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Inference of developmental parameters of pulse beetle, *Callosobruchus chinensis* (L.) on resistance screening of chickpea genotypes

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Abstract
Pulse Beetle, *Callosobruchus chinensis* (L.) is one most the devastating pests of chickpea. The effect of developmental parameters of pulse beetle, *Callosobruchus chinensis* (L.) was investigated on 15 chickpea genotypes and was found to differ significantly among the test genotypes. The highest fecundity was observed in C1025 (97.22 eggs/female), while minimum in C1021 (46.82 eggs/female). Percent loss in seed weight varied from maximum of 47.76% on C1025 to minimum of 09.81% on C1147. The adult emergence percent was least on C1088 (59.14%) and it was recorded to be maximum on C1022 (76.22%). The longest development time was observed on C1021 (30.06 days). The growth index for *C. chinensis* on the test genotypes varied from 2.09 to 3.10, with maximum on genotype C1120 and minimum on BG256. The comparison of growth index and percent adult emergence of the insect demonstrated that BG256 was the most tolerant genotype to this pest with performance at par with 7 other genotypes, while C1120 was found to be highly susceptible.

Keywords: Chickpea genotypes, *Callosobruchus chinensis*, susceptibility, growth index, percent adult emergence, developmental period

Introduction
Chickpea (*Cicer arietinum* L.) is one of the most important leguminous crops and is extensively cultivated in dry and rain-fed areas of the world. The pulses constitute a major source of protein (20-30%) which is almost 3 times higher than that found in cereals and provide high quality protein for the vegetarian population in India, South Asia, West Asia and the Southern European countries [1]. India is the leading producer of chickpea in the world with an area of 9.9 Mha, production 11.7 Mt and productivity 10.86 q/ha in 2020-21 [2]. In India, Madhya Pradesh (4.60 Mt), Maharashtra (1.78 Mt), Rajasthan (1.67 Mt), Karnataka (0.72 Mt), Andhra Pradesh (0.59 Mt), Uttar Pradesh (0.58 Mt), Gujarat (0.37 Mt), Chhattisgarh (0.32 Mt) and Jharkhand (0.29 Mt) are the major chickpea producing states contributing over 95% area [3]. The crop is economically important in Bihar with an acreage, production and productivity of 0.059 Mha, 0.067 Mt and 1140 kg/ ha; respectively [4].
Significant losses in quality and quantity of chickpea grains have been reported to occur during storage either due to physical factors like moisture content of grains, humidity, temperature or biological factors like insect pests, diseases and rodents. Chickpea grains are attacked by various insect pests and among them the pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae) causes significant damage upto 55.7 percent to the stored legumes during severe infestation [5]. It can infest cultivated host plant as well as few wild legumes both in the field and store [6]. These insects can be managed by insecticides but using resistant varieties has additional advantages of being economically feasible and non-hazardous for both humans and the environment. Therefore, the aim of the present study is to screen out chickpea genotypes for resistant/susceptible to the pulse beetle, *C. chinensis* on the basis of its developmental parameters under laboratory conditions. Such knowledge of the genotypes and biology of the pest on the crop would be fundamental in developing an integrated pest management (IPM) programme for chickpea.

Material and Methods
The experiments were conducted at the laboratory of Department of Entomology, Dr. Rajendra Prasad Central Agricultural University, Pusa during 2016-17. The Pulse beetle, *C. chinensis* was used as the test insect. Its nucleus culture was obtained by placing ten pairs of one day old

adults collected from storage house of Department of Seed Technology in each glass jar (25 cm × 15 cm × 10 cm) containing 500 g seeds for oviposition. After 48hrs, adults of *C. chinensis* were removed from the jars and discarded. Then the jars were covered with muslin cloth and tied up with rubber bands. These jars were kept in laboratory under optimum conditions. The cultures were maintained on chickpea seeds at room temperature for obtaining continuous fresh supply of adults of *C. chinensis* for the experiment.

