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Host preference studies of rice weevil, *Sitophilus oryzae* L. on various cereals

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Abstract
A laboratory experiment to study the host preference of rice weevil, *Sitophilus oryzae* L. was carried out at the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2020-21. The biology of rice weevil, *S. oryzae* was studied on different hosts *viz*., sorghum, wheat, maize, paddy, barley and oat under laboratory conditions and revealed that the maximum preference for oviposition period (54.00 days), fecundity (276.75 eggs/female), egg hatching (76.67%), the total number of adult emergence (85.00 males & 99.50 females), adult survival (67.96% and 69.26% male & female, respectively), total life cycle (92.25 & 121.25 days for male & female respectively), and shorter incubation period (4.25 days) were recorded on maize hosts; while, minimum preference for oviposition period (37.00 days), fecundity (138.50 eggs/female), egg hatching per cent (61.26%), the total number of adult emergence (32.50 male & 38.50 female, respectively), survival per cent of adult (40.69 & 47.76% for male & female, respectively), total life cycle (74.50 days & 94.75 days for male & female) and longer incubation period (5.75 days) were recorded on oat hosts. The order of host suitability or preference of different cereals were recorded as maize > paddy >sorghum>barley > wheat>oat.

Keywords: Storage pest, rice weevil, biology and total life cycle

Introduction
Maize (*Zea mays* L.) is one of most versatile emerging crop having wider adoptability under varied agro climatic conditions. Among the maize growing countries, India has 4th rank in area and 7th rank in production, representing around 4 per cent of world maize area and 2 per cent of total production (Anonymous 2021) [1]. The total area under maize cultivation in India was 79.14 lakh hectares with an annual production of 27.80 million tonnes and 1297 kg per hectare productivity during (Annual Report, 2018-19). Maize crop area and production may increase if seed is not constraint. The hybrids and varieties are reported to be highly susceptible to insect pest attacks both in the field and storage (Gimma *et al*., 2008) [16]. Hence, farmers are not as such beneficiaries of this increased production and productivity potential of new varieties and hybrids. More than 37 species of arthropod pests are associated with maize grain in storage (Abraham, 1991) [1]. Most of the maize grain harvested is stored on the farm, where post-harvest pest management practices are inadequate (Dubale, 2011) [15] leading to huge amounts of maize seed losses due to pests of stored grain. Among the several insects attacking maize grain during storage *viz*., rice weevil, *Sitophilus* spp (Linnaeus); lesser grain borer, *Rhizopertha domonica* (Fabricius); red flour beetle, *Tribolium castaneum* (Herbest); rice moth, *Corcyra cepholonica* (Stainton) and angoumois grain moth, *Sitotroga cereallela* (Oliver) which gained a economic importance. Among these pest scenario the rice weevil, (*Sitophilus* spp.) is the most destructive insect pest of the stored raw cereal grains in the world (Champ and Dyte, 1976) [13] and causes substantial losses to stored corn, amounting to 18.30 per cent (Adams, 1976) while a high damage of 92.40 to 98.30 per cent was reported by Bitran *et al.*, (1978) [11] in different parts of the world.
S. oryzae is universally regarded as one of the most destructive primary pests of stored cereals such as barley, maize, rice, and wheat (Atwal and Dhaliwal, 2002) [5]. Annual grain loss in storage due to these insects approaches 15% (Joshi *et al.*, 1991) [20]. It is estimated that 20% of the total maize harvest is lost annually due to insect pest attack (Upadhyay *et al*., 2001) [26]. In one study, the maximum grain loss in wheat attributable to a single weevil was measured at 19%, and it was nearly 57% in rice (Banerjee and Nazimuddin, 1985) [6].
The infestation starts in the field where, female weevil makes a small hole on the seed, deposits an egg and covers it with a gelatinous fluid. The apodus grub feeds inside the grain,

pupates there itself and emerges through a hole made on the seed (David and Kumaraswami, 1975) [14] and damage is multiplied by several folds under storage. In Rajasthan, maize seeds are often traditionally stored in jute bags, earthen bin, and bukhari. This leads to significant increase of moisture during rainy seasons, thereby creating congeal conditions for weevil infestation (Hossain, *et al*., 2007 and Zunjare *et al*., 2014) [18, 28]. Infested seed fetches lower market price due to reduced weight and also the seed viability of the damaged grain is drastically reduced and affects subsequent planting (Tefera, 2012) [25].

