ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 07, pp.33841-33846, July, 2016

INTERNATIONAL JOURNAL
OF CURRENT RESEARCH

RESEARCH ARTICLE

EFFECT OF AMBIENT ENVIRONMENTAL CONDITIONS ON THE LEVEL OF INFESTATION BY PULSE BEETLE ON DIFFERENT LEGUMES

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ARTICLE INFO

Article History:
Received 21st April, 2016
Received in revised form
09th May, 2016
Accepted 05th June, 2016
Published online 16th July, 2016

Key words:

Pulse beetle,
Cowpea,
Callosobruchus,
Biology,
Temperature,
Relative humidity.

ABSTRACT

Pulses (grain legumes) are the second most important group of crops worldwide. Globally, 840 million people are under nourished mainly on account of inadequate intake of proteins, vitamins and minerals in their diets. Under stored conditions , pulses suffer maximum grain loss due to dreaded stored grain bruchid pests. Studies on the biology of pulse beetle *Callosobruchus chinensis* (Linn) (Coleoptera: Bruchidae) on the stored pulses revealed multi climatic factors particularly temperature can extend or reduce the life cycle of insects and thermal thresh hold influence the insects cycle stage, growth or some internal metabolic activities. In addition to temperature insects also respond to a-biotic factors like humidity, light and food etc. in different ways. The damage caused by the insect differ depending upon the seasons. Infestation was higher during the rainy season and lowest during the winter. The average number of eggs laid per female was found to be maximum when insect were reared at 30˚C and minimum number of eggs was observed at 15˚C in all host pulses. The highest number of eggs were noted laid on kidney bean (175.35) at 30˚C. The most favorable humidity level for adult emergence was found 75±5 per cent, at which maximum adult emergence of 121.32 occurred from cow pea. The combined effect of relative humidity and temperature showed that maximum grain weight loss at 30˚C and 85±5 per cent relative humidity while minimum weight loss at 15˚C and 65±5 per cent relative humidity. Thus, fundamental to insect growth, however, are environmental factors of temperature, relative humidity and moisture content of food materials. When a combination of favorable factors leads to increased insect development there is a co-related increase in the damage to materials through eating, despoiling, burrowing and other activities.

Citation: Chakraborty, S. and Mondal, P. 2016. "Effect of ambient environmental conditions on the level of infestation by pulse beetle on different legumes", *International Journal of Current Research*, 8, (07), 33841-33846.

INTRODUCTION

Anthropogenic and natural environmental variations are voraciously affecting the arthropods with the passage of time. Certain factors like thermal affect is changing the status of pest by suppressing or stimulating genetic potential, rate of fecundity and mortality and range of hosts. These climatic and weather factors not only affect the status of insect pests but also affect their population dynamics, distribution, abundance, intensity and feeding behavior. In multi climatic factors particularly temperature can extend or reduce the life cycle of insects (Régnière *et al.*, 2012). High thermal thresh hold influence the insects cycle stage, growth or some internal metabolic activities. In addition to temperature insects also respond to a-biotic factors like humidity, light and food etc. in different ways. These a-biotic factors not only affect the behavior of insects but also disturb the physiological mechanism (Karl, 2011). When variation in a-biotic environment likes temperature, humidity, light and diet give a stress to host in return the host produce immune responses.

The most common insects which attack the stored products are belong to the order Coleoptera and Lepidoptera (Bekele *et al.*, 1997). These are the largest orders which contain most prominent stored pests. Pulse beetle, *Callosobruchus chinensis* is a serious damage, pest of the world; it attacks mainly on the pulses, cereals and different types of grains. The damage due to this pest affects the germinative ability and nutritive value of the seed (Sharma, 1984). Mukherjee *et al.* (1970) observed that pulse beetle caused 32-64% infestation in leguminous seeds than cucurbitaceous and solanaceous vegetable seeds as well as oil seeds (3%). Pulse beetle infestation to the tune of 50-60% was found in stored pulse grains after 6 months of traditional storage (Caswell, 1973). Maximum damage is caused in the

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months of July to October. The ecological factors like temperature, relative humidity, rainfall, photoperiod etc play an important role in population fluctuation of the insect to a greater extent. The infestation of this pest varies with place to place and also depends upon the environmental factors. The attack is severe in those areas where the numbers of cloudy days are more during the pest activity period (Patel *et al*., 2004).