Fifteen genotypes of chickpea viz., C1088, C1064, BG372, C1021, C1121, C1147, C1156, BG256, C1022, C1120, C1063, C1160, C1023, C1025 and C1165 were evaluated for resistance against pulse beetle on the basis of developmental parameters of the insect; by using the "No choice" test. In this test, chickpea seeds were preheated at 50 ºC for 2 hrs before usage in order to discard any chances for the presence of a concealed insect infestation in the seed lots. Hundred seeds of each chickpea genotypes were exposed to 5 pairs of one day old adult (5 males and 5 females) of *C. chinensis* and placed in an incubator at 30±2 ºC under 70±5% relative humidity. The released pulse beetles were removed after 72 hrs with the assumption of maximum oviposition during this period. The experiment was conducted in Completely Randomized Design (CRD) and replicated three times. The data pertaining to the developmental aspects of the insect were recorded in order to evaluate the chickpea genotypes. The number of eggs was counted three days after the release of insects using a magnifying glass. The adults that emerged from each jar were counted and removed from the day of first adult emergence until 45 days. Then percentage of adult emergence was calculated by using formula;

$$\text{Percentage of adult emergence} = \frac{\text{Total number of adults that emerged per jar}}{\text{Total number of eggs per jar}} \times 100$$

The initial weight and the final weight after completion of adult emergence was recorded for 100 chickpea seeds to determine the percent weight loss of grains using the following formula of Dobie *et al.* (1974) [7];

$$\text{Per cent grain weight loss} = \frac{I - F}{I} \times 100$$

Where, I = Initial weight of seeds, F = Final weight of seeds.

The developmental period of the pest was recorded as the time taken from the egg stage to the emergence of adult. It was expressed as the sum of incubation, larval and pupal period of the insect. The growth index of pulse beetle on different chickpea genotypes was calculated by using Singal (1987) formula [8].

$$\text{Growth Index} = \frac{\text{Percentage adult emergence}}{\text{Developmental period (days)}}$$

Based on the obtained growth index, the performance of each genotype was categorized on 1-3 scale as follows:

Category	Percent adult emergence for total eggs	Growth index	Genotypes
1.	< 60 %	<2.35	Less susceptible (Moderately Resistant)
2.	60 to 80 %	2.35 – 3.0	Moderately susceptible
3.	> 80 %	>3.0	Highly susceptible

Results

The results depict a significant effect of the assessed developmental parameters of the pulse beetle on fifteen chickpea genotypes. The mean number of eggs/female and mean number of adult emergence was found maximum in C1025 chickpea genotype (97.22 eggs/female and 60.12 adults) and minimum in BG256 (46.82 eggs/female) and C1160 (30.17 adults emergence) genotypes; respectively. The maximum percentage of adult emergence was found in C1022 (76.22 %) chickpea genotype and minimum in C1088 (59.14 %). The weight loss percent in different genotypes varied significantly from 9.81% to 47.76%. The pest infestation recorded maximum percent of weight loss in C1025 genotype followed by C1121 (46.07%) and minimum was found in genotype C1147 (9.81%). The development period of the test insect also varied significantly among the assessed genotypes. The highest development time was 30.06 days on C1021, and the lowest value of this period was obtained on C1120 (24.90 days). The incubation period (4.33 days), larval (16.00 days) and pupal period (4.57 days) were all found minimum in C1120 chickpea genotype. The growth index of the pulse beetles was found maximum in C1120 (3.10) and minimum in BG256 (2.09). On the basis of growth index range and percent adult emergence from total eggs, chickpea genotypes were distributed into three categories (Table 2). C1120 chickpea genotype came under highly susceptible category while nine chickpea genotypes (BG256, C1025, C1147, C1160, C1165, BG372, C1064, C1088 and C1156) under less susceptible category. Table 3 revealed correlations between developmental parameters of pulse beetles. It showed that growth index of *C. chinensis* had significant negative correlation with developmental period (r=-0.624), insignificant positive correlation with number of eggs laid (r=0.238) and weight loss percent (r=0.319) while highly significant positive correlation with percent adult emergence (r= 0.818) and percent adult emergence had significant positive correlation with mean no of eggs/female (r= 0.818).

Table 1: Effect of growth and development of pulse beetle (*C. chinensis*) on chickpea genotypes under laboratory conditions.