Material and Methods

Maintenance of Insect Culture

To maintain the stock culture of rice weevil, the sound and healthy grains of maize were cleaned and sieved to remove the fractions of grains or insects. The grains were sterilized at 60±5°C for eight hours in order to eliminate both visible and hidden infestation of insects and mites, if any. The nucleus culture of rice weevil was obtained from Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur. The live adults of rice weevil were transferred in a 5 kg jar containing 4 kg of healthy and infestation free maize seeds for further mass multiplication. This culture was maintained throughout the experimental period under the laboratory conditions. For proper aeration and to raise the moisture content for the fast multiplication of rice weevil, the jar was covered with muslin cloth with the help of rubber bands. The adults so emerged from the culture were used for further experimentation.

Host preference of rice weevil

The experiment to study on the biology of rice weevil on wheat, paddy, maize, sorghum, barley and oat was conducted in completely randomized design with four replications for each host. The observations were made on different biological parameters of stored grain insect pests *viz*., fecundity, oviposition and post-oviposition period, the total number of adults emerged, longevity of adults, survival per cent of adults and total developmental period/ total life period.

To study the fecundity of adult female, two pairs of freshly emerged male and female adults (0-24 hrs. old) were isolated from stock culture and released in plastic jars, containing 100 grains of relevant host separately, and replicated four times. The mouth of the jars was covered with muslin cloth with the help of rubber bands to allow aeration and to prevent escape of the adult. The jars were kept at room temperature in laboratory for observation. Released weevils were allowed to mate and oviposition. After 24 hrs, the grains containing eggs and grains were examined under microscope and replaced with the fresh healthy grains.

The same transferring processes of male and female weevils were carried till the death of adult and the total number of eggs laid by the female on grains was counted. After the death of the weevil pre oviposition, oviposition period and post oviposition period were also recorded. After counting the number of eggs, the grains having eggs were transferred into another set of petridishes and observed daily, until the emergence of adults. After hatching, the duration of larvae and pupa were recorded together, as most of the period spent in the grains. The total number of adults emerged, longevity of adults, survival per cent of adults and total developmental period/ total life period was also recorded. The data thus obtained was statistically analyzed by adopting suitable transformation.

Results and Discussion

Six different cereal hosts were evaluated for host preference of *S. oryzae* on the basis of fecundity, pre oviposition, oviposition and post-oviposition period, the total number of adults emerged, longevity of adults, survival per cent of adults and total developmental period/ total life period. The results of experiment have been presented in Table (1) and Fig. (1) showed that the most preferred host by rice weevil was maize with the shorter duration of life cycle while, longer duration of life cycle on oat host.

Ovipositional period

Among the tested cereals, maximum pre-oviposition period was recorded in barley (5.25 days) which was at par with sorghum (5.00 days) whereas, minimum pre-oviposition period was recorded in maize (3.50 days) followed by paddy (4.00 days). However, maximum oviposition period was recorded in maize (54.00 days) which was at par with paddy (51.75 days) while, minimum oviposition period was recorded in oat (37.00 days) followed by barley (46.25 days). Similarly, maximum post oviposition period was recorded in maize (25.00 days) which was at par with paddy (23.50 days) likewise, minimum post oviposition period was recorded in oat (17.50 days) followed by wheat (22.25 days). The result of present study confirmed to some of the other observations made by earlier workers in this regards by Bhanderi (2012) [8], pre-oviposition, oviposition and post-oviposition periods varied from 3 to 7 (Av. 4.95 ± 0.89), 33 to 61 (Av. 52.21 ± 8.16) and 18 to 37 (Av. 29.81 ± 4.52) days, respectively. Yavoor (2003) observed that pre oviposition and oviposition period with mean of 7.50 and 25.0 days and also similar kinds of observations were made by Bheemanna (1986) [9] and Sattigi *et al.* (1987) [22]. Similar finding were reported by Stejskal and Kucerova (1996) [24] who found *Sitophilus spp.* prefer large seeds for oviposition; large seed were more likely to be parasitized or contain more than one egg than smaller seeds. Gvozdenac *et al*. (2020) [17] also reported that maize as the most preferential grain for oviposition preference for both female weevils (maize reared and wheat reared).

