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Studies on efficacy of certain plant part powders against pulse beetle, *Callosobruchus chinensis* Linn. on chickpea, *Cicer arietinum* (L)

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Abstract
The present research was aimed to study the efficacy of certain plant part powders against pulse beetle, *Callosobruchus chinensis* linn. on chickpea, *Cicer arietinum* (L.) were conducted under laboratory conditions of 28 ± 1 ^{0}C temperature and 70 ± 5 per cent relative humidity in a B.O.D. incubator at Department of Agricultural Zoology & Entomology, College of Agriculture, Bikaner. Among the grain protectants four plant part powders viz., *neem* leaf, garlic bulb, garlic leaf and onion bulb @ 20, 40 and 60 g/kg grains were evaluated. *Neem* leaf powder at 60 g/kg grains was found to be most effective in inhibiting the oviposition (55.40%), reduction in eggs hatching (40.88%) and reduction in adult emergence (67.71%). Whereas next to it was garlic bulb resulting reduction in same parameters with 33.15, 30.29 and 55.72 per cent, respectively. The tested plant part powders did not affect the germination of treated chickpea grains.

Keywords: *Callosobruchus chinensis,* efficacy, plant part powders, chickpea

Introduction
Role of pulses in Indian Agriculture need hardly any emphasis, grain legumes, particularly pulses play an important role to cater the quantitative and qualitative protein requirement of a large parts of humanity. Chickpea, *Cicer arietinum* (L.) is one of the major pulse crops grown during the *rabi* season. Chickpea, besides a rich source of highly digestible dietary protein (17-20%), is also a rich source of calcium, iron, niacin, vitamin 'C' and vitamin 'B'. Its leaves consist of mallic acid which is very useful for stomach ailments and blood purification. Its feed and straw are highly rich in nutrients and are mostly used as productive ration for animals. Amongst pulses, chickpea is the most important crop and has significant contribution in the pulse economy of the country.

In 2014-15, the total area under chickpea cultivation is about 8.2 million hectares and the production is nearby 7.2 million tonnes with the productivity 875 kg/ha in India (Anonymous, 2015-16) [1, 2]. Among gram grown areas in India, Rajasthan is one of the major state which occupies 1256323 hectares with the production of 911085 tonnes with the productivity is 875 kg/ha in 2014-15 (Anonymous, 2014-15). The annual loss in pulses during post-harvest handling in India is nearly 8.5 per cent of which 5 per cent loss is due to insects.

In case of serious infestation cent-percent damage can be caused by several species of pulse beetle belonging to the genus *Callosobruchus* to the stored pulses including chickpea. Out of these, *C. chinensis* (Bruchidae: Coleoptera) is one of the most important pulse damaging species. Dias and Yadav (1988 a) [3] reported that damage is caused by the grubs which feed up on the entire content of the grain leaving only the shell behind. The attack of these beetles often starts in the field from where the infestation is carried over to the storage.

C. chinensis is of Asian origin, where it is still the dominant species, but now widely distributed throughout the warmer parts of the world (Hill, 1990) [6]. The control measures of bruchis infestation including extensive use of fumigants and other toxic chemicals have been suggested by several authors in past. (Munro, 1961; Pingale, 1964 and Lindgran *et al*., 1968) [9, 11, 8]. Alarmingly, these toxic chemicals have evidently posed serious problems like chronic and acute toxicity, residual toxicity, hazards, development of insect resistance, insecticide residue and environmental pollution. Besides this, an enactment of Insecticide Act, 1968 does not allow mixing of any insecticide with the food grains and, therefore, emphasis was being stressed for safer protective techniques.

In India, efforts have been made to minimize storage loss in pulses due to insects by using various locally available materials such as sand, ash, clay, talc etc. and other mineral powders. The problem of grain adulteration is the reason that most of these materials are not universally accepted (Singh *et al*; 1978, Doharey *et al*., 1985) [14, 4]. Among the other protection techniques the use of plant part powders & edible oils as grain protectant is an age old practice and gaining rapid popularity providing safer conditions to human health, easy to handle and with no deleterious effect on stored products.

Therefore, the present studies have been proposed to explore the possibility of using some plant products as grain protectants against *C. chinensis.*

Materials and Methods

Maintenance of the insect culture

The present studies on efficacy of certain plant part powders against *C. chinensis* linn. on chickpea were conducted under laboratory conditions in the Department of Agricultural Zoology & Entomology, College of Agriculture, Bikaner. A culture of the test insect *C. chinensis* was developed on conditioned chickpea grains by releasing a single gravid mated female. Subsequently, for maintaining further insect culture 50 pairs of one day old adult insects of 1st generation were released in the glass jars containing 200 g grains for oviposition for a period of three days. The jars were covered with muslin cloth which was kept in position with rubber bands. After 3 days the insects were removed from the jars. In order to obtain a continuous supply of the *C. chinensis* adults for experimentation dated culture was maintained at a regular time interval from the nucleus culture following above described procedure. The jars containing egged grains were subjected to 28 ± 1 ^{0}C temperature and 70 ± 5 per cent relative humidity in a B.O.D. incubator. Utmost care was taken not to touch the grains and test insects by hand. During experimentation forceps and camel hairs brushes were invariably used for transferring the grains and insects, respectively.

