The Pharma Innovation Journal 2022; 11(11): 1935-1940

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 1935-1940

www.thepharmajournal.com
Received: 08-08-2022
Accepted: 12-09-2022

Abhijit Waman
M.Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dapoli, Maharashtra, India

Ajay Munj
Junior Entomologist, Regional Fruit Research Station, Vengurla, Sindhudurg, Maharashtra, India

Tushar Thorat
Associate Professor, Department of Agronomy, College of Agriculture, Dapoli, Maharashtra, India

Arshad Shaikh
M.Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dapoli, Maharashtra, India

Corresponding Author:
Abhijit Waman
M.Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dapoli, Maharashtra, India

To study the ovipositional preference and developmental stages of pulse beetle, *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae) infesting different genotype of cowpea, *Vigna unguiculata* (L.)

Abhijit Waman, Ajay Munj, Tushar Thorat and Arshad Shaikh

Abstract
The laboratory experiment was carried out at laboratory of Department of Agricultural Entomology, College of Agricultural Dapoli, Ratnagiri Maharashtra during the year 2021-22. Eight different genotypes of cowpea were examined for the ovipositional preference and developmental period of *C. maculatus*. The overall study resulted that, the genotype SNJ-11 was observed to be the least preferred by *C. maculatus* for oviposition. Also, the minimum number of eggs (113.67) were laid on the same genotype with minimum hatching percentage (50%), adult emergence (27.00 adults). The genotype CP-13 was observed to be the most preferred by *C. maculatus for* oviposition. Also, the maximum number of eggs were laid (147.33) on same genotype with maximum hatching percentage (86.67%), adult emergence (49.72 adults) and the least adult longevity (7.40 days), total life cycle (22.63 days), respectively. The percent seed weight loss was also more (8.48%) in the CP-13 genotype.

Keywords: *Callosobruchus maculatus*, cowpea, ovipositional preference

Introduction
Pulses are the most cost-effective source of protein, along with all necessary amino acids. They also supply nutrient-rich food for cattle, as well as nitrogen to the soil which improves soil fertility and increases productivity of the farmland. The cowpea, *Vigna unguiculata* (L.) is one of the several species of widely cultivated genus *Vigna*. Cowpea provides one of the most variable species in case of plant growth, maturity, morphological characters, grain types, etc. among different cultivated crop plants (Singh, 2014) [27]. The cowpea crop has the ability to fix nitrogen from the atmosphere through the root nodules. It thrives well in poor soils, producing more than 85 percent of normal seeds in less than 0.2 percent organic matter, low sand content, and high phosphorus levels. It is a good intercrop for maize, millet, other cereals, cotton, sorghum and sugarcane, etc. (Olufajo *et al*., 2002) [19]. Amongst several insect pests, bruchids are serious pests of stored pulses especially stored cowpea, which are commonly called as pulse beetles. The different species of pulse beetle viz., *C. chinensis, C. maculatus, C. analis and C. phaseoli*, (Coleoptera: Chrysomelidae) are commonly occurring and considered to be the most serious insect pests of stored pulses. Every year, over 8.5% of all pulses in India are wasted during post-harvest and storage. Eggs are glued to seed coats by ovipositing females. Grubs chew up the seed directly underneath the oviposition site, on hatching the grubs penetrate into the seed leaving upper shell intact. Grub destroys the endosperm completely, leaving only seed coat. In storage, pulse beetles multiply rapidly as they are internal feeders. A lot of germplasms of cowpea are available at different Agriculture Universities. Therefore, it was decided to study the ovipositional preference of *C. maculatus* to cowpea germplasm. Also, the developmental period of *C. maculatus* on different cowpea genotypes have been studied which will give a clear idea about the biology of this pest. Based on the results of present study, 'the ovipositional preference and different developmental stages of pulse beetle, *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae) infesting different genotypes of cowpea, *Vigna unguiculata* (L.),' the cowpea germplasm which was less preferred by *C. maculatus* for its development can be made available to the farmers.