Fecundity

Among the cereals, significantly maximum egg laid by per female recorded in maize with 276.75 eggs followed by paddy and sorghum (234.50 & 229.50 eggs, respectively) whereas, significantly minimum egg laid by per female was recorded in oat with 138.50 eggs followed by barley and wheat with 182.50 and 195.25 eggs, respectively. Similarly, the total number of egg laid by single rice weevil female varies from 360.3 to 394 eggs (Akhter *et al.*, 2017). Barbhuiya *et al.* (2002) [7] observed the total number of eggs laid was 225 on wheat, 160 on sorghum, 115 on maize and 54 on rice, indicating that fecundity was high on preferred hosts. Bhanderi (2012) [8] reported the fecundity ranged from 122 to 265 with an average of 163.87 ± 27.37 eggs per female during its entire life cycle. The increase in the number of eggs per kernel appears to result from an increase in number of visits resulting in oviposition rather than an increase in the number of eggs laid during a visit (Campbell, 2002) [12].

Mean incubation period

The number of days between eggs laid to hatching (emerging young's) was recorded differ in all cereal hosts (sorghum, wheat, maize, paddy, barley & oat) with range of 4.25 to 5.75 days. The longer incubation period was recorded in oat with 5.75 days which was at par with wheat (5.25 days) and barley (5.00 days). However, the shorter incubation period was recorded in maize (4.25 days) which was also at par with 4.50 days recorded in paddy and sorghum. While the result of present study conformed some of the observations made by earlier workers in this regard, it was in contrast to some others. It is consonance with the observations of Bheemanna (1986) [9] recorded incubation period of 5 to 8 days on sorghum; Bhuiyah *et al.* (1990) [10] observed 5 to 6 days on maize; Barbuiya *et al.* (2002) reporetd 5 to 7 days on rice. Yevoor (2003) [27] was observed 5 days on maize grains whereas, the incubation period varied from 3.78 to 6.12 day with an average of 4.87 ± 0.31 day (Bhanderi, 2012) [8]; while, Singh (2017) [23] found that incubation period of 6-7 days on rice.

Egg hatching per cent

The egg hatching per cent of rice weevil recorded in different cereal hosts with the range of 61.26 to 76.67 per cent; whereas, maximum egg hatching per cent was recorded in host maize (76.67%) which was statistically at par with paddy (72.37%) and sorghum (71.30%) However, minimum egg hatching percentage was recorded in host used as oat (61.26%) which was also at par with wheat (65.83%) and barley (68.08%). Similarly Bhanderi (2012) [8] also observed that the hatching percentage of eggs varied from 66.00 to 82.00 per cent with an average of 74.95 ± 5.50 per cent.

Larval pupal period

It was observed that the larvae of *S. oryzae* moulted three times to attain maturity. Grub development took place inside the grain. Body was covered with small setae. The larval pupal period was observed different in all cereal which was range from 29.75 to 33.50 days. The longest period of larval pupal was recorded in maize (33.50 day) followed by paddy (32.25 day) and sorghum (31.75 day); whereas, shortest period of larval pupal was recorded in oat followed by wheat and barley with the range of 29.75, 30.25 and 31.50 days, respectively. It is consonance with the observation of Singh (2017) [23] found that larval stage lasted for 21-27 days and pupation period varied between 7-8 days with a mean of 7.5 days. According to Sattigi (1982) [22], the larval period ranged from 23 to 33 days with an average of 28 days and pupal period occupied 6 to 9 days (Av. 8.00 days). Yevoor (2003) [27] reported larval period of 27.25 days on maize grains and pupal period of 8 to 9 days on maize. The larval and pupal period ranged from 16 to 20 and 8to 9 days on maize grain, respectively (Bhuiyah *et al.*, 1990) [10]. Rice weevil *S. oryzae* when reared on maize grains, the developmental period from egg to pupation was longer than on rice as studied by Pittendrigh *et al.* (1997) [21].

