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RESEARCH ARTICLE

PHYSICO-CHEMICAL PARAMETERS OF PULSES AFFECTING THE BRUCHID (*CALLOSOBRUCHUS CHINENSIS* LINN.) INFESTATION

***Chakraborty, S. and Mondal, P.**

Department of plant protection, Pally Siksha Bhavana, Visva Bharati, Shriniketan, Birbhum, West Bengal-731235, India

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ABSTRACT

Members of the family Bruchidae (Coleoptera) are important pests of a variety of seed material. The adults oviposit on stored seeds or on developing seedpods in the field. The larval and in most species, the pupal stages are completed within the seed and the adult eventually emerges through a small exit hole. Due to this mode of development bruchids are easily transported along with the seed material from one country to another thus spread very quickly. Forty-eight species of bruchids have been recorded from different localities of India. Out of these, 23 species belong to Bruchidius, 8 to Caryedon, 5 to Callosobruchus, 4 to Spermophagus, 2 each to Bruchus, Conicobruchus and to Specularius and 1 each to Zabrotes and Sulcobruchus. As many as 13 species are associated with edible seeds especially pulses. The genera Callosobruchus restrict their activities to the stored pulses. In the North-East India three species i.e., C. chinensis, C. maculatus and C. analis are abundant and they feed on several hosts such as green gram, red gram, cow pea, bengal gram, grass pea, pea, lentil, black gram and moth bean. Amongst these, C. chinensis is the most serious pest in the Terai agro-climatic region of West Bengal. Studies revealed that relative preference of C. chinensis to different pulses vary widely depending upon their physical and chemical characteristics. Ovipositional preference was dependent on the seed color, seed texture, seed weight, thickness of seed coat, seed moisture and various chemical parameters. Concentrations of phenol, OD phenol and protein were studied in chemical investigations. Studies on correlation between the physico-chemical characters of different legumes on ovipositional behaviour, adult emergence and total developmental period of the insect revealed that moisture content of seeds, single geed weight and seed coat thickness had negative correlation with oviposition, adult emergence percentage and total developmental period while phenol content, OD phenol content and protein content had positive correlation with oviposition and developmental period while negative correlation with adult emergence percentage.

INTRODUCTION

Pulses may be defined as the dried edible seeds of cultivated legumes. They belong to the families of peas, beans and lentils. The English word pulse is taken from the Latin *puls*, meaning pottage or thick pap. The pulses are a large family and various species are capable or surviving in very different climates and soils. Traces of pulse crops have been found from ancient times in archaeological sites of both the Old and New Worlds and they appear to have been among the earliest domesticated plants. These findings indicate an almost simultaneous arrival of cereals and pulses around 10,000 BC. The pulses have played a vital role in the improvement of agricultural economy of different countries (Sarwar *et al*., 2003; Deeba *et al*., 2006). Pulse crops are susceptible to many insect pests both during the field and storage.

Corresponding author: Chakraborty, S.
Department of plant protection, Pally Siksha Bhavana, Visva Bharati, Shriniketan, Birbhum, West Bengal-731235, India.

The most important species of storage insect pests of food legumes include: *Callosobruchus chinensis* Linn., *C. maculatus* Fab., *C. analis* Fab., *Acanthoscelides obtectus* Say. and *Bruchus incarnatus* Boh. (Bushara,1988 and Kashiwaba,2003). In addition, *B. rufimanus* Boh. , *B. dentipes* Baudi., *B. quinqueguttatus* Oli., B. *emarginatus* W. , *B. ervi* Fro., *B. lentis* W. and *B. pisorum* Linn. may also cause significant losses in some legumes (Bazzano *et al*.,2001). Of many insect pests the pulses are badly damaged by pulse beetles of the genus *Callosobruchus* (Coleoptera : Bruchidae) during storage throughout the world and this discourages the poor farmers from large-scale production and storage of pulses. In India 117 species of bruchids belonging to 11 genera have been recorded infesting different pulses (Arora, 1977). The genus *Callosobruchus* attacks grain legumes during both pre and post harvest stages all over the world. But in India, pulses are damaged by pulse beetles such as *C. chinensis* Linn., *C. maculatus Fabr*., *C. analis* Fabr., *C. affinis* Frol., *C. emerginatus* All., *C. phaseoli* Gyll., *C. albacallosus* Pic., and

