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Effect of temperature on progeny emergence, weight loss and grain damage caused by *Sitophilus oryzae* L. feeding on sorghum and split pulses

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Abstract
An experiment was carried out at the Entomology Laboratory, Horticultural College and Research Institute for Women, Trichy to estimate the comparative storage losses in split pulses caused by *Sitophilus oryzae* L. under room and controlled conditions. A completely randomized design (CRD) was used with seven treatments (T_1 = Sorghum, T_2 = Red Gram, T_3= Chick Pea, T_4 = Black Gram, T_5 = Green Gram, T_6 = Fried Gram and T_7 = Lentil) each replicated four times. The assessed parameters were per cent weight loss, number of F_1 progeny and per cent grain damage. Among the split pulses red gram dhal was found to be the most suitable host of pulse feeding population with 77.25 and 54.25 F_1 progeny production, 97.25 and 95.25 per cent grain damage and 34.12 and 52.74 per cent weight loss under room and controlled condition followed by green gram, chick pea, black gram, fried gram and lentil. The assessed parameters were higher in sorghum feeding population on sorghum grains than at pulse feeding population on pulse grains.

Keywords: *Sitophilus oryzae*, Split pulses, F_1 progeny, per cent weight loss, per cent grain

Introduction

The rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), is one of the most destructive pest of stored cereals worldwide. It is classed as a primary pest, cosmopolitan in nature and is known to infest sound cereal seeds (Hill, 1990) and causes severe loss in rice, maize, barley and wheat (Bhatia *et al*. 1975; Singh *et al*, 1980; Neupane, 1995) [4, 21, 17]. Though the storage grain loss is caused by insect pests, pathogens and rodents it is generally believed that half of the storage loss is usually caused by insects. Considering the loss caused by storage insect pests, effective methods of control are of paramount importance. Control often depends on a sound knowledge of the ecology and on the effects of a multitude of environmental factors on the life history of a pest.

Reports about its occurrence on legumes are scanty. Pemberton *et al*. (1981) [18] studied its breeding behaviour on carob, *Ceratonia siliqua* (L.), a tree legume native to the Mediterranean region. Coombs *et al.* (1977) [6] reported the successful development by Trinidad strain of *S. oryzae* on yellow split pea. In India, the pest was recorded for the first time to feed on red gram at Coimbatore. In the present investigation, the suitability of other split pulses was studied for its development in comparison to the population that occurs on sorghum in terms of F1 progeny, per cent weight loss and per cent grain damage.

Materials and Methods

The two population of rice weevil, *S. oryzae*, was mass cultured on their respective hosts namely sorghum and red gram dhal under laboratory. The development of *S.oryzae* population reared on split pulses was studied in comparison to that of sorghum. The experiment was laid out in a completely randomized design (CRD) with seven treatments *viz.*, T_1 = sorghum, T_2 = split red gram dhal, T_3 = split chick pea dhal, T_4 = split black gram dhal, T_5 = split green gram dhal, T_6= split fried gram dhal and T_7= split lentil dhal and each replicated four times. The experiment was conducted under room (temperature 30.5 to 35.25 for 60 days period, RH range 77-84%) and controlled conditions (35 ºC, 80% RH).

In a small plastic container with punctured lid, 100 grains from each material sample were placed. Each container was infested with 10 pairs of one week old adult rice weevils. Weevil sex was determined by rostra length and rostra pit discrimination (Reddy, 1951) [20] and by abdominal tip shape (Qureshi, 1963) [19]. Separate set of containers each with 100 grains and 10 pairs of adult were maintained for observations on per cent grain damage, per cent weight loss and number of F1 progeny produced.

For F_1 progeny study, released adults were separated from test materials via a #10 sieve and discarded after a week period and then the samples were replaced in their respective containers. Each container was carefully observed on daily basis, beginning on the 30th day of removal. Emerging progenies in each container were separated from the sample grain daily via #10 sieve, counted and then discarded. This process continued until there was no progeny emergence in all containers.