Effect of temperature on the development of *C. chinensis* was studied by Singh (2004) and revealed that normal development occurs at 30°C and 70% RH. Temperature below 30°C was not suitable for the growth and development of the pest. Temperature above 35°C seemed to be sublethal for the development of the pest. Similarly RH level of 60% or less prevented normal development. *C. maculatus* was reared by Adhikary and Barik (2012) on four varieties of khesari seeds at four constant temperatures and a relative humidity of 70±5%. They found that the insect cannot complete development at 20˚C. Insects had a faster developmental time at 30˚C and longest at 25˚C. Further they noticed that longevity of males and females was found to be shorter at 35˚C and longest at 20˚C.Fecundity was maximum at 30˚C over an incubation period of 6.27-7.08 days; whereas this was minimum at 20˚C, but failed to hatch. Survival and growth responses of the species were the highest at 30°C and least at 35°C as reported by Chandrakanta *et al.* (1986). Patro *et al*. (2005) have conducted an laboratory experiment to study to study the effect of different levels of *C. chinensis* infestation on seed deterioration of pigeonpea (var. UPAS 120) and green gram (var. K. 851) under ambient conditions (27±4°C temperature and 84±10% r.h.) The results indicated that in both pigeon pea and green gram the level of bruchid infestation was directly proportional to the germination percent. From the experiment done by Mandi and Ghosh (2008) revealed that changes in the range of temperature and humidity have profound influence on the duration of incubation period and larval-pupal durations. As temperature increased from 20˚C to 30˚C followed by the RH from 30% to 80% the incubation period and larval-pupal durations get decreased up to 2-4 days in average. Raina (1970) worked out on the biology of *Callosobruchus* sp. in the laboratory of the seeds of mung at 30°c and 70% r.h. He observed that 94-99% eggs were hatched and the developmental period was 18.8 days in case of *C. chinensis.* Kim and Choi (1987) reported from Korea that in laboratory the bruchid, *C. chinensis* had 4 generations in a year, and the larvae over wintered within beans. The optimum temperature range for oviposition was found to be 25-30˚C. Azukibean (*Vigna angularis*) was preferred for oviposition, followed by mungbean, (*V. radiata*), soybean, kideny bean (*Phaseolus vulgaris*), black soybean and pea. At the optimum temperature 25˚C, the development of *C. chinensis* averaged 29, 31 and 49 days, respectively, on the first three food plants, and 46 and 34 days on the last two. Hatching and adult emergence rates were highest on *V. angularis* and *V. radiata*, and lowest on black soybean and *P. vulgaris* (no adult emergence). Lifespan at different temperatures was 4-5 days at 35˚C, 5-7 days at 25˚-30˚C, 10-15 days at 20˚C and 9-24 days at 15˚C. Azukibeans damaged by *C. chinensis* did not germinate at all, and the germination rate for damaged black soybean and peas was 5 and 7 per cent, respectively.

Pulse beetle causes not only quantitative but also qualitative losses like nutritive loss, germination loss and make the pulse grain unfit for marketing as well as for human consumption. The present studies were carried out to study the biology of the pest insect in cow pea. Therefore, an attempt has been done to review the role of different abiotic factors especially temperature and humidity on population fluctuation and also their influence on infestation on pulses as follows:

MATERIALS AND METHODS

Studies on the effect of ambient environmental conditions on the levels of pest infestation of *C. chinensis* were done on five different pulses viz. black gram, small pea, kidney bean, cowpea and green gram. Fifty healthy seeds of each type of legumes were first weighted and kept in plastic container. Afterwhich, five pairs of freshly emerged adult male and female insects were released in each container. The containers were covered individually with perforated plastic cap and maintained under four different types of temperature and r.h. regimes (room temperature & r.h.; 30°C and 85± 5% r.h.; 25°C and 75± 5% r.h.; 15°C and 65± 5% r.h.). After five days, the insects were replaced from the containers. Total number of eggs laid in each container was counted without damaging the eggs. The grains were carefully kept in the respective container again and covered with perforated plastic lid. The adult emergence was observed daily and the number of adult emerged were recorded till the caesure of the adult emergence. When no more adults were emerged, the grains were poured down from the containers and weight of the 100 grains was noted. The healthy and damaged grains were separated and weights were taken separately.

RESULTS AND DISCUSSION

Perusal of Table 1 and 2 revealed the assessment of the per cent seed damage and quantitative weight loss caused by *C. chinensis*. The damage caused by the insect differ depending upon the seasons. Infestation was higher during the rainy season and lowest during the winter. Average damage was recorded highest on cow pea (34.95%) followed by green gram (32.73%), black gram(30.76%), small pea(1.45%) and of kidney bean (0.55%). Very few adult emergence were recorded from small pea and kidney bean during the winter (Table 1). Similarly, weight loss (%) caused by *C. chinensis* on different pulses were observed maximum during rainy season while minimum during winter. Maximum weight loss was recorded in green gram(23.55%) followed by cow pea (11.47%), black gram(8.53%), small pea(3.67%) and the minimum was from kidney bean(1.62%) (Table 2). Thus, both temperature and humidity have profound effect on various biological parameters of many insect .Hence four different sets of temperature and humidity regime were fixed to rear the insect on five different pulses.