Preparation of the concentration of plant part powders

The fresh green leaves plucked from the *neem* tree were dried in shade and powdered with the help of grinder. These were used after passing through 60 mesh sieve. Similarly, garlic leaf powder was prepared. For garlic and onion bulb powders the bulbs were procured from market, cut in to pieces, dried thoroughly in shade and then powdered in ordinary grinder. These were also passed through 60 mesh sieve. For individual treatment 2.0, 4.0 and 6.0 g powder for 100 g grains were used and mixed thoroughly to prepare the desired concentrations of 20, 40 and 60 g/kg treatments. For the control no powder was mixed in the grains.

Table 1: Details of different plant part powders

S. No.	Common Name	Scientific Name	Source	Doses
1.	*Neem* leaf	*Azadirachta indica* A. Juss	*Neem* tree	20, 40 and 60g/kg grains
2.	Garlic bulb	*Allium sativum* L.	Local market	20, 40 and 60g/kg grains
3.	Garlic leaf	*Allium sativum* L.	Local market	20, 40 and 60g/kg grains
4.	Onion bulb	*Allium cepa* L.	Local market	20, 40 and 60g/kg grains

Effect of grain protectants

In each plastic container having 200 treated / untreated chickpea grains five freshly emerged unmated pairs of *C. chinensis* adults were released. The containers were covered with muslin cloth held in position with the help of rubber bands. These containers were kept in B.O.D. at a temperature of 28 ± 1 ^{0}C and 70 ± 5 per cent relative humidity. The adults released were removed after 10 days.

To evaluate the effect of the test materials three parameters were undertaken: (i) Oviposition inhibition (ii) Effect on hatching and (iii) Adult emergence. The observations were taken for egg count in each treatment 10 days after the release of test insect. For the oviposition, total egg count was considered. For fetching effect the shrunken egg shells were counted as hatched and white dry eggs were taken as dead & unviable. To determine the effect of tested materials on the adult emergence, total number of adults emerged in each treatment were counted 35 days after the oviposition.

Effect of grain protectants on germination of chickpea grains

To examine the effect of test materials on viability of the treated grains, the germination of untreated and treated grains was observed. For this, 100 grains from each treatment in three replications were taken at random from treated and untreated unused grain lots and were placed in petri dishes (15 cm diameter) lined with moistened blotting paper. These petri dishes were kept at room temperature (28-32 ^{0}C) for six days which allowed the grains sufficient time to germinate. The number of sprouted and unsprouted grains was counted and germination percentage was determined.

Calculations

The oviposition inhibition percentage was calculated by using following formula:

$$O.I. = 100\left(1-\frac{ET}{EC}\right)$$

Where,
OI = Oviposition inhibition
ET = Mean number of eggs in treatment/female
EC = Mean number of eggs in control/female

Similarly, per cent hatching inhibition was calculated.

Observations on adult emergence were converted to per cent adult emergence in each treatment using the number of eggs laid and the number of adults emerged out of them. The per cent adult emergence inhibition was also computed using similar formula as above.

The percentage of grain weight loss caused by *C. chinensis* was calculated with the help of following formula:

$$\text{Per cent weight loss} = \frac{(U.Nd)-(D.Nu)}{U(Nd+Nu)} \times 100$$

Where,
U = Weight of undamaged grains
Nu = Number of undamaged grains
D = Weight of damaged grains
Nd = Number of damaged grains

The germination percentage of grains was calculated by using the formula given below:

$$G.P. = \left(\frac{TG - UG}{TG}\right) \times 100$$

Where,
G.P. = Germination percentage
T.G. = Number of total grains
U.G. = Number of ingeminated grains

The data obtained with regards to oviposition inhibition, adult emergence, weight loss and germination were subjected to analysis of variance after their angular transformation. S.Em. values & critical difference at 5 per cent level of significance were also worked out.