C. pirorum Linn. Among these, five species of bruchids of the genus Callosobruchus was known to abundant in India of which *C. maculatus, C. analis* and *C. chinensis* are the predominate pest specie (Raina, 1970). *C. chinensis* is the most serious pest in North-East India. The insects spends its entire immature life in individual legumes seeds, where they cause weight loss, decrease germination potential and diminish the market as well as nutritional value of the commodity. In India Gujar and Yadav (1978) recorded 32.2 to 55.7 per cent loss in seed weight and 17.0 to 53.5 per cent loss in protein content. In case of severe infestation 100% damage is caused by the pest (Pruthi and Singh, 1950). However, all species and varieties of stored pulses are not equally susceptible to the attack and damage. Although the accurate estimation is not available, pulses in storage suffer from a substantial damage due to bruchids. According to Mokherjee *et al*., (1970), the degree of damage caused by *C. chinensis* was mung bean> grass pea > chick pea > lentil > black gram > pea.

Gundurao and Majumdar (1964) listed the order of preference of food of this pulse beetle as green gram, cowpea, bengal gram, bean and pea. Gokhale (1973) observed the growth and development of *Callosobruchus maculatus* on 13 species of pulses. On the basis of growth index, mothbean proved to be maximum food value to the insects, followed by green gram, pigeonpea, cowpea, bengal gram, chick pea, black gram, pea and hycianth bean in a descending order. Mitchell (1975) showed that, all other things being equal, female beetles will select the largest seeds with the fewest eggs on which to lay their eggs. This idea has developed through the work of Wilson (1988) and more recently Horng (1997) who have elaborated progressively more sophisticated models to explain why and how females choose one seed over another. The broad conclusion remains valid but there is evidence that some populations of *C. maculatus* are more discriminating than others. The South India population lays eggs more uniformly among seeds than other populations and this is associated with its more competitive larvae (Messina and Tinney, 1991).

The bionomics of different species of *Callosobruchus* have been studied by many investigators namely Arora and Singh (1970), Begum *et al*. (1982), Giga and Smith (1983) and Khare and Johari (1983). Singh *et al*. (1980) studied the ovipositional preference, growth and development of both *C. chinensis* and *C. maculatus* on different of pulses. The authors also reported a resistant factor influencing the growth of *C. chinensis* and *C. maculatus* on black gram. The descending order of preference of *C. chinensis* for oviposition is cowpea> black gram> Lentil> red gram> chick pea> green gram> pea wherein *C. maculatus* chick pea> black gram> green gram> cowpea> red gram> pea > lentil. *C. chinensis* can complete the growth and development on cowpea, lentil, red gram, green gram, chickpea, and pea but it fails to complete development on black gram. Green gram was found to be the most suitable and lentil is the most unsuitable for growth and development in case of *C. maculatus*. On lentil, the developmental period was prolonged and the size and weight of adults, fecundity and life span were reduced while in another experiment Bhargava *et al.* (2008) studied the biology of *C. chinensis* on cowpea, mung bean, moth bean (*Vigna aconitifolia*), gram, pigeon pea, pea and soybean. They revealed that fecundity, adult emergence and adult longevity were greatest on cow pea and lowest on soybean. Based on biological parameters and growth index, the susceptibility of hosts for test insect followed the order: cowpea> mung bean> moth bean> gram> pigeon pea > pea> soybean. In terms of index of susceptibility too, green gram was found to be most suitable host for both the bruchid pests. According to Teotia and Singh (1966) who reported that wrinkled, depressed or rough seed coat of the host seed was relatively less preferred for oviposition and were unsuitable for development of insects. On contrary Lema (1994) proposed that beetles laid most of their eggs on cultivars having smooth seed coat, and displayed a strong non-preference for the genotypes with morphologically rough seed coat.