Effect of temperature and humidity on the Oviposition

The average number of eggs laid per female was found to be maximum when insect were reared at 30˚C and minimum number of eggs was observed at 15˚C in all host pulses.

Table 1. Damage caused by the *C. chinensis* in different pulses in different season

Pulses	Damage (%)			Mean damage (%)
	Winter	Summer	Rainy	
Black gram	23.25 (28.82)	31.33 (34.03)	37.69 (37.87)	30.76
Small pea	0.02 (0.81)	1.06 (5.90)	3.29 (10.45)	1.45
Green gram	24.56 (29.70)	33.87 (35.58)	39.75 (38.08)	32.73
Cow pea	27.36 (31.53)	36.25 (37.02)	41.25 (39.96)	34.95
Kidney bean	0.001 (0.18)	0.43 (3.76)	1.23 (6.36)	0.55
S.Em (±)	0.28	0.41	0.42	
CD (p = 0.05)	0.68	1.06	1.39	
CV	8.69	9.36	9.45	

Data in parentheses indicate angular transformed value

Table 2. Loss of weight caused in different pulses due to *C. chinensis* infestation in different season

Pulses	Wt. loss (%)			Mean (%) wt. loss
	Winter	Summer	Rainy	
Small pea	01.25 (6.41)	03.45 (10.70)	06.32 (14.56)	03.67
Green gram	05.81 (13.95)	07.77 (16.19)	09.97 (19.40)	23.55
Cow pea	10.04 (18.37)	11.70 (20.01)	12.67 (22.85)	11.47
Kidney bean	0.010 (0.54)	0.52 (4.13)	04.35 (12.04)	1.62
Black gram	07.81 (16.21)	08.23 (18.67)	09.56 (18.01)	8.53
S.Em (±)	1.28	0.71	0.39	
CD (p = 0.05)	4.12	2.31	1.09	
CV	9.22	9.57	10.57	

Data in parentheses indicate angular transformed value

Table 3. Effect of ambient environmental conditions on the egg laying, adult emergence and weight loss of different pulses

Commodity	Properties	15˚C & 65±5%	25˚C & 75±5%	30˚C & 85±5%	*27±5 ˚C & 79±5%
Black gram	Egg laid/ female (no.)	29.68	36.58	41.36	44.33
	Adult emergence(%)	20.25	32.65	36.36	39.33
	Seed wt. loss(g)	0.32	0.55	0.81	0.96
Small pea	Egg laid/ female (no.)	65.36	86.65	105.02	101.00
	Adult emergence(%)	46.32	65.81	86.23	79.67
	Seed wt. loss(g)	0.43	0.93	1.41	1.33
Kidney bean	Egg laid/ female (no.)	51.23	82.36	175.35	165.00
	Adult emergence(%)	6.32	7.36	13.23	12.66
	Seed wt. loss(g)	0.26	2.31	0.39	1.03
Cow pea	Egg laid/ female (no.)	46.23	56.48	148.36	75
	Adult emergence(%)	61.56	31.25	121.32	49.67
	Seed wt. loss(g)	1.96	2.4	4.1	3.5
Green gram	Egg laid/ female (no.)	39.23	53.25	79.32	82.66
	Adult emergence(%)	25.32	46.15	70.48	74.33
	Seed wt. loss(g)	0.21	0.78	1.05	1.16

* indicates room temperature and r.h.

The highest number of eggs were noted laid on kidney bean (175.35) at 30˚C. The data obtained on the effect of relative humidity clearly indicated that the most favorable relative humidity found for maximum egg laying was 85±5 per cent on which 175.35 eggs laid by a single female on kidney bean followed by148.36, 105.02, 79.32 and 41.36 on cow pea ,small pea, green gram and black gram respectively. The interaction of temperature and relative humidity revealed that most suitable combination for egg laying was 30˚C and 85±5 per cent relative humidity on which maximum number of eggs were laid by female on more or less all host pulses. The minimum fecundity was recorded at 15˚C and 65 ± 5 per cent relative humidity.