Result and Discussion

Laboratory experiments were conducted using the most susceptible variety *i.e.* Bikaner Local to test the efficacy of plant part powder on the basis of following criteria:

(i) Effect on oviposition

The data presented in Table1 revealed that all the plant part powders were significantly effective over control in reducing the oviposition except in the treatment of onion bulb powder at the lowest dose tested. Data revealed that higher doses of all the treatments gave more oviposition inhibition as compared to lower doses. *Neem* leaf, garlic bulb, garlic leaf and onion bulb powders at the highest dose of 60 g/kg grains gave an oviposition inhibition of 55.40, 33.15, 15.62 and 17.50 per cent respectively as compared to control. In the next dose of 40 g/kg an inhibition of oviposition recorded was 39.50, 25.02, 12.80 and 13.88 per cent in case of *neem* leaf, garlic bulb, garlic leaf and onion bulb powders, respectively. Similarly, in the lowest dose of 20 g/kg in above treatments, the oviposition inhibition ovserved was 31.81, 16.41 9.70 and 8.16 per cent, respectively. The mean per cent oviposition inhibition was highest (42.11) in *neem* leaf followed by garlic bulb (24.51), garlic leaf (12.61) and onion bulb powder (12.91) as compared to control where it was only considered as nil. Similarly, among the doses the mean per cent oviposition inhibition was highest (29.39) in the dose of 60 g/kg followed by 21.97 (40 g/kg dose) and 15.59 (20 g/kg dose). The maximum oviposition inhibition (55.40 per cent) was noticed with highest dose 60 g/kg grain in case of *neem* leaf powder and the minimum of 15.12 per cent with same dose of garlic leaf powder. These findings are in conformity with those of Singh and Sharma (2001) [13] who reported reduction in egg laying of *C. chinensis* with *neem* leaf powder.

(ii) Effect on egg hatching

All the plant part powders were effective significantly over control in reducing the egg hatching. The higher doses of all the treatments gave more egg hatch inhibition as compared to the lower doses. *Neem* leaf, garlic bulb, garlic leaf and onion bulb powders at the highest dose of 60 g/kg grains gave an egg hatch inhibition of 40.88, 30.29, 14.06 and 13.89 per cent respectively as compared to control. The lower dose of 40 g/kg gave 32.00, 23.15, 11.06 and 10.27 per cent egg hatch inhibition in the treatments of *neem* leaf, garlic bulb, garlic leaf and onion bulb powders, respectively. Likewise, in the lowest dose of 20 g/kg of *neem* leaf, garlic bulb, garlic leaf and onion bulb powders the egg hatching inhibition was recorded as 22.25, 15.56, 8.35 and 8.52 per cent respectively. The mean data of Table showed that among the treatments, the mean egg hatch inhibition was highest in *neem* leaf powder reaching to 31.46 per cent followed by garlic bulb (22.71%), garlic leaf (11.06%), onion bulb (10.79%) considering no inhibition in control. Also, among the doses the mean egg hatch inhibition was highest (23.89%) in the dose of 60 g/kg followed by 18.31% in 40 g/kg and 13.19% in 20 g/kg. The present observations are in agreement with those of Sundria *et al.* (2002) [15] who found plant part powders effective at different doses in reducing the egg hatching of *C. chinensis*.

(iii) Effect on adult emergence

Data given in the Table2 further revealed that higher doses of all the treatments brought about higher adult emergence inhibition as compared to lower doses. *Neem* leaf, garlic bulb, garlic leaf and onion bulb powders at the highest dose of 60 g/kg grains resulted in adult emergence inhibition as 69.71, 55.72, 40.15 and 40.50 per cent respectively as compared to control. In 40 g/kg treatment inhibition was recorded as 57.06, 49.70, 32.21 and 31.27 per cent in case of *neem* leaf, garlic bulb, garlic leaf and onion bulb powders, respectively. Likewise, in the lowest dose of 20 g/kg of *neem* leaf, garlic bulb, garlic leaf and onion bulb powders the per cent adult emergence inhibition obtained was 49.90, 45.88, 25.70 and 24.44 respectively.

The mean data showed that among the treatments, the mean adult emergence inhibition was highest in *neem* leaf powder reaching to 59.04 per cent followed by garlic bulb (50.43%), garlic leaf (32.55%) & onion bulb (31.90%). Also, among the doses the mean adult emergence inhibition was highest (51.64%) in the dose of 60 g/kg followed by 42.39% in 40 g/kg and 36.07% in 20 g/kg as compared to untreated. The maximum reduction in adult emergence was observed in the treatments of *neem* leaf powder followed by garlic bulb, garlic leaf and onion bulb. The reduction in adult emergence increased with the increase in doses of each treatment. Similar results were also observed by Sundria *et al*. (2002) [15] who reported appreciable reduction in adult emergence of pulse beetle by *neem* leaf powder. The present findings are also comparable with those of Rahman and Motoyama (2000) [12].