2. Materials and Methods

2.1 Culture of Pulse beetle

The initial culture of pulse beetle, *Callosobruchus maculatus* (Fab.) was obtained from the cowpea grains already infested by bruchids from local market and godowns where old infested cowpea was available and kept in glass jar. For initial culture, healthy and uninfested seeds of cowpea were procured from local market and kept in 32×22.5 cm size cylindrical jar and twenty adults isolated from original culture were released into the jar containing healthy grains. The top of the jar was covered with black muslin cloth secured firmly by rubber band. The newly emerged adults were introduced into the cowpea seed kept in a series of cylindrical jars for building up a homogenous population. Adults of uniform age were used from this colony for the experiment. These studies were conducted at room temperature and relative humidity under ambient conditions.

2.2 Different genotypes and varieties of cowpea used for experimentation

Genotypes (8)

1) CP-06	2) CP-08
3) CP-13	4) SNJ-11
5) SNJ-22	6) SNJ-27
7) SNJ-32	8) PP

2.3 To study the ovipositional preference of *C. maculatus* to selected cowpea genotypes

Preference of pulse beetle *C. maculatus* towards different cowpea genotypes was tested by conducting free choice test. In this test olfactometer was used for the study. The details are given below. The free choice test was implemented using olfactometer. The details of olfactometer are as follows:

Olfactometer: An olfactometer designed by Gibson and Raina (1972) [9] and subsequently modified by Jadhav *et al.* (2015) [11] was prepared by using circular plastic box of 15 cm in diameter and 5 cm in height with a lid. Test tubes each of 2.5 cm in diameter and 15 cm in length were fixed at equidistance in a slanting position to outside wall of circular plastic box. The mouth of test tube was kept open just inside the sidewall of a box to have free choice for beetles to orient and oviposit. Three such olfactometers were prepared and used during present study.

Ten gram grains of different cowpea genotypes were kept in separate test tubes fixed to the container of olfactometer. Accordingly, all selected genotypes were examined. Three such olfactometers were used in order to maintain three replications. Eight pairs of freshly emerged adults were released in the centre of circular container to study the ovipositional preference of pulse beetle.

2.4 To study the developmental stages of *C. maculatus* on different cowpea genotypes

To study the developmental period of *C. maculatus* on different cowpea genotypes, the laboratory experiment was laid out in randomized block design (RBD) with eight treatments consisting of different genotypes of cowpea, which were replicated thrice. Fifty gram seeds of above mentioned eight genotypes of cowpea were kept separately in the plastic bottles. Five mated adult females of *C. maculatus* were released in each plastic bottle. The mouth of plastic bottle was closed tightly with black muslin cloth with rubber band. The beetles were allowed to lay eggs on the cowpea seeds placed in plastic bottles until death. Three such replications were maintained for each genotype. The observations were recorded on following parameters for developmental period of pulse beetle.

2.4.1 Fecundity

The newly emerged adult beetles were allowed to oviposit on seeds of different genotypes of cowpea until death. The dead beetles were removed from each treatment. All seeds were observed carefully from each treatment and number of eggs laid were counted.

2.4.2 Incubation period and hatching percentage

The incubation period was worked out by counting the number of days from egg laying to eggs hatching. Ten eggs were observed continuously from egg laying till hatching to work out the incubation period. The incubation period of each egg was recorded and the average incubation period was worked out.

Ten eggs were kept separately to observe the hatching percentage. Three such sets were maintained. Hatching percentage was calculated based on number of eggs hatched.

$$\text{Hatching Percentage} = \frac{\text{No. of eggs hatched}}{\text{Total no. of eggs observed}} \times 100$$

2.4.3 Adult emergence

Total number of adult insects emerged from each treatment (genotype) were recorded on the basis of number of seeds with exit holes which were counted on each alternate day from the date of emergence. The data obtained were analysed statistically and presented.