For both per cent weight loss and grain damage assessment the containers were maintained 60 days. Damaged and undamaged grains from the 100 grain samples in each container were separated manually using a magnifying glass at 15, 30, 45, and 60 days after release for both room and controlled conditions. Per cent grain damage was computed using the formula: Grain damage (%) = (number of damaged grains / total number of grains) × 100.

The per cent weight loss was calculated using initial and final grain weight measurements (60 day period). Weight Loss was worked out by using the formula (Adams and Schulton, 1978) [1].

$$\text{Per cent Weight Loss} = \frac{(UND) - (DNU)}{U\,(ND+NU)} \times 100$$

Where,

U-Weight of uninfested grains (g)

NU-Number of uninfested grains (g)

D-Weight of infested grains (g)

ND-Number of infested grains (g)

Susceptibility indices were used as measure of the susceptibility of test food grains to infestation by *S. oryzae*. The higher the index, the greater the susceptibility of the food grains (Gudrups *et al*. 2001) [9]. These indices are defined by the following formula:

$$\text{Dobie Index: D.I.} = \frac{Ln F \times 100}{DME}$$

Where D.I. is the susceptibility index,

Ln is the natural logarithm,

F is the total number of F1 adults, and DME the date of median emergence of F1 (days).

Percentage data were processed by arcsine and square root transformation wherever required. These processed values were subjected to an Analysis of Variance (ANOVA) test at 1% and 5% significance levels. The mean separation for treatments was done using Duncan's Multiple Range Test (DMRT).

Results and Discussion

The data obtained on F_1 progeny, per cent grain damage and per cent weight loss were analysed and used as parameters to determine the suitability of various split pulses for the *S. oryzae* population collected from red gram dhal. Similar observations were also made on the population of *S. oryzae* developing on sorghum. The population of *S. oryzae* collected from red gram was found to develop on other split pulses namely green gram, chick pea, black gram, lentil and fried gram. However among the spilt pulses the number of F_1 progeny emergence was significantly higher in red gram at both room and controlled conditions. Under room (30.5 to 35.25 º C and 77 to 84% RH) and controlled temperature (35 ºC, 80% RH) the number of F_1 progeny emergence was significantly higher in redgram. The number of progenies emerged was 77.25 adults in redgram followed by green gram (72.75 adults) and least in fried gram (35.75 adults) under room temperature condition. Similarly under controlled condition (35 ºC and 80% RH) also the progeny emergence was significantly higher in redgram (54.25 adults) and was on par with green gram (50.75 adults) followed by chick pea (45.75 adults), respectively (Table 1). In case of sorghum, the number of F1 progeny produced was 95.25 adults and 66.75 adults at room and controlled temperature condition and it was significantly superior to all the treatments.

After 60 days of release, the per cent weight loss caused by *S. oryzae* under room temperature was 34.12 in redgram, 29.66 in green gram, 21.15 in chick pea, 13.43 in lentil and 12.90 in black gram. The lowest per cent weight loss (10.02) was recorded in fried gram. Under controlled condition feeding by *S. oryzae* has resulted in 52.74, 34.76, 25.14, 18.07, 17.15, 11.28 per cent weight loss in redgram, green gram, chick pea, lentil, black gram and fried gram respectively (Table 1). The corresponding weight loss in sorghum was 42.71.94 and 48.25 per cent weight loss under room and controlled condition, respectively. In case of sorghum, the number of F1 progeny produced was 72.75 and 57.5 at room and controlled temperature condition and it was significantly superior to all the treatments.

The per cent grain damage under room temperature condition was 60.75 in redgram, followed by green gram (60.25), chick pea (43.75), lentil (41.25), black gram (35.25) and fried gram (27.50) on 30 days after release. Under controlled condition, the per cent grain damage at 30 days after release was significantly higher in redgram (52.75) followed by green gram (48.75), respectively. At 45 days after release per cent grain damage was 86.75 and 76.00 in redgram and 81.25 and 71.75 in green gram followed by other hosts under room and controlled condition (Table 2). The per cent grain damage at 60 days after release was 97.25 and 95.25 in redgram followed by green gram (96.25 and 93.75) and these pulses were on par with each other under room and controlled temperature condition. However, they significantly differed from other treatments during the entire study period. Per cent grain damage recorded in sorghum by the respective population during the period of study was significantly higher than that of pulses, ranging from 60.25 to 98.75 and 51.25 to 98.25 under room and controlled condition respectively (Table 2).The calculated Dobie index was increased in the order of fried gram (11.92 and 11.78), black gram (12.73 and 11.87), lentil (12.82 and 12.21), chick pea (13.20 and 12.74), green gram (14.29 and 13.09), redgram (14.49 and 13.31) and sorghum (16.27 and 15.0) under room and controlled temperature respectively (Figure 1).

