during 2006–07. Five plants of each germplasm line and recombinant inbred line raised in a single pot of 35 cm diameter filled with garden soil and amended with farmyard manure constituted a single replication. The experiment was laid according to randomized block design with 3 replications. The parents, F₁, F₂ and F₃ generations of the cross 'JPBB 3' × 'FC 1' were grown in the field during 2004–05 for studying inheritance of pustule size and number of aecial cups/pustule. The agreement between observed and expected frequencies was tested using chi-square test.

Both 'JPBB 3' and 'FC 1' were resistant but distinct in terms of pustule size (0.3 and 2.3 mm, respectively in field) and average number of aecial cups/pustule (4.0 and 9.4, respectively in the field) with similar latent period and comparable for number of pustules/leaf. There were 5 plants of each parent, i.e. 'JPBB 3' and 'FC 1', 20 plants in F₁, 40 plants in F₂, and 40 progeny rows, each row having 10 plants in F₃.

Standard inoculation technique (Chand *et al.* 2004) was followed in the field as well as in the polyhouse, at the pre-flowering stage (50–55 days after sowing). Size of pustule was recorded on the 10th nodal leaf 20 days after inoculation, i.e. at 68–73 days after sowing (pod formation stage), according to the key described in Fig 1. The number of

*Short note

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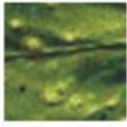




Pictorial representation	Pustule size (mm)	Aecial cups / pustule(range)	Group
	No symptom	–	0
	Less than 0.7mm	6.9 –12.2	1
	0.8 – 1.4 mm	7.8 –17.2	2
	1.5 – 2.1 mm	8.3 –17.5	3
	2.2– 2.8 mm	17.3 –18.6	4
	Above 2.8 mm	14.8 –17.0	5

Fig 1 Pictorial representation of size of pustule in pea against *Uromyces fabae* Pers de Bary

pustules/leaf was recorded on the same leaf. Number of aecial cups/pustule was counted with the help of a magnifying glass (×5) from the leaf of the same plant. Mean of 5 pustules on each leaf were considered for the aecial cup counts.

Data was collected for 2 years and analyzed for test of significance. The number of pustules erupted up to 20th day after inoculation was counted and correlated with other slow rusting components using Pearson’s linear coefficient of correlation.

Disease severity was visually assessed on 0–9 scale (Sokhi *et al.* 1984). First scoring was done when disease severity was around 50% on the susceptible check (‘HUVP 1’) and 5% on the resistant check (‘FC1’) (Kushwaha *et al.* 2007). Subsequently, two more readings were taken at 4 days interval, and were used to calculate AUDPC as

$$\Sigma [(Y_i + Y_{(i+1)}) \times (t_{(i+1)} - t_i)]$$

where Y = disease severity at time t_i and $(t_{(i+1)} - t_i)$ = number of days between 2 disease scores (Das *et al.* 1993).

All the germplasm lines screened showed compatible reaction to rust. The size of pustules varied between 0.6 mm and 2.9 mm. Out of the 50 germplasm lines screened, not a single genotype showed flecks and belonged to group (0), 3 genotypes belonged to group (1), 17 belonged to group (2), 25 fell in group (3), 3 genotypes occurred in group (4) and 1 genotype was placed in group (5). Data for 25 genotypes representing the complete distribution pattern is presented in Table 1. The coefficient of determination indicated 3.5% variation in AUDPC to be due to pustule size. Small size of pustules was associated with high levels of resistance in wheat, barley, oat and pea (Chand *et al.* 2006). Size of aecial cup did not vary significantly between the genotypes, but the number of aecial cups/pustule as well as pustule size varied across the genotypes indicating different mechanisms acting to limit the size of aecidia. Correlation coefficient between pustule size and number of aecial cups/pustule was

moderate (0.58, $t = 4.909$). This is not surprising since the arrangement of aecial cups in different pustules varies from compact to loose; more numbers of aecial cups were accommodated in a compact pustule than in a loosely arranged pustule. Therefore, pustule size may not be a good indicator of its inoculum producing ability. In contrast, number of aecial cups/pustule would be a more precise estimator of the inoculum producing ability of a pustule (Fig 2). Further, unlike in estimation of pustule size based on visual estimation, the chances of error in recording number of aecial cups/pustule

