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Variability studies for six slow rusting traits in pea (*Pisum sativum* L.)

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Pea rust caused by *Uromyces viciae-fabae* (Pers.) J. Schrot is an important pathogen of vegetable and field pea distributed globally in pea growing regions. Pea rust is a major problem under late sown conditions in India and has been reported from different parts of the country (Chauhan *et al.*, 1996). The pathogen develops in warm, humid weather and the disease usually appears during mid-spring when the crop is at flowering or pod-filling stage. The severity of the rust generally results in the breakdown of physiological and biochemical processes in the plant, and photosynthesis is particularly reduced. Most of the leaves fall down and pods remain under developed that may results into the complete loss of yield. Cultivation of rust resistant varieties is one of the safe options for the management of the disease. However, there is lack of complete rust resistance in pea and the available sources of resistance are of slow rusting types (Singh *et al.,* 2008). Slow rusting (SR) resistance is characterized by a reduced rate of epidemic development, despite a compatible host-pathogen interaction. Slow rusting resistance can be measured in the field by recording disease severity at weekly intervals and then calculating the area under disease progress curve (AUDPC). Such kind of resistance is characterized by the combined effect of a longer latent period, smaller uredinium size, lower receptivity (i.e., lower infection frequency) and reduced spore production (known as slow rusting components).

The materials of this experiment comprised of 50 germplasm of pea of diverse origin. The experiment was laid out in RBD with two replications in polyhouse at BHU Varanasi. Seeds were sown in pots (12 inch), after germination five plants per pot were maintained for final observation in two pots each representing one replication.

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The lines planted were screened against rust disease severity on 0-9 scale during main season Rabi 2007-2008. The inoculum was multiplied on the susceptible genotype HFP 4. Twenty severely infected leaves of HFP 4 were soaked in 500 ml water for 4 hours and the spore suspension was filtered through cheese cloth to collect spore suspension (Chand *et al*., 2004). Water was added to adjust the spore density to 10^4 spore/ml. Spore suspension was sprayed by hand sprayer during evening. The inoculation was done at the pre-flowering stage (50-55 days after sowing). The observations were taken on six slow rusting traits i.e. number of pustules/leaf, number of non-bursting pustules, pustule size (0-5 scale), number of aecial cups/pustule, latent period (LP) and AUDPC. The latent period was calculated by counting the number of pustules that were erupted each day beginning from 7th day after inoculation to 25th day. Number of pustules were counted on the 10th nodal leaf from the base on each plant. The LP was calculated by the formula given by Kuhn *et al.* (1980) as following;

$$LP = \Sigma\ [(Pi - Pi\text{-}1)/Pn]t_1$$

where, P_i is the percent of pustules appeared on 1th day, P_{i-1}, percent of pustules appeared on the previous day (i-1th day), P_n is percent of pustules appeared on the last day of recording (nth day) and t_1 is days after inoculation.

Disease severity was recorded on 0-9 scale on individually tagged plant on three dates, and AUDPC values ware worked out by the formula given by Shaner and Finney (1977):

$$AUDPC = [\{(y_i+y_{(i+1)})/2 \text{ x } (t_{(i+1)}-t_i)\}]$$

where, $y_i = d_1$ (date on which 1st observation was taken) or disease level at time t_i, $y_{(i+1)}$ = time in days between d_1, d_2 and $(t_{(i+1)} - t_i)$ = time (days) between 2 disease scores.

Average of different character ware used for statistical analysis. The analysis of variance for RBD was performed. Mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance and correlation

Table 1. Range, coefficient of variation, heritability, genetic advance in pea

Parameters	No. of pustules /leaf	Non busting pustules	Pustule size (0-5 scale)	No. of aecial cups/pustules	Latent period (days)	AUDPC
Range	21.50-572.00	3.84-68.67	2.67-5.00	6.34-11.67	11.59-22.27	96.25-758.33
Grand Mean	22.4	15.76	3.79	8.27	18.39	389.96
Coefficient of Variation	1.95	11.29	7.40	13.12	1.90	4.49
Heritability (%)	90	91	80	61	90	65
Genetic Advance as Percentage of Mean	303.69	20.02	1.05	2.19	6.26	482.77
GCV (%)	65.66	62.66	15.41	16.47	16.63	60.26
PCV (%)	65.68	63.67	16.73	21.06	16.74	60.43

coefficient were calculated at the phenotypic level (Thomas and Tapsel, 1983).

A wide range of variability was observed for six slow rusting traits under study. The analysis of variance exhibited significant differences among genotypes as well as for all the six slow rusting characters studied.

The phenotypic coefficient of variation was higher than their respective genotypic coefficient of variation due to the effect caused by the environment. The estimate of PCV and GCV indicated the existence of high degree of variability for number of pustules/leaf, non-busting pustules and AUDPC (Table 1). Relatively lower values were obtained for pustule size, number of aecial cups/ pustule and latent period. Barilli *et al.* (2009) also observed a wide range of disease responses against rust among the germplasm of pea. In an another study, Herrera-Foessel *et al*. (2007) observed the varying field responses for three slow rusting traits against leaf rust of durum wheat. Heritability estimates of AUDPC was moderate coupled with high degree of genetic advance indicating that this trait is influenced by additive gene effect and thus selection would be effective in such cases. Estimate of heritability was high as well as differences between GCV and PCV was less for latent period which might serve as a reliable parameter during selection for slow rusting resistance. According to Broers (1989), latent period was the most reliable component in bread wheat mainly due to its repeatability. High heritability coupled with low genetic advance for characters viz. latent period, non-bursting pustules is indicative of the involvement of non-additive gene action and the high heritability is being exhibited due to the favourable influence of the environment rather than genotypes.

Correlation studies among different characters for fifty germplasm of pea were also worked out assuming AUDPC as a dependent slow rusting trait and other five as independent. Significant and positive associations of AUDPC with number of pustules/leaf, pustule size and number of aecial cups/pustule were observed. However, negative and highly significant correlation existed between AUDPC and latent period (Table 2).

Negative and significant correlation noticed between LP and number of pustules/leaf, pustule size, number of aecial cups/pustule was observed. However, number of non-bursting pustules exhibited a positive association with LP indicating that non-bursting pustules are responsible for delayed onset of rust disease in pea. Herrara-Foessel *et al.* (2007) investigated that LP and uredinium size (pustule size) has a strong association with disease responses in the field measured as AUDPC and final disease severity. Singh *et al.* (1991) in another study observed the significant correlation between receptivity (number of pustules) and latent period and between uridinium size. Keeping in view the above findings, it is evident that for enhancing resistance against pea rust, component based selection should be practiced rather than disease as a whole. Most of the SR traits investigated are governed by one or few genes which are mostly additive in nature. Therefore, it is

Table 2. Phenotypic correlation coefficient among 50 germplasm lines of pea for slow rusting traits and AUDPC

SR traits	No. of pustules /leaf	Non- busting pustules	Pustule size (0-5 scale)	No. of aecial cups/pustules	Latent period (days)	AUDPC
No. of pustules /leaf	1.00	-0.111	0.171	0.143	-0.725**	0.853**
Non-busting pustules		1.00	0.030	0.269*	0.267*	0.045
Pustule size (0-5 scale)			1.00	0.756**	-0.287*	0.237**
No. of aecial cups/pustules				1.00	-0.361*	0.258*
Latent period (days)					1.00	-0.795**

possible to develop lines having high level of SR resistance with higher durability.

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