Effect of temperature and humidity on the adult emergence

The result in Table 3 clearly indicated that maximum adult emergence (72.91%) was recorded when insect was developed

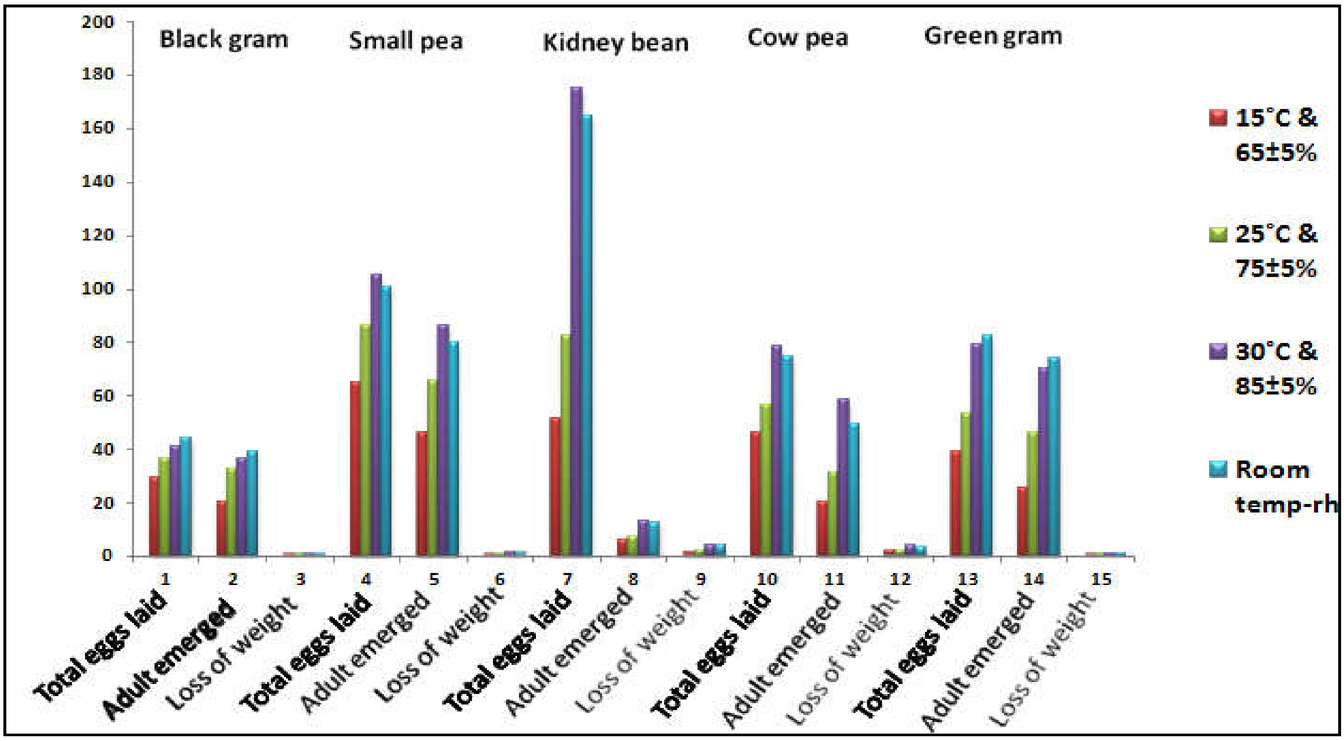

Fig. 1. Effect of ambient environmental conditions on the egg laying, adult emergence and seed weight loss in different pulses

at 30˚C followed by 25˚C , 15˚C. The most favorable humidity level for adult emergence was found 75±5 per cent, at which maximum adult emergence of 121.32 occurred from cow pea followed by small pea(86.23), green gram (70.48), black gram(36.36) and kidney bean(13.23). The results shows the highest number of adult emergence in respect to each host pulse. The combined effect of temperature and humidity indicated that the combination of 30˚C and 85± 5 per cent relative humidity was found best in respect to adult emergence, whereas, the combination of 15˚C and 65±5 per cent relative humidity only shows to be not suitable for adult emergence. In that combination lowest number of adults were emerged from kidney bean (6.32) followed by black gram (20.25), green gram (25.32), small pea (46.32) and cow pea (61.56). The results shows the lowest number of adult emergence in respect to each host pulse.