2.4.4 Adult longevity

Freshly emerged ten adult beetles were separated in another test tubes individually from each treatment. Same adults were observed regularly till the death of each adult. The date of adult emergence and date of death of adult was recorded to measure the average adult longevity in each genotype.

2.4.5 Total life cycle

Since the pulse beetle is internal feeder, it is difficult to take the observations of larval and pupal period by breaking the seeds of cowpea. Hence for the study of total life cycle of bruchid, the period required from egg laying to death of adults was recorded, which also includes larval and pupal period.

2.4.6 Percent weight loss

Initially, known quantity (50 g) of seeds of each genotype was taken (initial weight). After adult emergence, the seeds of each genotype were weighed (final weight) with the help of electronic balance. The percent weight loss in seed of different genotypes was worked out using the formula.

$$\text{Percent weight loss} = \frac{\text{Initial seed weight-Final seed weight}}{\text{Initial seed weight}} \times 100$$

3. Results and Discussion

The present experiment entitled with, "the ovipositional preference and different developmental stages of pulse beetle, *Callosobruchus maculatus* (fab.) (Coleoptera:

Chrysomelidae) infesting different genotypes of cowpea, *Vigna unguiculata* (L.)" was conducted at laboratory of Department of Agricultural Entomology, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The results of the experiment presented in the preceding part of this chapter and have been discussed and elucidated as follows.

3.1 To study the ovipositional preference of *C. maculatus* to different cowpea genotypes

The data recorded on ovipositional preference of *C. maculatus* towards different genotypes of cowpea under free choice test in olfactometer. From the data, it is evident that, the genotype SNJ-11 was observed to be the least preferred (11.67 eggs) by *C. maculatus*. Whereas, the most preferred genotype for oviposition by *C. maculatus* was CP-13 with the highest number of eggs laid (27.67).

Many other workers have studied the ovipositional preference of *C. maculatus* on different cowpea varieties/genotypes. Dabi *et al.* (1979) [5] examined the reaction of different cowpea varieties to *C. maculatus* and reported that, the genotype RS-9 was the least susceptible, whereas, the varieties RS-42, RS-118 and NO-5-19-4-1 were the most susceptible to *C. maculatus*. Messina and Renwick (1985) [16] reported that, among the different cowpea genotypes tested against cowpea bruchids, two lines (IT81D-985 and IT81D-1137) of cowpea with rough seed coat were resistant to bruchid larvae with non-preference resistance to ovipositing adults. Mueke (1985) [17] reported that among the ten different cowpea varieties tested, VITA-5 was the least preferred for oviposition by *C. maculatus*. Shivanna *et al.* (2011) [24] reported that, the cowpea variety CP-17 was the least preferred for oviposition by *C. maculatus*. Tripathi *et al.* (2020) [28] reported that among different cowpea varieties tested, EC528387 variety was the least preferred by *C. maculatus* for oviposition. The differences observed in the ovipositional preference of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

3.2 To study the developmental period of *C. maculatus* on different cowpea genotypes

3.2.1 Fecundity

The observations recorded on average number of eggs laid by *C. maculatus* until death on 50 g seeds of different genotypes of cowpea. From the data it is evident that, the average number of eggs laid by *C. maculatus* ranged from 113.67 to 147.33 eggs per 50 g seeds. The lowest number of eggs (113.67 eggs/50 g seed) were laid on the genotype SNJ-11, followed by genotype CP-06 (125.33 eggs/50 g seed). Genotype CP-13 recorded the highest egg laying (147.33 eggs/50 g seed), followed by genotype SNJ-32 (143.33 eggs/50 g seed), CP-08 (140.67 eggs/50 g seed) and SNJ-22 (138.33 eggs/50 g seed).