The results showed that number of F_1 progeny and per cent grain damage were higher in red gram and green gram under room condition (30.50-35.25 ºC, 77-84% RH) compared to controlled condition. However the per cent weight loss was higher in red gram and green gram under controlled condition (35 ºC-80% RH) compared to room temperature. Deepthi and Manjunatha (2015) [7] reported that split legumes seed size influenced the progeny production of *S. oryzae*. However, the size of legumes can not be compared with sorghum, with respect to progeny production. This is because sorghum is the traditional host of *S. oryzae*, hence higher production is expected.

Subedi *et al*. (2009) [22] reported similar findings that the F1 progeny (138.8 adults) and per cent grain damage (18.75) were higher under room temperature (25±3 ºC) in case of polished rice compared to controlled condition. However under controlled condition (35 ºC, 80% RH) the per cent weight loss (14.11) was higher in polished rice compared to room temperature.

The present findings indicated that there was a highly significant positive correlation between F1 progeny, per cent weight loss and per cent grain damage in both room and controlled temperature. Similar findings were reported in earlier works like *S. oryzae* damage in maize (Ahmad *et al*. 1986 [2] and Navarro *et al*. 1978) [16], *Trogoderma granarium* in wheat (Khattak *et al*. 2000) [13], *Tribolium castaneum*, *Tribolium granarium* and *Rhizopertha dominica* in wheat (Khan and Kulachi, 2002) [12].

Table 1: The F_1 progeny and weight loss in sorghum and split pulses due to *Sitophilus oryzae* L. infestation under room and controlled temperature

S. No	Treatments	F_1 Progeny (Mean)*		Per cent Weight Loss** 60 Days After Release	
		Room Temperature®	Controlled Temperature©	Room Temperature®	Controlled Temperature©
1.	Sorghum	95.25 (9.76)^{a}	66.75 (8.17)^{a}	42.71 (40.81)^{a}	48.25 (44.00)^{b}
2.	Red gram	77.25 (8.79)^{b}	54.25 (7.36)^{b}	34.12 (35.74)^{b}	52.74 (46.57)^{a}
3.	Chick Pea	52.50 (7.25)^{d}	45.75 (6.76)^{d}	21.15 (27.37)^{d}	25.14 (30.09)^{d}
4.	Black gram	45.50 (6.74)^{e}	39.00 (6.24)^{e}	12.90 (21.04)^{e}	17.15 (24.45)^{e}
5.	Green gram	72.75 (8.53)^{c}	50.75 (7.12)^{c}	29.66 (33.00)^{c}	34.76 (36.12)^{c}
6.	Fried gram	35.75 (5.98)^{f}	29.00 (5.38)^{f}	10.02 (18.45)^{f}	11.28 (19.61)^{f}
7.	Lentil	46.75 (6.84)^{e}	42.25 (6.50)^{d}	13.43 (21.48)^{e}	18.07 (25.15)^{e}
	SEd	0.0824	0.0874	0.5711	0.5861
	CD Value (0.05)	0.1713	0.1818	1.1877	1.2189

* Mean of four replications. Figures in parantheses are square root transformed values. Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

** Figures in parantheses are arc sin transformed values. Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

® Room Temperature ranges 30.5 to 35.25 ºC, RH ranges from 77-84%

© Controlled Temperature ranges from 35 ºC, 80% RH

Table 2: The grain damage of sorghum and split pulses due to *S. oryzae* infestation under room and controlled temperature