MATERIALS AND METHODS

Tests for susceptibility was done through the egg lying preference of *C. chinensis* in five different stored pulses under laboratory condition. Free- choice and No-choice test was done to identify the physico-chemical parameters for host preference.

Free- choice test

Four big plastic jars (30 cm diameter x 10 cm) having perforated lids were taken. Within each jar five petridishes (2' and 4' diameter) have been adjusted at the base. In each petridish 100g healthy, clean and disinfected pulse seeds were kept. Ten pairs of males and females were taken from nucleus culture and released at the centre of the base of the jar. Number of eggs laid by the females were recorded from the day after release of the beetles and continued for five days at an interval of 24 h in a random sample of 100 grains. After which, the experiment was terminated. The experiment was replicated for four times.

The different steps followed for the experiment are summarized below:

Hundred gram of pulses of the different legume seeds were taken in plastic jars of 5" diameter x 3.5 size. Five pairs of freshly emerged adult insects were introduced into each of the containers. The mouth of the bottles was covered with a thin voil cloth. Each treatment had four replications. The number of eggs laid was counted for five days at 24 h interval in a random sample of 100 grains, which were replaced after counting.

RESULTS

The host preference was studied on five different species of pulses, which were collected from the farmers. The different kinds of stored pulses were studied group wise for their physical characters such as single seed weight, thickness of seed coat, moisture and also for phenol contents. Interaction of physico-chemical characters on the degree of infestation by assessing the number of eggs laid/female, emergence of adult/female and developmental period on different pulses were studied during summer. The color and shape of the seeds have no effect on the egg deposition behaviour. But the texture had definite relation with the ovipotion of eggs. Only kidney bean and black gram are deeply colored with tan brown and black coat color respectively. Small pea and cow pea was creamy white and green gram was light green colored.

Regarding the texture green gram, small pea and kidney bean are smooth glossy. Black gram and cowpea were with rough texture. The rough texture have affect on oviposition of *C. chinensis* to some extent.

Ovipositional preference by no choice test

Ovipositional preferences of *C. chinensis* was studied during two different seasons through no choice test to identify the effect on various physico-chemical parameters of seed legumes on the egg laying behaviour of the insect pest. The study was undertaken on five different species of pulses during both summer and winter seasons. The values regarding their rate of infestation differ greatly. During summer the insect laid eggs in different quantities in different pulses. The mean number of eggs laid by a female *C. chinensis* on green gram were the highest (97.3) followed by cow pea (86.0), black gram (76.3), small pea (51.6) and kidney bean (49.6). The pattern of egg laying preference for the pulses was somewhat similar during the winter season also. *C. chinensis* preferred green gram the most. Less preferred host is the kidney bean as less eggs were deposited on the pulse followed by small pea(46.3), cow pea (49.0), black gram (65.0) and then green gram (76.3) (Table 1).

Table 1 . Ovipositional preference of C. chinensis by No Choice Test

Pulses	Mean no. of eggs /♀	
	Summer	Winter
Green gram	97.3	76.3
	(9.72)	(8.62)
Cow pea	86.0	49.0
	(9.31)	(6.89)
Black gram	76.3	65.0
	(8.62)	(8.23)
Kidney bean	49.6	38.3
	(6.94)	(6.31)
Small pea	51.6	46.3
	(7.23)	(6.78)
SEm (±)	0.09	0.11
CD (p = 0.05)	0.26	0.31
CV	9.68	8.97