The present results are more or less in conformity with Singh and Sharma (2003) [26] who reported the fecundity of 98.1 to 99.5 egg in eight different varieties of cowpea. Tripathi *et al.* (2020) [28] assessed 103 different cowpea varieties and reported that *C. maculatus* laid eggs ranging from 52.7 to 437 per 20 seeds. The lowest number of egg laying was observed in variety EC528387 (52.7 eggs). El Halfwy (1972) [7] reported that, the average number of eggs laid by *C. maculatus* on blackeyed cowpea and fertriate cowpea were 62.4 and 39.4 eggs, respectively. Badii *et al.* (2013) [3] reported the highest egg laying of *C. maculatus* in cowpea genotype SARC 3-122-2 (149.5 eggs) and the least number of eggs were laid on genotype SARC 1-132-1 (16 eggs). Ofuya and Credland (1995) [18] studied the lifetime fecundity of *C. maculatus* on cowpea and inferred that, the fecundity was lowest in IT84S-275-9 cowpea variety. The differences observed in the fecundity of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

3.2.2 Incubation period and hatching percentage

Data recorded on incubation period of *C. maculatus* on eight different genotypes of cowpea. From the data it is seen that, the incubation period of *C. maculatus* was ranged between 3.25 to 5.50 days in all the tested genotypes. The maximum incubation period was observed in genotype SNJ-32 (5.50 days). The minimum incubation period was observed in genotype SNJ-22 (3.25 days). The average incubation period was found to be 4.38 days.

These observations are in accordance with Seddiqi (1972) [21] who reported the average incubation period of *C. maculatus* as 5.50 days on cowpea. Also, Jadhav *et al.* (2015) [11] reported that, the incubation period of *C. maculatus* on different cowpea varieties ranged from 3.86 to 4.41 days. Sharma *et al.* (2016) [23] recorded the average incubation period of 4 to 5 days in V-578 variety of cowpea. Jaiswal *et al.* (2018) [12] reported the incubation period of *C. maculatus* as 4.15 ± 0.87 days in chickpea. Augustine and Balikai (2019) [2] studied the incubation period of pulse beetle in DC-15 variety of cowpea which was ranged from 4 to 6 days with the mean of 4.6 ± 0.70 days. The differences observed in the incubation period of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

The observations regarding hatching percentage indicated that, there is marked variation (50% to 86.67%) in hatching percentage in the tested genotypes of cowpea and the overall average percentage of hatching was 70.83 percent. The lowest hatching percentage was observed in genotype SNJ-11 (50.00%) and the highest hatching percentage was recorded in genotype CP-13 (86.67%).

Adenekan *et al.* (2018) [1] reported the highest egg hatching of 44 ± 4.1 at 30 ºC. and the lowest hatching of 3.5 ± 1.0 eggs at 10 ºC. The differences observed in the hatching percentage of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

3.2.3 Adult Emergences

The data recorded on adult emergence of *C. maculatus* from eight different cowpea genotypes. From the data it is evident that, the adult emergence of *C. maculatus* ranged between 27.00 to 49.72 per 50 g seeds of different genotypes of cowpea. The least number of adults (27.00) emerged in the genotype SNJ-11, whereas, the maximum number of adults (49.72) were found emerged in the genotype CP-13. None of genotype was found to be totally resistant to bruchid attack.

These results are more or less in conformity with Fawki *et al.* (2012) [8] who reported the highest adult emergence of 90.42% in cowpea variety dokki-331. Badii *et al.* (2013) [3] studied the adult emergence of *C. maculatus* in twenty two genotypes of cowpea and reported the adult emergence in the range of 8.3 to 11.3. Manohar and Yadav (1990) [15] concluded that among different pulses tested, cowpea showed highest adult emergence (70 to 90%) of pulse beetle. Also, Javaid *et al.* (1993) [13] reported the comparatively higher adult emergence of *C. maculatus* on black eye variety of cowpea than other evaluated land races. The differences observed in the adult emergence of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

3.2.4 Adult longevity

The data obtained on adult longevity of pulse beetle, *C. maculatus* on different cowpea genotypes. The data showed that the adult longevity varied in the range of 7.40 to 9.20 days. In CP-13 genotype, the mean adult longevity of 7.4 days was observed which was the lowest amongst all other genotypes. The highest adult longevity of 9.2 days was observed in genotype SNJ-22.