Adult emergence

The emergence of adult was significantly affected by the different cereal hosts with number of male and female varied from 32.50 to 85.00 and 38.50 to 99.50 adults, respectively. The significantly maximum number of adult emergence of male and female was observed in maize hosts with 85.00 and 99.50 followed by paddy (65.75 & 82.25) which was statistically at par to sorghum host (64.00 & 75.50) respectively. Whereas, significantly minimum number of adult emergence of both sex, male and female was observed in oat with 32.50 and 38.50 followed by barley (47.25 & 58.75) which was statistically at par to wheat grains as host (48.75 & 60.25) respectively. The persent findings are in accordance with the observation of Gvozdenac *et al.* (2020) [17] that significantly higher emergence of males and females from maize and barley grains, compared to the wheat. On average, 18.62 males and 19.33 females emerged from maize, 12.71 males and 11.85 females emerged from barley, whereas 1.5 males and 2.0 females emerged from wheat. In contrast, Jacob (1992) [19] observed greater *S. oryzae* adult emergence in wheat than in raw rice, parboiled rice and paddy rice.

Adult longevity

The males lived for slightly shorter period as compared to females and significantly difference was recorded in the longevity of adult weevils of both sexes reared on different cereal hosts. The adult longevity of male and female varied from 39.00 to 54.75 days and 59.25 to 82.75 days, respectively on different hosts. The highest adult male and female survival days was recorded on maize with 54.75 and 82.75 days respectively, followed by paddy (53.25 days & 79.25 days) and sorghum (49.00 and 77.50 days) for both male and female, respectively. Whereas, the lowest adult male and female longevity was recorded in oat with 39.00 and 59.25 days respectively, followed by wheat (41.00 and 72.75 days) and barley (43.00 and 73.25 days) for both sexes, respectively. The present findings draw the support of Bheemanna (1986) [9] who observed adult longevity ranging from 14 to 165 day and 7 to 11 day with and without food, respectively. Sattigi (1982) [22] reported that longevity of adult weevil ranging from 16 to 172 day with food. While, the longevity of adult male and female was 14 to 115 and 119 to 120 day, respectively, when one day old adults were released into 2 kg sacks of maize (Bhuiyah *et al.*, 1990) [10]. Yevoor (2003) [27] observed that female lived for 115.76 days; male lived for 97.42 days with food. Female lived for 9.50 days; male lived for 7.32 days without food. Adult longevity with food, adult females survived for 81 to 101 day with an average of 86.98 ± 5.17 day while males survived for 55 to 60 day with an average of 57.75 ± 1.84 day (Bhanderi, 2012) [8].

Table 1: Effect of different cereals host on the various biological parameters of rice weevil, *S. oryzae*