Data in parentheses indicate √x transformed values

Table 2. Adult emergence of C. chinensis by No Choice Test

	Mean per cent adult emerged / female	
	Summer	Winter
Green gram	63.2	46.3
	(52.1)	(42.8)
Cow pea	53.2	44.3
	(46.8)	(41.7)
Black gram	6.1	0.97
	(14.2)	(5.6)
Kidney bean	0.02	0.001
	(0.61)	(0.1)
Small pea	0.18	0.24
	(2.4)	(2.8)
SEm (±)	0.59	0.34
CD (p = 0.05)	1.56	1.01
CV	7.36	9.65

Figure in parentheses indicate angular transformed values

Adult emergence in No Choice Test

Percentage of adult emergence in no-choice test of *C. chinensis* proved best in summer from green gram (63.2) followed by cow pea (53.2), Black gram (6.1), small pea (0.18) and kidney bean (0.02). The percentage of emergence was too low in kidney bean. During the winter same pattern of emergence was recorded with some numerical variations. The highest emergence was recorded from green gram (46.3) followed by cow pea(44.3), black gram (0.97), small pea (0.24) and then kidney bean (0.001). Interestingly, there was very few adult emergence in case of kidney bean during winter (Table 2). Perusal of Table 3 depicted that the oviposition of *C. chinensis* on five different pulse grains under no-choice test. The results on the overall preference of the beetle for oviposition considering all the five days together revealed that the highest number of eggs (50.5) was laid in kidney bean and cow pea (48.4). Among the hosts *C. chinensis* laid significantly low number of eggs (32.6) on green gram.

Table 3. Influence of different pulses on the oviposition of C. chinensis (No Choice Test)

	Mean per cent adult emerged / female	
	Summer	Winter
Green gram	63.2	46.3
	(52.1)	(42.8)
Cow pea	53.2	44.3
	(46.8)	(41.7)
Black gram	6.1	0.97
	(14.2)	(5.6)
Kidney bean	0.02	0.001
	(0.61)	(0.1)
Small pea	0.18	0.24
	(2.4)	(2.8)
SEm (±)	0.59	0.34
CD (p = 0.05)	1.56	1.01
CV	7.36	9.65

Data in parentheses indicate √x transformed values

Table 4. Ovipositional preference of C. chinensis on different pulses by Free Choice Test

Pulses	No. of eggs laid/ female					Mean
	1	2	3	4	5	
Green gram	24.5	31.6	32.5	37.0	37.4	32.6
	(4.78)	(5.59)	(5.63)	(6.06)	(6.08)	
Cow pea	34.5	43.0	48.4	58.6	57.5	48.4
	(5.61)	(6.49)	(6.91)	(7.42)	(7.55)	
Black gram	34.4	41.5	44.0	51.5	52.5	44.8
	(5.82)	(6.32)	(6.57)	(7.11)	(7.22)	
Kidney bean	35.6	44.0	51.5	59.0	62.5	50.5
	(5.91)	(6.59)	(7.16)	(7.67)	(7.87)	
Small pea	26.0	32.5	33.6	38.5	39.4	34.0
	(5.07)	(5.71)	(5.75)	(6.27)	(6.23)	
SEm (±)	0.79	0.03	0.14	0.05	0.05	
CD (p = 0.05)	0.25	0.12	0.56	0.21	0.19	
CV	11.36	10.21	8.36	8.61	7.14	

Data in parentheses indicate √x transformed values

Table 5. Mean adult emergence (%) of C. chinensis on different pulses by Free Choice Test

	Mean per cent adult emerged / female	
	Summer	Winter
Green gram	64.5	59.1
	(53.4)	(50.2)
Cow pea	60.3	48.3
	(50.8)	(44.1)
Black gram	46.3	42.6
	(42.8)	(40.7)
Kidney bean	0.03	0.001
	(0.99)	(0.18)
Small pea	1.01	0.002
	(5.70)	(0.31)
SEm (±)	1.02	1.98
CD (p = 0.05)	2.82	5.87
CV	9.25	11.25