These results are nearly matching with some earlier workers. Seddiqi (1972) [21] reported the adult longevity of pulse beetle as 6.5 days in cowpea. Also, Kazemi *et al.* (2009) [14] noted the adult longevity of 5.87 ± 0.08 days of *C. maculatus* in cowpea. Sharma *et al.* (2016) [23] recorded the adult longevity of *C. maculatus* ranging from 8-15 days in V-578 variety of cowpea. The differences observed in the adult longevity of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

3.2.5 Total life cycle

The observations regarding total time needed to complete the life cycle in eight cowpea genotypes was recorded. From, the data it is evident that, the average number of days to complete life cycle of *C. maculatus* on different cowpea genotypes ranged from 22.63 to 27.77 days. The minimum life cycle period of *C. maculatus* was observed on genotype CP-13 (22.63 days). The maximum life cycle period was recorded in genotype PP (27.77 days) followed by CP-06 (27.62 days).

These obtained results are more or less supported by Senthilraja and Patel (2020) [28]. They recorded total life cycle period of *C. maculatus* ranging from 19.67 to 22.67 days in different genotypes of cowpea. Sharma *et al.* (2016) [23] recorded the average total life cycle of 8 to 15 days in different genotypes of cowpea. El Halfwy (1972) [7] studied the total life of cycle *C. maculatus* in black eyed cowpea and fertriate cowpea from egg to adult which lasted for 26 and 29 days, respectively. Badii *et al.* (2013) [3] reported the total life cycle of 21.5 days as the highest and 18.5 days as the lowest in different genotypes of cowpea. Gill and Ramzan (1998) [10] reported the life cycle of *C. maculatus* on green gram as 35.35 days in the months of October- November. Singal (1998) [25] reported the total life cycle period of pulse beetle as 35.5 days in laboratory conditions which is somewhat more than our findings. Jaiswal *et al.* (2018) [12] recorded total developmental period of pulse beetle in chickpea was 32.85 ± 3.42 days. The differences observed in the total life cycle of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

3.2.6 Percent weight loss

The data recorded on percent weight loss in the seed weight of different genotypes of cowpea due to *C. maculatus*. The data on mean percent weight loss ranged from 3.88 to 8.48 percent. The minimum weight loss in cowpea seed was recorded in genotype CP-06 (3.88%) and the maximum weight loss (8.48%) was observed in genotype CP-13.

Deshpande *et al.* (2011) [6] recorded the least weight loss of 8.87 percent in IC20278 variety of cowpea. Badii *et al.* (2013) [3] recorded the weight loss of 4.3-9.6% in SARC 1-132-1, SARC 3-90-2 and SARC 3-103-1 genotypes of cowpea. Senthilraja and Patel (2021) [22] reported little higher weight loss (13.03 to 24.92%) in different varieties of cowpea due to feeding of *C. maculatus*. The differences observed in the percent weight loss of *C. maculatus* reported by other workers may be due use of different cowpea genotypes.

Table 1: Ovipositional preference of *C. maculatus* in selected genotypes of cowpea

Sr. No.	Cowpea genotypes	No. of eggs laid
1.	CP-06	15.33(4.039) *
2.	CP-08	19.00 (4.471)
3.	CP-13	27.67 (5.353)
4.	SNJ-11	11.67 (3.555)
5.	SNJ-22	17.33 (4.279)
6.	SNJ-27	15.67 (4.080)
7.	SNJ-32	24.33 (5.027)
8.	PP	17.00 (4.242)
	Mean	18.50(4.381)
	S.E.m.±	0.089
	C.D.@5%	0.274