Effect of temperature and humidity on loss of seed weight

The data recorded in Table 3 clearly indicated that the maximum weight loss was recorded at 30˚C while minimum weight loss at 15˚C. The results obtained on the effect of relative humidity clearly indicated that the maximum weight loss was recorded at 85±5 per cent relative humidity. The minimum weight loss was observed under 65±5 per cent relative humidity. The combined effect of relative humidity and temperature showed that maximum grain weight loss at 30˚C and 85±5 per cent relative humidity while minimum weight loss at 15˚C and 65±5 per cent relative humidity. Thus, successful insect development is dependent on a number of factors. The availability, quality and quantity of suitable food is a primary one, but other factors such as light, access to undisturbed areas, proximity to other insects of the same species, are others. Fundamental to insect growth, however, are environmental factors of temperature, relative humidity and moisture content of food materials. When a combination of favorable factors leads to increased insect development there is a co-related increase in the damage to materials through eating, despoiling, burrowing and other activities (Brundrett, 1990). For most insect pests, temperatures above 15˚C up to 35˚C cause increasing energy levels that lead to greater mobility, higher feeding rate, higher reproduction rates, great egg production and lower mortality. Insects have high moisture contents and owing to their size, have very high surface area to volume ration, so they can readily lose moisture through evaporation. Investigation on percent damage in different seasons caused by *C. chinensis* and loss of weight caused in different pulses due to infestation revealed that infestation was higher during the rainy season and lowest during the winter. Average damage was recorded highest on cow pea (34.95%) followed by green gram (32.73%), black gram(30.76%), small pea(1.45%) and of kidney bean (0.55%). No emergence of adults were recorded from small pea and kidney bean during the winter (Table 1). Similarly, weight loss (%) caused by *C. chinensis* on different pulses were observed maximum during rainy season while minimum during winter. Maximum weight loss was recorded in green gram (23.55%) followed by cow pea (11.47%), black gram(8.53%), small pea(3.67%) and the minimum was from kidney bean(1.62%) (Table 2). The result was corroborate with the works of Kazemi *et al.* (2009).

Perusal of Table 3 reveal the fact that temperature have profound effect on the fecundity, duration of larval development and adult emergence. 30˚C is the optimum temperature for egg laying, development and adult emergence in case of *C. chinensis*. The result was corroborated with the results of Adhikary and Barik (2012) who concluded that temperature had significant effect on total larval duration, developmental time from egg hatching to adult emergence, longevity of males and females, and fecundity of *C. maculatus* when reared on four varieties of khesari seeds. Results of their studies quite similar to the present day studies that the insect is sensitive to low temperature (20˚C) and optimal developmental temperature was 30˚C. The results of the present studies are somewhat supported by Bashir *et al*. (2014) who concluded that the life span of the adults was temperature dependent and were in range of 5-10 days at 31.37˚C and 10-27 days at 24˚C (Fig. 1).

All insects have a waxy layer on the external cuticle which waterproofs it from loss of body moisture. However, they still lose water through respiration and defecation (Busvine, 1980). Some insects can absorb moisture directly from the air. But most insects rely on the relationship between high relative humidity and moisture contents in associated materials. Most insect pests therefore prefer areas of high humidity. Thus, in addition to the physico-chemical factors the variations of biological parameters during two seasons are also responsible for the fluctuation of environmental conditions, especially the temperature and relative humidity (El Sawaf, 1956; Howe and Currie, 1964).

Mating takes place soon after emergence from grain, the time depending entirely upon temperature and humidity. The results under the present studies indicated that maximum ovipositional potential of the beetles was observed at 30˚C in all host pulses. The maximum number of eggs laid per female was observed at combinations of 30˚C and 75±5 per cent relative humidity and 30˚C and 85±5 per cent relative humidity . No work on the effect of temperature and humidity on the ovipositional potential of the pulse beetles is available, however Khare and Agrawal (1963) observed favorable temperature for oviposition was 30˚C and 75 per cent relative humidity for growth and development of *S. oryzae* and *R. dominica,* support the present findings. Similarly, Singh (2004) concluded that 30˚C and 70 percent r.h. was the optimum for proper growth and development of *C. chinensis*. Temperature above 35˚C seemed to be sub-lethal and r.h. level of 60 percent or less prevent development (Fig. 3). Moisture content of the grain plays an important role in deterioration of the stored product. Through the present day study, it was found that storage structures play an important role in the retention or change in the moisture content of stored produce.

Conclusion

The results of the study show that the developmental period of the egg to adult was around a month or more than that. During optimum period of growth the total developmental period is less than a month thus causing huge damage to seeds and the optimum conditions depending on the food supply, temperature and humidity duration of developmental period may increase or decrease. Data pertaining from the experiments shows that the damage caused by the insect differ depending upon the seasons and infestation was higher during the rainy season and lowest during the winter. Thus, economic loss caused due to insect infestation also fluctuates depending upon the abiotic factors of different seasons. So, farmers must take care of their stored pulses giving emphasis on the seasonal environmental conditions. The current research paves the way to provide awareness to the farmers about the nature and extent of damage caused by the beetle in storage in various seasonal conditions.

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