Figure in parentheses indicate angular transformed value

Table 6. Influence of different pulses on the oviposition of C. chinensis (Free- Choice Test)

Pulses	No. of eggs laid/ female					Mean
	1	2	3	4	5	
Green gram	38.4 (6.27)	56.0 (7.26)	73.5 (8.48)	74.0 (8.31)	75.4 (8.58)	63.5
Cow pea	38.5 (6.35)	72.6 (8.52)	78.8 (9.01)	79.6 (8.92)	80.0 (9.92)	69.4
Black gram	40.4 (6.86)	63.5 (7.96)	72.4 (7.46)	78.6 (8.79)	80.4 (8.96)	67.3
Kidney bean	39.2 (6.72)	73.4 (8.61)	80.0 (10.21)	81.2 (9.03)	81.6 (9.03)	71.1
Small pea	39.6 (6.59)	56.7 (7.49)	74.6 (8.81)	76.5 (8.64)	76.8 (8.72)	64.8
SEm (±)	0.016	0.058	0.082	0.081	0.69	
CD (p = 0.05)	0.06	0.19	0.28	0.18	0.22	
CV	9.36	9.11	10.23	11.11	10.36	

Data in parentheses indicate √x transformed value

Table 7. Different developmental parameters of C. chinensis on various pulses

Pulses	Incubation Period (days)	*Hatching (%)	Larval and pupal period (days)	Total life span (days)	*Adult emergence (%)	**Fecundity (No. eggs laid/ ♀)
Green gram	3.0	96.00 (78.46)	23	25	64.5 (53.42)	82.25 (9.06)
Cow pea	3.0	97.12 (80.22)	21	24	60.3 (50.94)	119.25 (10.92)
Black gram	3.0	86.65 (68.56)	22	26	46.3 (42.87)	112 (10.58)
Kidney bean	4.5	24.01 (29.34)	31	33	0.03 (0.97)	105.25 (10.26)
Small pea	3.5	56.21 (48.56)	25	28	1.01 (5.76)	98.75 (9.93)
SEm (±)		0.85			0.93	0.081
CD (p = 0.05)		2.03			2.36	0.26
CV		8.36			10.21	7.58

**Figure in parentheses indicate √x transformed values
*Figure in parentheses indicate angular transformed values

Ovipositional preference in Free Choice Test

The test was carried out during summer with 0-1 day old 5 pairs of male and female adult beetles. The average number of eggs laid by each female was considered. There were differences in ovipositional preference of *C. chinensis* to different species of stored grains. *C. chinensis* laid highest number of 26.7 eggs on kidney bean followed by cow pea (20.1), small pea (16.5), black gram (15.3) and minimum eggs were laid on green gram. Black gram and small pea showed a similar pattern of ovipositional preference with negligible differences.

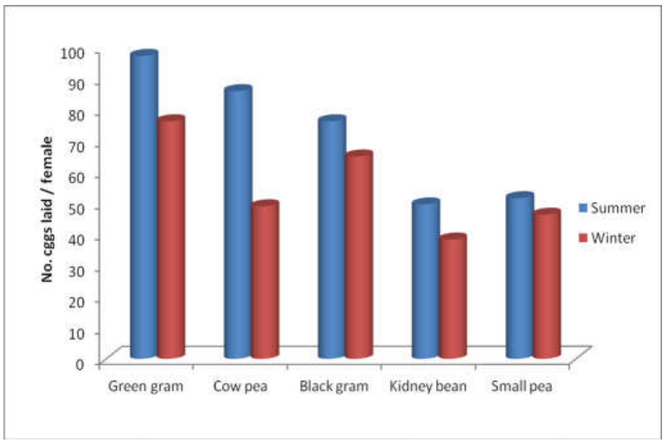

Fig. 1. Ovipositional preference of C. chinensis during summer and winter (No Choice Test)

These here less preferred grain is seemed to be the green gram and most preferred was the kidney bean during summer (Table 4). During winter, *C. chinensis* preferred to lay maximum number of eggs on kidney bean (18.3) followed by cowpea (12.6), small pea (11.3), black gram(10.6) and less number of eggs were found to lay on the green gram (9.3). Thus the overall result is quite smaller to the results of summer with some difference in number. Much less number of eggs were laid during the winter time.