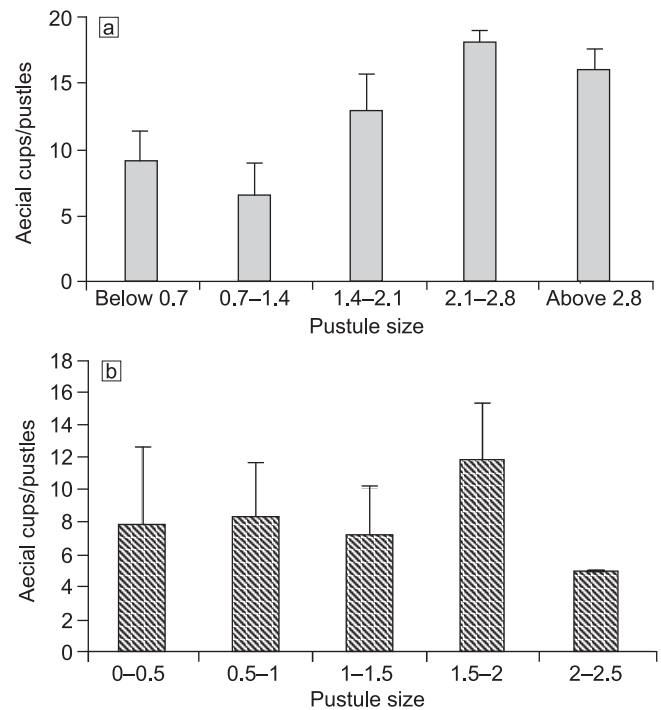


Fig 2 Variation in number of aecial cups/pustule in different categories of pustule size in germplasm lines (a) and recombinant inbred lines (b).

Table 1 Variation for AUDPC, pustule size, number of pustules/leaf and number of aecial cups/ pustule, in 25 germplasm lines screened in 2003–04 and 2004–05

Genotypes	AUDPC		Pustule/leaf		Pustule size(mm)		Aecial cups/pustule	
	Field	Polyhouse	Field	Polyhouse	Field	Polyhouse	Field	Polyhouse
'Pant P 20'	7.0	32.7	18.3	25.0	1.4	1.6	15.0	10.8
'HUP 12'	9.7	42.0	29.7	34.0	0.9	0.8	7.4	7.0
'JPBB 3'	10.3	40.0	28.3	30.0	0.3	0.5	4.0	6.0
'Pant P 11'	18.7	54.0	26.7	27.7	0.7	0.9	9.8	7.0
'Pant P 12'	20.3	56.7	28.3	25.7	1.8	1.9	5.2	6.4
'HUP 10'	25.7	64.7	103.7	90.7	0.6	0.8	5.4	18.0
'HUP 18'	25.7	74.7	64.7	57.0	0.8	0.8	10.8	8.0
'KPMR 660'	26.7	84.0	60.0	61.3	0.9	1.0	9.4	7.4
'FC 1'	28.0	96.67	30.0	31.7	2.3	2.4	14.2	13.0
'IARI 2964'	46.7	104.0	39.3	44.0	1.8	1.9	19.0	7.6
'IARI 3238'	48.3	124.0	79.3	85.3	2.0	2.0	18.2	14.0
'IARI 3160'	39.0	132.0	32.0	41.0	1.5	1.6	17.4	16.2
'KPMR 641'	56.7	148.0	31.0	34.7	1.5	1.7	11.6	16.4
'HUP 11'	68.3	155.3	64.7	76.3	1.6	1.9	9.0	7.6
'KPMR 606'	93.3	198.7	36.0	51.0	1.2	1.1	10.8	6.6
'HUP 2'	116.7	230.7	123.3	142.7	1.5	1.5	14.6	16.0
'KPMR 400'	116.7	247.3	43.7	56.3	1.0	0.9	18.6	20.0
'IARI 3440'	151.7	278.7	163.7	196.0	0.8	0.8	8.2	18.8
'IARI 3030'	135.0	298.7	136.7	154.7	0.8	0.9	5.4	11.0
'Pant P 5'	146.7	313.3	128.3	150.3	1.8	1.9	18.2	12.6
'DDR 57'	170.0	340.0	103.0	118.3	1.4	1.0	8.6	8.8
'HFP 9431'	193.3	364.7	96.3	106.7	0.7	0.7	9.4	11.6
'DDR 50'	183.3	366.7	116.3	134.0	2.3	2.2	15.6	9.0
'HUV P 1'	305.0	550.0	150.0	192.0	1.0	1.5	9.6	17.6
'HFP 9830'	315.0	553.3	301.3	317.0	1.7	1.7	4.0	5.8
LSD ($P=0.05\%$)	14.9	19.98	20.2	54.9	0.7	0.6	5.3	4.2