S. No	Treatments	Per cent Grain Damage Room Temperature ®				Per cent Grain Damage Controlled Temperature©			
		15 th day	30 th day	45 th day	60 th day	15 th day	30 th day	45 th day	60 th day
1.	Sorghum	60.25 (50.92)^{a}	72.25 (58.22)^{a}	94.25 (76.16)^{a}	98.75 (83.67)^{a}	51.25 (45.72)^{a}	65.75 (53.88)^{a}	85.25 (67.42)^{a}	98.25 (82.61)^{a}
2.	Red gram	48.25 (44.00)^{b}	60.75 (51.21)^{c}	86.75 (68.69)^{b}	97.25 (80.56)^{b}	41.50 (39.52)^{b}	52.75 (46.58)^{b}	76.00 (60.68)^{b}	95.25 (77.46)^{b}
3.	Chick Pea	37.50 (37.76)^{d}	43.75 (41.41)^{d}	76.75 (61.21)^{d}	94.25 (76.24)^{c}	32.75 (34.91)^{d}	37.50 (37.76)^{d}	66.00 (54.34)^{d}	91.25 (73.10)^{c}
4.	Black gram	29.25 (32.74)^{f}	35.25 (36.41)^{f}	42.50 (40.68)^{f}	62.75 (52.39)^{e}	25.25 (30.16)^{f}	27.25 (31.46)^{e}	36.75 (37.31)^{f}	53.50 (47.01)^{f}
5.	Green gram	42.25 (40.54)^{c}	60.25 (50.92)^{b}	81.25 (64.35)^{c}	96.25 (78.97)^{b}	39.00 (38.65)^{c}	48.75 (44.28)^{c}	71.75 (57.90)^{c}	93.75 (75.73)^{bc}
6.	Fried gram	24.25 (29.50)^{g}	27.50 (31.59)^{g}	33.75 (35.52)^{g}	64.25 (53.29)^{e}	21.50 (27.62)^{g}	24.75 (29.83)^{f}	33.75 (35.52)^{g}	63.25 (52.71)^{e}
7.	Lentil	33.25 (35.21)^{e}	41.25 (39.96)^{e}	62.25 (52.11)^{e}	83.25 (65.25)^{d}	27.75 (31.78)^{e}	37.25 (37.61)^{d}	55.75 (48.30)^{e}	80.50 (63.82)^{d}
	SEd	0.5334	1.0020	1.0512	1.1292	0.3966	0.5357	0.7202	1.6658
	CD Value (0.05)	1.1094	2.0838	2.1861	2.3483	0.8248	1.1140	1.4977	3.4643

* Mean of four replications

* Figures in parantheses are arc sin transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