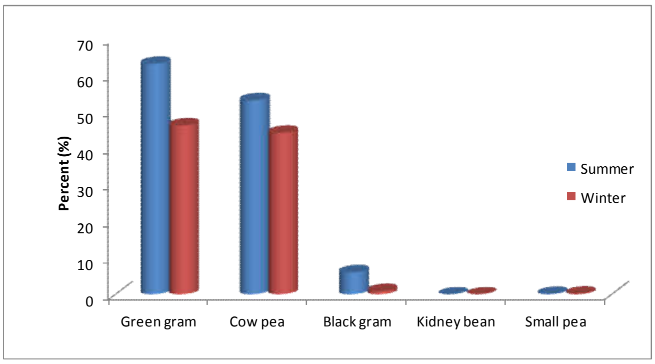

Fig. 2. Percent adult emerge per female C. chinensis during summer and winter (No Choice Test)

Emergence of adult in free choice test

The highest per cent of adults emerged from green gram (64.5%) during summer season followed by cow pea (60.3%), black gram (46.3%), small pea (1.01%) and least from the kidney bean (0.03%). During winter maximum percent of adult were emerged from green gram (59.1%) followed by cow pea (48.3%), black gram (42.6%). Interestingly, there was very low adult emergence in case of the insect species from kidney bean (0.001%) and small pea (0.002%) (Table 5). Perusal of Table 6 deals with the host preference of *C. chinensis* on pulse under free choice test.

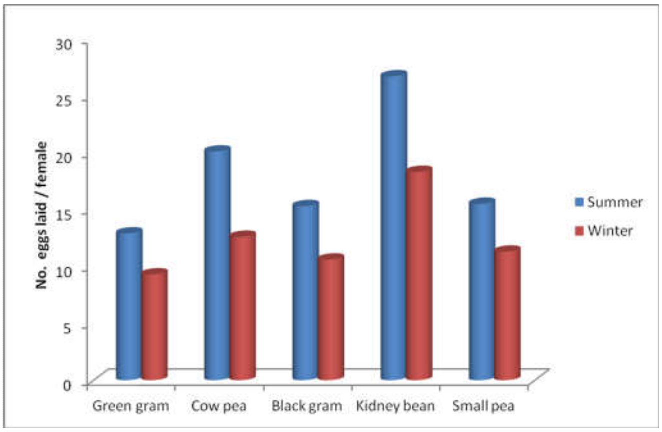

Fig. 3. Mean number of eggs laid per female of C. chinensis on different pulses during summer and winter (Free Choice Test)

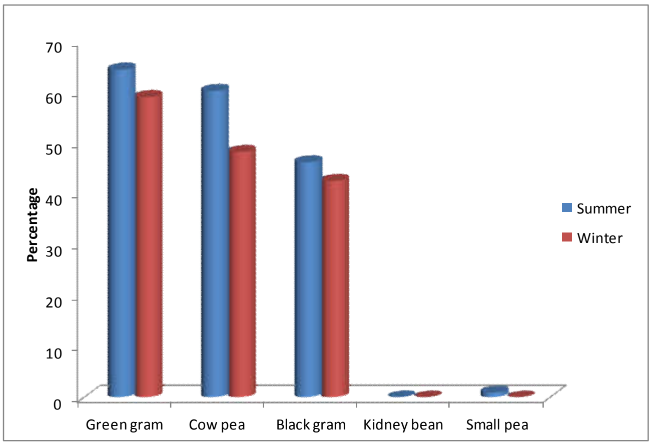

Fig. 4. Mean adult emergence of C. chinensis on different pulses during summer and winter (Free Choice Test)