are expected to be much lower. Such information may help in screening procedure in rust diseases where aecial state gains prominence.

Significant but weak positive correlation (0.36) existed between pustule size and number of pustules/leaf in the germplasm lines screened. However, pustule size and number of pustule/leaf were negatively correlated in resistant category (-0.57), while it was positive in the susceptible category (0.69). This indicated that some mechanisms in the resistant genotypes operated to limit the pathogen's growth and development within the host resulting in low disease severity. However, in susceptible genotypes these 2 components reinforced each other to attain high disease severity indicating compensatory effects between the slow rusting components as also reported in *Phaseolus* bean (Habu and Zadocks 1995).

'JPBB 3' had small (0.3 mm) whereas 'FC 1' had big (2.9 mm) pustules. F_1 showed big pustules with 12 aecial cups/pustule indicating the dominance of high number of aecial cups/pustule over the low number. In F_2 generation, the number of aecial cups/pustule segregated to yield 27 plants

with high and 13 plants with low number of aecial cups/pustule which showed a good fit with 3: 1 ratio ($\chi^2=1.2$, $P<0.05$). In F_3 generation 13 families had high aecial cups/pustule, 12 families had low aecial cup number, while 15 families had plants with low as well as high aecial cups/pustule numbers. This showed an agreement with 1: 2: 1 ratio (2.55, $P<0.05$). These data reveal a single gene control of the trait number of aecial cups/pustule. The heritability of number of aecial cups/pustule in F_3 generation was high (87%), indicating the possibility of an effective selection of pustule size in breeding programme. Since number of aecial cups/pustule is easy to observe and record genotypes with enhanced resistance can be selected by using low number of aecial cups/pustule as a selection criterion along with other components of slow rusting.

SUMMARY

Field and polyhouse studies indicated wide variation in number of aecial cups/pustule in pea (*Pisum sativum* L.) against *Uromyces fabae* Pers de Bary. Size of pustules varied from 0.6 mm to 2.9 mm. Correlation coefficient (r) between

pustule size and AUDPC was -0.19 . The coefficient of determination indicated that 3.5% of variation in AUDPC was due to pustule size. Correlations between pustule size and number of pustules/leaf were negative in resistant categories and positive in the susceptible categories, indicating compensatory effects between these traits. Size of aecial cups did not vary significantly, but the number of aecial cups/pustule varied across the genotypes. A single gene seems to govern number of aecial cups/pustule and high number of aecial cups/pustule seems to be dominant over low number. Number of aecial cups/pustule may be useful as a criterion for selection slow rusting in pea.

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