Hosts	Ovipositional period (days)			Fecundity (No. of eggs laid/female	Mean Incubation period (days)	Egg hatching per cent	Larval + Pupal period	Adult emerged (no.)		Adult Longevity(Days)		Adult survival (%)		Mean developmental period (days)	
	Pre-Oviposition	Oviposition	post-Oviposition					Male	Female	Male	Female	Male	Female	Male	Female
Sorghum	5.00	5.00	5.00	229.50 (15.16)*	4.50	71.30 (57.61)**	31.75	65.75 (8.14)	75.50 (8.72)	49.00	77.50	57.59 (49.36)	60.23 (50.90)	85.75	113.75
Wheat	4.50	4.50	4.50	195.25 (13.99)	5.25	65.83 (54.23)	30.25	48.75 (7.02)	60.25 (7.79)	41.00	72.75	60.13 (50.84)	64.00 (53.13)	78.00	107.00
Maize	3.50	3.50	3.50	276.75 (16.65)	4.25	76.67 (61.12)	33.50	85.00 (9.25)	99.50 (10.00)	54.75	82.75	67.96 (55.53)	69.26 (56.33)	92.25	121.25
Paddy	4.00	4.00	4.00	234.50 (15.33)	4.50	72.37 (58.29)	32.25	64.00 (8.03)	82.25 (9.10)	53.25	79.25	55.30 (48.04)	59.03 (50.20)	88.00	116.00
Barley	5.25	5.25	5.25	182.50 (13.53)	5.00	68.08 (55.60)	31.50	47.25 (6.91)	58.75 (7.70)	43.00	73.25	48.01 (43.86)	55.50 (48.16)	79.25	108.50
Oat	4.75	4.75	4.75	138.50 (11.79)	5.75	61.26 (51.51)	29.75	32.50 (5.74)	38.50 (6.25)	39.00	59.25	40.69 (39.63)	47.76 (43.72)	74.50	94.75
S.Em ±	0.36	0.36	0.36	0.15	0.34	1.50	0.72	0.13	0.14	1.35	2.20	0.74	0.93	1.95	2.98
CD (p=0.05)	1.08	1.08	1.08	0.46	1.01	4.45	2.13	0.40	0.42	4.02	6.52	2.21	2.76	5.79	8.85

Figure in the parentheses are *square root transformed value, **angular transformed values and their outside are original values

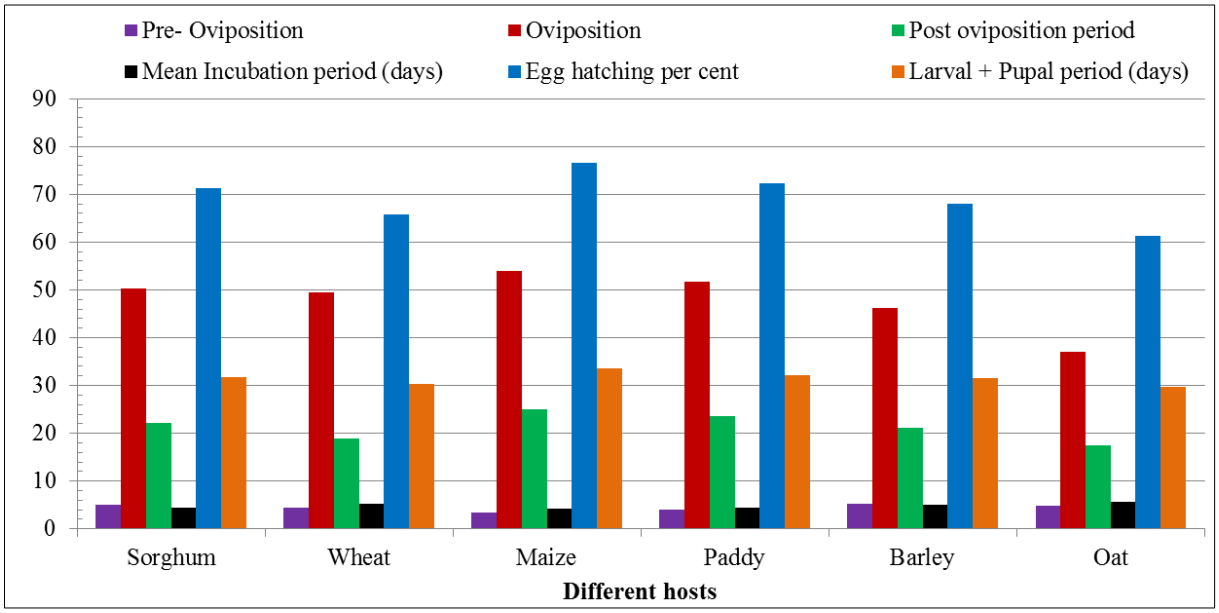

Fig 1: Effect of different hosts on biological parameter of rice weevil, *Sitophilus oryzae*

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