The daily observations made on the number of eggs laid from the first to fifth day after infestation revealed that the insect laid more number of eggs in kidney bean seeds when compared to other pulses. The number of eggs laid on cow pea is quite close to the number of eggs laid on kidney bean. The least number of eggs were recorded in green gram seeds. There was significant differences in the number of eggs laid by *C. chinensis* on different pulses. The biological parameters of *C. chinensis* fed on different pulses was presented in Table 7. The adults of *C. chinensis* were found to mate between 50-60 minutes after their emergence. The mating lasted for 4-8 minutes. The oviposition commenced roughly 8-10 hours after mating. The eggs were first laid were transparent and the incubation period varied with various pulses. The mean incubation period on various pulses was found to range between 3-5 days. On green gram, cowpea and black gram, eggs hatched in 3 days while it took 3.5 days in small pea and 4.5 days in kidney bean. All the eggs laid were not found to hatch and there was significant difference in the percentage of hatching of eggs on different pulses tested. The hatching percentage was the highest (97.12%) in cow pea, followed by green gram (96.00%), black gram (86.65%), small pea (56.21%) and kidney bean (24.01%) of hatching which was significantly low among all the pulses treated. The larva feeds on the contents of the grains and moults 4 times inside the seed. The larva before pupation cuts a circular window on the testa on the seed incubating the beginning of the pupal period. The combined larval and pupal period significantly varied among the various pulses tested. In cow pea 21days, black gram 22 days, green gram 23 days, small pea 25 days and kidney bean 33 days, being the highest. There was no apparent difference in the time taken for the development of either sex.

The total number of days taken for the completion of life cycle (from the day of oviposition till adult emergence) varied significantly with different pulses. The minimum number of days taken by the insects that development from cow pea was 24 days followed by green gram 23 days, black gram, small pea and kidney bean within 26 days, 28 days and 33 days respectively. The longest duration to complete the lifecycle was recorded to be in kidney bean. The adults emerged out by drilling the window of the seed coat. There was significant difference in the percentage of adults emerged between different hosts. The highest percentage of adults (64.5%) emerged from green gram followed by cow pea (60.3%). In black gram and small pea 46.3% and 1.01% adults emerged respectively from the seeds. The lowest percentage of adult emergence was recorded in kidney bean (0.03%). The fecundity tested in relation to different hosts exhibited significant variation. The number of eggs laid by a single female insect varied depending upon each host seeds. The highest number of eggs was recorded on cow pea (119.25), followed by black gram (112), kidney bean (105.25), small pea (98.75). The lowest number of eggs was recorded in green gram (82.25) (Table 7).

DISCUSSION

In no choice test, it had been observed that during summer *C. chinensis* lays the highest number of eggs on green gram and lowest on kidney bean. The beetle lay maximum number of eggs during summer (Table 1 and Fig 1.). The insect failed to complete their life cycle properly in kidney bean during winter as was evidenced from very little of adult emergence (Table 2 and Fig 2.). Observation on mean egg count laid by a single female depicted that green gram is the most preferred host while least preferred host is the kidney bean (Table 3). In free choice tests, it appeared that *C. chinensis* prefer to oviposit on seeds during summer and winter in the following order kidney bean > cow pea > small pea > black gram > green gram (Table 4 and Fig 3.). Result found from the free choice test revealed that cow pea and green gram are the most preferred host of *C. chinensis* as also found by Shivanna *et al*. (2011) in *C. maculatus and C. analis*. The less susceptible gram is the kidney bean as in that gram the developmental period is prolonged and maximum larval mortality was found thus the rate of adult emergence is lowest. As the surface of the seeds is greatest so the beetles can lay maximum number of eggs, penetration and initial development was also noticed thus the loss of grain weight is maximum, but the rate of developmental success is less in compared to the other grains. Percent adult emergence of the insect species differs significantly in respect of pulse species during summer and winter. Maximum emergence of adult beetles occurs during summer which is the suitable season than the winter. Emergence of *C. chinensis* has been the highest from green gram and the least from kidney bean. A mere or less result has also been observed during winter also (Table 5 and Fig 4.) *C. chinensis* unable to complete their growth and development in the kidney bean and small pea. Similar result was reported by Srivastava and Pant (2000). Thus, green gram is the most preferred host while least preferred host of *C. chinensis* was kidney bean.