Table 2: Developmental period of *C. maculatus* in different genotypes of cowpea

Sr. No.	Different Life stages of *C. maculatus*	Maximum	Minimum	Mean
1.	Fecundity	113.67 eggs	147.33 eggs	133.71 eggs
2.	Incubation period	3.25 days	5.50 days	4.38 days
3.	Eggs Hatched	56.67%	86.67%	70.83%
4.	Adult emergence	27.00 adults	49.72 adults	37.73 adults
5.	Adult Longevity	7.40 days	9.20 days	8.23 days
6.	Total life cycle	22.63 days	27.77 days	25.41 days
7.	Percent weight loss	3.88%	8.48%	5.42%

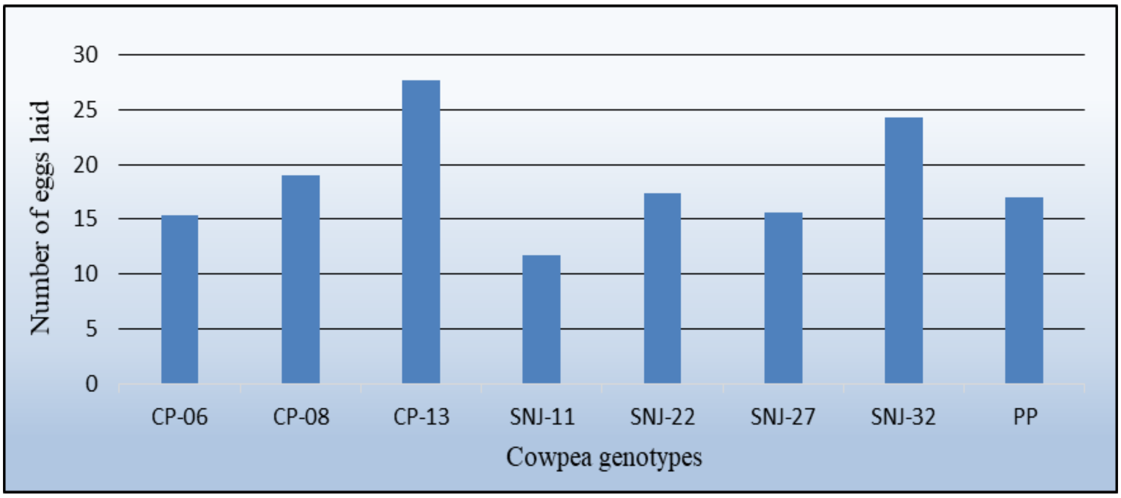

Fig 1: Ovipositional preference of *C. maculatus* in different genotypes of cowpea