® Room Temperature ranges from 30.5 to 35.25 ºC, RH ranges from 77-84%

© Controlled Temperature ranges from 35 ºC, 80% RH

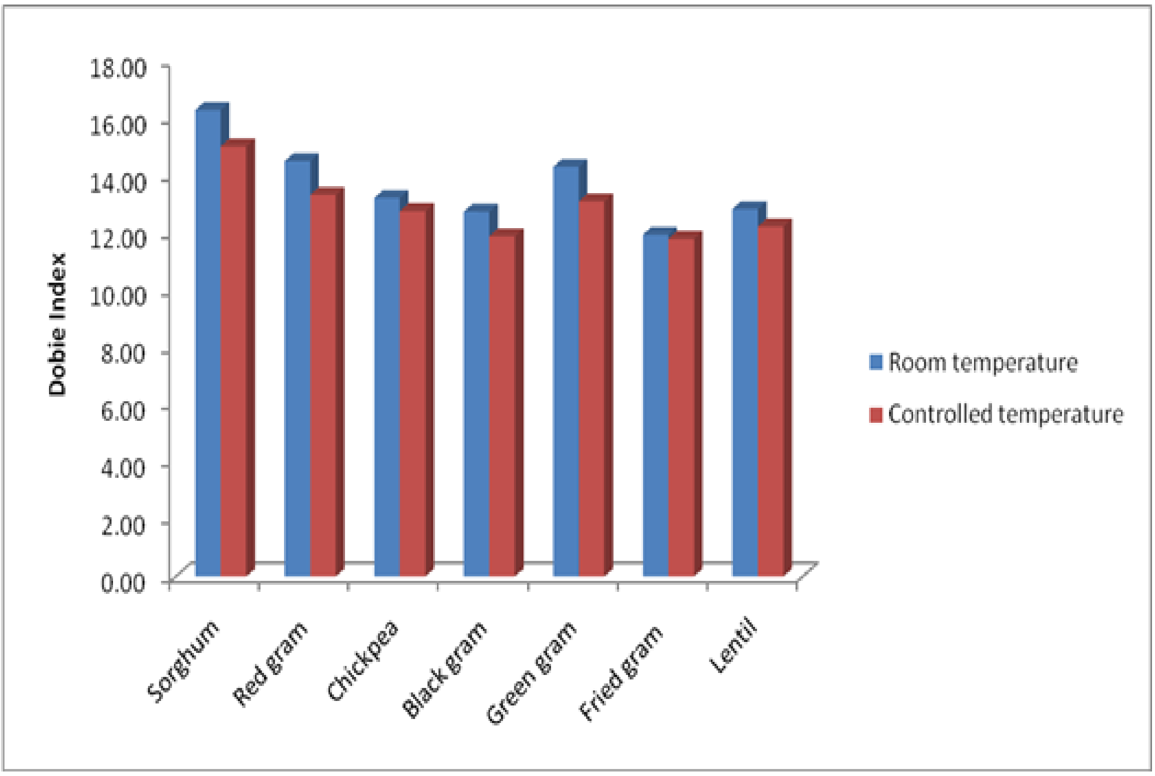

Fig 1: Dobie index (D.I.) of susceptibility of six different food grains to *S. oryzae*. The higher the index, the greater the susceptibility level. (Room temperature ranges from 30.5 to 35.25 ºC, RH ranges from 77 to 84 %. Controlled temperature ranges from 35 ºC, 80% RH)

Compton *et al*. (1998) [5] reported that *S. zeamais* caused maximum per cent grain damage (85-93%) at 60 days after release in case of maize under room temperature condition. This was attributed to the susceptibility of the hosts and climatic conditions (28 °C and 65% RH).

The weight loss caused by storage insects depends on many factors such as insect species, environmental conditions, period of storage and the product itself. In the present study, the weight loss caused by *S. oryzae* feeding on pulses ranged between 4.10-28.14% under room temperature and 8.61-37.15% under controlled condition, as compared to 32.94 and 34.76% in sorghum. Koura and El-Halfawy (1972) reported about 79-81% weight loss in barley, 56-74% weight loss in rice and 36-40% weight loss in wheat due to *S. oryzae* and *S. granarius* infestation under natural conditions at 25°C and 70% RH. The loss recorded in grain sample weight due to the feeding of *S. oryzae* varied from 4 to 52% in different sorghum varieties during storage up to 9 weeks at 30°C and 72% RH (McMillian *et al*. 1981) [15].

The variation in host preference is caused by physical characteristics as well as nutritional components and can be attributed as one reason for differential preference. Split pulses have a high nutritional value and are rich in proteins *viz*., red gram (44%), green gram (48%), chick pea (38%), black gram (50%), lentil (52%) and fried gram (30%). Apart from protein the amino acid content and composition also can influence the development of *S. oryzae* (Baker, 1976).

During the experiment, *S. oryzae* population obtained from split red gram pulses completed their development on all the split pulses tested namely red gram, green gram, chick pea, black gram, fried gram and lentil. However, red gram and green gram were found to be the most preferred host on the basis of progeny production, percent grain damage and weight loss. Coombs *et al*. (1977) [6] also reported the development of *S. oryzae* on grain legumes peas, lentils, green and black gram. However, progeny production, percent grain damage and weight loss by this population on split pulses was significantly lower than that of sorghum feeding population on sorghum. Its mainly due to the host preference of two different populations. *S. oryzae* is the important pest of cereals. Recently it was found to the split pulses. The pulse breeding population did not survive the cereals these mainly attributed to the food volatiles of cereals and pulses.

Conclusion
Based on the results observed on F_1 progeny, per cent weight loss and per cent grain damage it is concluded the red gram and green gram dhal were the most preferred among the six split pulses tested against *S. oryzae* strain population collected from red gram dhal.

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