Cowpea , kidney bean and green gram possess smooth skinned seed texture and bigger in size. This have encourages the beetles to prefer more for egg laying. The present finding are true with report of Girish *et al*., (1974) where the ovipositional and developmental period of few stored pulses seems to be guided by smoothness of seed coat and size of the grain. Bhaduria and Jakhmola (2006) reported that the ovipositional preference and survival of the pulse beetles on kidney bean, black gram and pigeon pea which were less preferred for oviposition. The kidney been proved to non-suitable host because in the subsequent generation the survival rate become reduced and the developmental period become enlarged. Cow pea was the most preferred host for oviposition and survival. Mehta and Chandel (1990) was reported that the *C. analis* were provided with a mixture of the seeds of various grain most of the beetle preferred cow pea, green gram, peas for egg laying. Percent weight loss and per cent adult survival was also significant. Similar result was revealed from the studies done by Rahdha and Susheela (2014) as they studied five different legumes in respect to ovipositional preference of *C. maculatus* and noticed that cowpea seeds are the most vulnerable legume seeds and the most suitable host. This host seeds had the maximum number of eggs laid, shortest developmental period, highest susceptibility index and maximum weight loss. Moreover, as the surface of seeds of kidney bean is smooth and seeds also provide maximum surface insects used to deposit maximum number of eggs per day as found both from the free choice and no choice tests. A combination of several factors such as texture, seed size, surface area and shape, weight and volume of the seed and the seed colour have been suggested to be responsible for the ovipositional preference of bruchids to different pulses (Nwanze, 1975; Mitchell, 1975; Satya Vir and Jindal, 1981; Manohar and Yadava, 1990). Due to the dark tan brown color of kidney bean seeds insect preferred to lay maximum amount of eggs because darker colored seeds were preferred most for oviposition over white seeds especially in free choice situation , the present findings showed that mean number of eggs laid per day was maximum in kidney bean (71.1) in free choice test (Table 6). The result was similar with the findings of Chavan *et al.* (1997).

Observation made by Singh *et al.* (1980) was somewhat similar to the present study. Mehata and Chandel (1990) studied the host preference of *C. analis* to ten different species of stored pulses. The highest number of eggs were laid on cowpeas, followed by peas, green gram and black gram and a few on kidney bean, soybean, split gram and horse gram. No eggs were laid on chick pea and lentil. It was found by Mitchell (1990) that females distribute eggs in a manner that reflects relative mass of seeds better than relative seed surface area. Instead, females must either use cues other than surface area when estimating seed mass, or must have the ability to extrapolate non-linearly from surface area to seed mass, allowing them to super parasitize seeds in an adaptive manner. Avidov *et al.* (1965) proposed that the females identify seed size according to surface curvature. Cope and Fox (2003) reported that variation in seed size is important during oviposition periods.

Conclusion

Thus, present findings shows that as the surface area of the seed is greatest in kidney bean followed by cowpea, small pea, black gram and green gram. Number of eggs laid also varied according to the surface area and as random distribution of eggs need large areas so seeds with large surface are favored. Such a result emerges just because larger beans have larger surface area and thus just by chance get more hits. Phenol, OD phenol and protein contents of seeds also has significant contributions in influencing the egg deposition behavior.

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