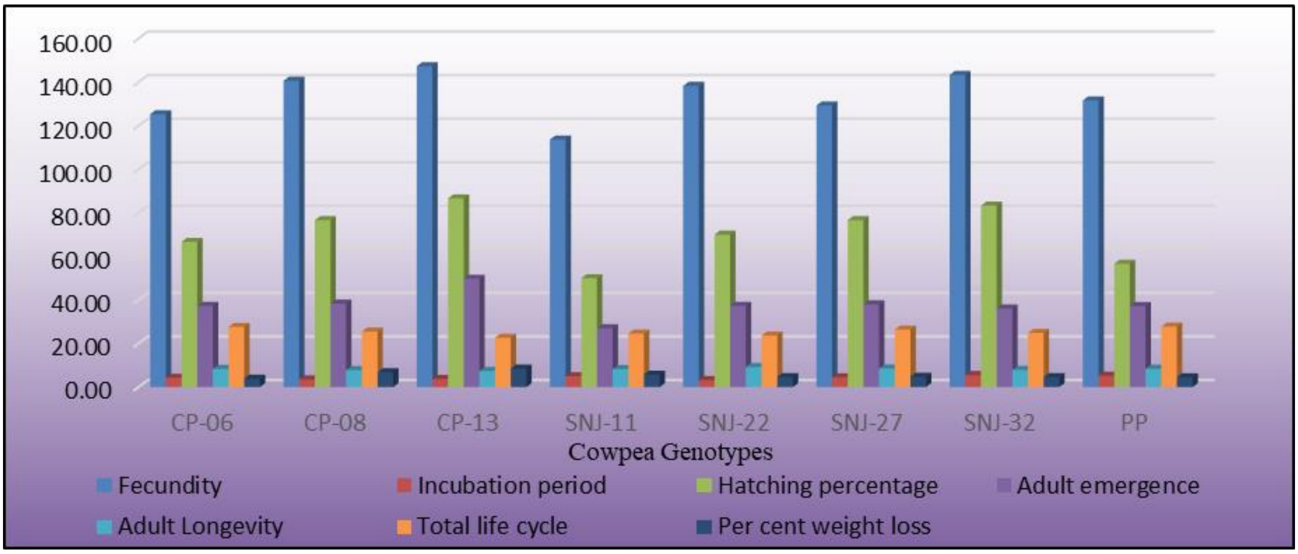

Fig 2: Graph representing different developmental stages of *C. maculatus* in different genotypes of cowpea

4. Conclusion

In the present investigation, it was observed that the genotype SNJ-11 was observed to be the least preferred by *C. maculatus* for oviposition. Also, the minimum number of eggs were laid on the same genotype. The minimum hatching percentage, adult emergence and total life cycle period was also least on the same genotype. The genotype CP-13 was observed to be the most preferred by *C. maculatus* for oviposition. Also, the maximum number of eggs were laid on same genotype with maximum hatching percentage, adult emergence whereas minimum adult longevity and total life cycle of *C. maculatus* was observed. The percent seed weight loss was also more in the same genotype.

5. Acknowledgement

Author is thankful to, Department of Agricultural Entomology, College of Agriculture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli-415712, dist-Ratnagiri, Maharashtra (India), to provide necessary facility and valuable suggestion during investigation.

References

1. Adenekan MO, Ajetunmobi OT, Okpeze VE, Aniche DC. Residual effect of different temperature regimes on the developmental stages of F1 Progeny of *Callosobruchus maculatus* (F) (Coleoptera: Bruchidea) on cowpea seeds. Int. J. Agric. Innov. Res. 2018;6(6):2319-1473.
2. Augustine N, Balikai RA. Biology of pulse beetle, *Callosobruchus chinensis* (Linnaeus) on cowpea variety DC-15. J. Ent. Zool. Stud. 2019;**7**(1):513-516.
3. Badii KB, Asante SK, Sowley ENK. Varietal susceptibility of cowpea (*Vigna unguiculata* L.) to the storage beetle, *Callosobruchus maculatus* F. (Coleoptera: Bruchidae), 2013.
4. Chavan PD, Singh Y, Singh SP. Ovipositional preference of *Callosobruchus chinensis* for cowpea lines. Indian J. Ent. 1997a;59(3):295-303.
5. Dabi RK, Gupta HC, Sharma SK. Relative susceptibility of some cowpea varieties to pulse beetle, *C. maculatus.* Indian J Agri. Sci. 1979;49(1):48-50.
6. Deshpande VK, Makanur B, Deshpande SK, Adiger S, Salimath PM. Quantitative and qualitative losses caused by *Callosobruchus maculatus* in cowpea during seed storage. Plant Archives. 2011;11(2):723-731.
7. El Halfwy MA, Nakhla JM, Isa NH. Effect of food on the fecundity, longevity and development of the southern cowpea weevil, *Callosobruchus maculatus* F. Agricultural research review, 1972.
8. Fawki S, Khaled AS, Fattah HMA, Hussein MA, Mohammed MI, Salem DA. Physical and biochemical