Chickpea genotypes	Mean no. of eggs/female	Mean no. of adults emerged	% Adult emergence	Weight loss (%)	Development period (days)				Growth index
					Incubation period	Larval period	Pupal period	Total Development period	
C1088	51.33	30.49	59.14	37.20	6.06	17.67	6.33	25.67	2.34
C1064	54.88	35.45	64.39	35.93	5.24	17.00	6.00	28.24	2.29
BG372	53.43	35.54	67.35	31.15	6.67	17.61	6.33	29.61	2.27
C1021	46.82	31.06	71.14	24.82	4.33	16.00	6.00	30.06	2.36
C1121	55.71	38.71	68.73	46.07	5.00	16.67	6.37	28.04	2.48
C1147	60.25	38.84	64.44	09.81	6.33	17.67	5.45	29.45	2.19
C1156	63.89	39.99	63.44	31.57	5.11	16.67	5.33	27.11	2.34
BG256	47.78	32.51	59.74	26.14	6.33	17.33	6.40	29.06	2.09
C1022	56.50	42.52	76.22	28.84	5.33	17.00	5.07	27.40	2.76
C1120	79.20	50.84	76.08	42.84	4.33	16.00	4.57	24.90	3.10
C1063	70.84	50.95	72.86	23.84	5.10	17.00	6.14	28.24	2.56
C1160	50.32	30.17	60.10	14.85	5.22	16.33	6.67	27.22	2.21
C1023	79.59	51.17	64.45	30.46	5.00	16.33	5.67	26.00	2.46
C1025	97.22	60.12	61.87	47.76	6.33	17.07	6.67	29.07	2.12
C1165	60.29	40.35	66.76	10.05	6.67	17.00	6.74	29.41	2.26
SEm±	2.95	4.68	9.11	8.06	-	-	-	0.93	0.19
CD(P=0.05)	7.58	12.84	24.97	22.11	NS	NS	NS	2.80	0.58

Table 2: Correlation matrix of growth index and growth parameters of pulse beetle, *C. Chinensis* on chickpea genotypes

Variable	Growth index	Developmental period	Adult emergence (%)	No. of eggs	Weight loss (%)
Growth index	-	-0.624*	0.818**	0.238^{NS}	0.319^{NS}
Developmental period			-0.076	-0.259	-0.379
Adult emergence (%)				0.818**	0.098^{NS}
No. of eggs					0.238^{NS}
Weight loss (%)					-

(*) Significant at 0.05 level and (**) Significant at 0.01 level

Table 3: Frequency distribution of differential reaction of chickpea genotypes to pulse beetle, *C. chinensis*

Category	(%) adult emergence from total eggs	Growth index range	Number of chickpea genotype	Reaction of chickpea genotypes to *C. chinensis*
Less susceptible	< 60	< 2.35	9	BG256, C1025, C1147, C1160, C1165, BG372, C1064, C1088 and C1156
Moderately susceptible	60 to 80	2.35 to 3.0	5	C1021, C1023, C1121, C1063 and C1022
Highly susceptible	>80	>3.0	1	C1120

Discussion

The above findings of experiments were also confirmed by Kumari *et al.* (2020) that the fecundity of a beetle ranged from 71-87 eggs/female, percent adult emergence varied from 81.33 to 98.79%, incubation period from 3-6 days, combined larval and pupal period from 20-23 days and total developmental period varied from 30-37 days [9]. Singh *et al.* (2013) reported that each beetle laid an average of 80-98 eggs and this dissimilarity was accorded due to the variations in the seed size, seed shape and its colour [10]. Kamble *et al.* (2016) had reported 73.19-89.32% adult emergence on chickpea genotypes while Ahmad *et al.* (2019) reported mean number of adult emerged and percent adult emergence on chickpea which varied from 17.00-28.00 adults and 15.53-20.63 % respectively [11, 12]. Deepika *et al.* (2019) reported 33.92 to 62.48 % average weight loss in genotypes due to infestation of pulse beetles [13]. According to Ahmad *et al*. (2016) the incubation period (5.33-7.0 days), larval period (17.0-18.67 days) and pupal period (5.67-7.33 days) of *C. chinensis* in different varieties which did not differ significantly, however, significant variation were found in the total development period (28.67-32.33 days) of insect in different varieties [14]. This is in concurrence with our studies. The difference in the duration of incubation, larval and pupal period might be either due to presence of anti-nutritional plant secondary metabolite or non-preference of chickpea genotypes. Similarly, the growth index of the insect also varied significantly among the different varieties (0.52-0.71) and is supported by the studies by Sharma and Thakur (2014) who reported growth index range of *C. chinensis* from 1.28 to 2.13 on different chickpea genotypes [15]. Ahmad *et al.* (2017) observed a highly significant positive correlation ($P<0.05$) between the number of eggs laid and number of adult emergence (r = 0.865), and a non-significant positive influence on the weight loss (0.598) [16]. On the other hand, the growth index showed highly significant positive correlation (r = 0.780) with the number of adult emergence while Divya *et al.* (2012) reported significantly positive correlation between adult emergence, percent insect damage and percent weight loss [17].

Conclusion

On the basis of the current findings it may be concluded that BG256, C1025, C1147, C1160, C1165, BG372, C1064, C1088, and C1156 are the least susceptible genotypes among the fifteen genotypes evaluated. These showed moderate resistance and can be used in the breeding programme as a

source to develop promising varieties and emerge as a better alternative for other harmful management practices in chickpea pulse beetle management programme.

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