Effect of grain protectants on the germination of chickpea grains

All the treatments including control the germination of chickpea grains was above 90%. All the treatments showed no significant effect on the germination of chickpea when compared with each other as well as with control. In the germination process in treatments as well as in control no abnormality was observed. Such findings conclude that these grain protectants are quite safe for the grains stored for seed purposes. Findings agreed with those of, Gupta *et al.* (1991) [5], Khaire *et al.* (1992) [7] who used different plant part powders. Trematerra *et al.* (1999) [16] used *Allium* plants as grain protectant and observed no adverse effect of these products on the viability of the treated grains.

Table 2: Effect of plant part powders on anti-ovipositional activity, egg hatching, adult emergence of *C. chinensis* with on germination of chickpea grains

Plant part powders	Percent oviposition inhibition*				Percent egg hatching inhibition*				Percent adult emergence inhibition*				Percent germination*			
	Dose (g/kg grains)				Dose (g/kg grains)				Dose (g/kg grains)				Dose (g/kg grains)			
	20	**40**	**60**	**Mean**	**20**	**40**	**60**	**Mean**	**20**	**40**	**60**	**Mean**	**20**	**40**	**60**	**Mean**
Neem leaf	31.81	39.50	55.40	42.11	22.25	32.00	40.88	31.46	49.90	57.06	69.71	59.04	92.01	91.32	91.67	91.68
	(34.34)	(28.94)	(48.10)	(40.46)**	(28.15)	(34.45)	(39.74)	(34.11)	(44.94)	(49.06)	(56.61)	(50.20)	(73.59)	(72.88)	(73.22)	(73.23)
Garlic bulb	16.41	25.02	33.15	24.51	15.56	23.15	30.29	22.71	45.88	49.70	55.72	50.43	92.01	91.68	91.01	91.58
	(23.91)	(30.03)	(35.15)	(29.69)	(23.23)	(28.76)	(33.39)	(28.46)	(42.63)	(44.83)	(48.29)	(45.25)	(73.59)	(73.23)	(72.55)	(73.12)
Garlic leaf	9.70	12.80	15.62	12.61	8.35	11.06	14.06	11.06	25.70	32.21	40.15	32.55	91.32	92.01	91.69	91.68
	(18.15)	(20.97)	(23.28)	(20.80)	(16.80)	(19.44)	(22.02)	(19.44)	(30.46)	(34.59)	(39.32)	(34.79)	(72.68)	(73.59)	(73.25)	(73.24)
Onion bulb	8.16	13.88	17.50	12.91	8.52	10.27	13.89	10.79	24.44	31.27	40.50	31.90	92.01	92.34	91.69	92.01
	(16.61)	(21.87)	(24.74)	(21.07)	(16.97)	(18.69)	(21.88)	(19.18)	(29.64)	(34.00)	(39.52)	(34.39)	(73.59)	(73.93)	(73.25)	(74.59)
Mean	15.59	21.97	29.39	0.00	13.19	18.31	23.89	0.00	36.07	42.39	51.64	0.00	91.86	91.85	91.52	0.00
	(23.25)	(27.95)	(32.82)	(0.00)	(21.29)	(25.34)	(29.26)	(0.00)	(36.91)	(40.62)	(45.94)	(0.00)	(73.41)	(73.40)	(73.07)	(0.00)
	S.Em±		CD at 5%	C.V.(%)	S.Em±	CD at 5%		C.V.(%)	S.Em±	CD at 5%		C.V.(%)	S.Em±	CD at 5%		C.V.(%)
Treatments (T)	0.55		1.13	4.15	0.47		0.97	3.95	0.29		0.59	1.48	0.44		NS	1.26
Doses (D)	0.47		0.98		0.41		0.84		0.25		0.51		0.38		NS	
T×D	0.95		1.96		0.82		1.68		0.50		1.02		0.76		NS	

*Average of 3 replications

** ( ) = Percentage transformed to angles; outside values are back transformation to percentages.

Conclusion

Efficacy of plant part powders against *C. chinensis* at the doses of 2, 4 and 6 g/100g chickpea grains were undertaken using the parameters of oviposition, egg hatching, adult emergence and germination of treated grains. The *neem* leaf powder was highly effective as compared to other treatments. The maximum oviposition inhibition (55.40%) was observed in *neem* leaf powder at the dose of 6 g/100 g grains, followed by garlic bulb powder (33.15%), onion bulb powder (17.50%) and garlic leaf powder (15.62%). The maximum egg hatching inhibition (44.88%) and reduction in adult emergence (69.71%) was observed in *neem* leaf powder at the dose level. The lowest dose of 2 g/100 g grains also could bring down. No adverse effect of the tested plant part powders was observed on the germination of chickpea grains.

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