basis of resistance in some cowpea varieties against *Callosobruchus maculatus* (F.). Egypt. J Pure Appl. 2012;(1):51-61.
9. Gibson KE, Raina AK. A simple laboratory method of determining seed host preference of Bruchidae. J. Econ. Ent. 1972;65(4):1189-1190.
10. Gill HS, Ramzan M. Development biology of *C. maculatus* (F.) on green gram in the Punjab. J. Insect Sci. 1998;11(2):176-177.
11. Jadhav SS, Mehendale SK, Hegde PB. Ovipositional preference and development of *Callosobruchus maculatus* Fab. (Coleoptera: Chrysomelidae) on different pulses and cereals. Trends. Bioscience. 2015;8(17):4667-4671.
12. Jaiswal DK, Raju SVS, Kumar D, Vani VM. Studies on biology of pulse beetle, *Callosobruchus chinensis* (L.) on stored chickpea under laboratory conditions. J. Pharmacogn. Phytochem. 2018;7(6):464-467.
13. Javaid MA, Poswal T, Mokgatle OS, Mathodi SM. Comparative susceptibility of various cowpea land races to infestation by *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) Afr. Ent. 1993;1(2):255-257.
14. Kazemi F, Talebi AA, Fathipour Y, Farahani S. A comparative study on the effect of four leguminous species on biological and population growth parameters of *Callosobruchus maculatus* (F.) (Col.: Bruchidae). Adv. Environ. Biol. 2009;3(3):226-32.
15. Manohar SS, Yadav SRS. Varietal susceptibility of cowpea varieties against *Callosobruchus maculatus*. Indian J. Ent. 1990;52:180-183.
16. Messina FJ, Renwick JA. Resistance to *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) in selected cowpea lines. J Environ. Ent. 1985;14(6):868-872.
17. Mueke JM. Varietal susceptibility of cowpea to *Callosobruchus maculatus* (F) (Coleoptera: Bruchidae) E. Afr. Agri. 1985;49(3):84-88.
18. Ofuya TI, Credland PF. Responses of three populations of the seed beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) to seed resistance in selected varieties of cowpea, *Vigna unguiculata* (L.) Walp. 1995;31(1):17-27.
19. Olufajo OO, Singh BB. Advances in cowpea cropping systems. Challenges and opportunities for enhancing sustainable cowpea production; c2002. p. 267.
20. Satyavir. Note on relative susceptibility of different varieties of cowpea to *Callosobruchus maculatus* (Fabricious). Ind. J Agri. Sci. 1981;51(11):813-81.
21. Seddiqi PM. Studies on longevity, oviposition, fecundity and development of *Callosobruchus chinensis* (L.). Zeitschrift für Angew. Ent. 1972;72(1):66-72.
22. Senthilraja N, Patel PS. Screening of cowpea varieties/genotypes against the pulse beetle, *Callosobruchus maculatus* (F.). J Ent. Zool. Studies. 2021;9(1):680-684.
23. Sharma R, Devi R, Soni A, Sharma U, Yadav S, Sharma R, *et al*. Growth and developmental responses of *Callosobruchus maculatus* (F.) on various pulses. Legume Research. 2016;39(5):840-843.
24. Shivanna BK, Ramamurthy BN, Naik GB, Devi GS, Mallikarjunaiah H, Naik KR. Varietal screening of cowpea against pulse beetles, *Callosobruchus maculatus* (Fab.) and *Callosobruchus analis* (Fab.) Internal. J Sci. and Nat. 2011;2(2):245-247.
25. Singal SK. Biology of pulse beetle, *Callosobruchus chinensis* (L.) on cowpea under field and laboratory conditions. J. Insect Sci. 1998;11(2):130-132.
26. Singh S, Sharma G. Preference of pulse beetle to some cowpea varieties. Indian J Ent. 2003;65(2):273-276.
27. Singh BB. Cowpea: The food legume of 21st Century. Crop science Society of Americaed. ACSESS Publications; c2014.
28. Tripathi K, Prasad T, Bhardwaj R, Jha S, Semwal D, Gore P, *et al*. Evaluation of diverse germplasm of cowpea [*Vigna unguiculata* (L.) Walp.] against bruchid [*Callosobruchus maculatus* (Fab.)] and correlation with physical and biochemical parameters of seed. Plant Genetic Resource Characterisation Util. 2020;18(3):120-129.