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Biology of stored mite, *Tyrophagus putrescentiae* (Schrank) on different hosts

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Abstract

The biology of *T. putrescentiae* was carried out on ten different types of broken grains, i.e. groundnut, wheat, rice, bajra, sorghum, black gram, pigeon pea, kabuli gram, green gram and white urd dal. The total developmental period was shortest when acarid mite fed on broken groundnut $(14.98 \pm 1.42 \text{ days})$ and the oviposition period was highest $(18.77 \pm 1.78 \text{ days})$, when reared on broken groundnut and it was followed by broken grains of wheat $(15.36 \pm 1.19 \text{ days})$. The life span of female acarid mite was maximum when fed on broken groundnut $(41.50 \pm 2.94 \text{ days})$ whereas the highest number of eggs was laid by the females reared on broken groundnut $(106.71 \pm 5.49 \text{ eggs}/\text{female})$.

Keywords: Biology, stored mite, Tyrophagus putrescentiae (Schrank)

Introduction

Grain provides an abundant source of nutrients to a variety of organisms. The interactions between grain and organisms/pests largely depend upon the micro-environment, the grains are stored in, which may lead to bio-deterioration of the grain ^[1]. More approximate damage to stored grains and grain products is done by pests in tropical zone (20-30 per cent), which is very high as compared to temperate zone (5-10 per cent). Sometimes, damage is very high reaching upto 40 per cent, especially in developing and under developed countries as modern storage technologies have not been introduced ^[1]. Mites act as secondary invaders among storage pests as they cannot infest sound grain instead feed upon broken kernels, debris, high moisture seeds or damaged grain by primary insect pests. These invaders contribute directly to grain spoilage after establishment, just as primary pests do ^[2]. Stored-grain mites damages usually go unnoticed until the grain is removed from the storage facility. Mites from family Acaridae are gaining importance as storage pests due to their increasing incidence and their association/ interaction with fungi and insects causing rapid qualitative and quantitative deterioration of grains ^[3]. Studies on acarid mites infesting stored products have been conducted in several regions throughout the world [3]. Among the stored grain mite Tyrophagus putrescentiae Schrank^[4] is a ubiquitous, agriculturally, medically important mite species and is considered a severe pest of number of stored commodities with high fat and protein content throughout the world. The mite, T. putrescentiae is a common and serious pest of stored grains due to its ability to tolerate low humidity and a wide range of temperatures ^[5]. It can cause problems for many foodstuffs ranging from weight reduction and degradation of stored foods to accumulation of harmful residues (fungi, dead mites, faeces, eggs and bits of food) through their activities ^[5, 8]. This makes the infested grain storage unhygienic. World over, there is an increasing trend among grain buyers towards zero-tolerance to these contaminants. For effective and economical management of the mite, T. putrescentiae it is very important to know its biology on various hosts. The present study therefore is an attempt to understand the biology on various hosts.

Materials and Methods

For the experimental purpose the acarid mites, *T. putrescentiae* were taken from a year old stock culture maintained on broken groundnut. The mite, *T. putrescentiae* was reared in plastic Petri dishes with tight fitting lid. In Petri dishes, a central hole was created in a lid, for air circulation and humidity. Culture was maintained on broken groundnut seeds and yeast in the ratio of 4:1. These rearing petri dishes were placed in a desiccators containing super saturated solution of Potassium chloride to provide desired humidity which in turn placed in BOD. Thus, stock culture of acarid mite, *T. putrescentiae* was maintained in the laboratory at $27 \pm$

1°C and 80-85% R. H. The biology of T. putrescentiae was undertaken on various food materials under the laboratory condition at 27 \pm 1 $^\circ C$ and 80-85 per cent RH. For this, different broken grains were taken and then the mite were released on them for 24 hours, the eggs laid by the mite were placed individually in the various food materials in the plastic petri dishes having 10 g of the broken grains of various food stuff. Mite larvae were reared individually on each stored source in petri dishes (9 cm diameter and 1.5 cm height) and observed, after every 12 h. until reached to adulthood. As soon as females emerged, males were introduced for mating. Eggs were collected during 12 h. post-oviposition. Eggs were placed into glass rings with the help of camel hair brush or bird's feather and incubated at the same conditions mentioned above. Fifteen eggs were reared on food material and regularly observed after every 12 h. until hatching and, the mite become adult. Eggs laid by each female mite were counted daily until the death of female. Various biological parameters like larval period, proto and deutonymphal period, total developmental period, adult period, sex ratio, fecundity etc. of acarid mite, T. putrescentiae were recorded. The mean and standard deviation were computed from the data thus obtained.

Results and Discussion

The biology of acarid mite, *T. putrescentiae* on different hosts were presented under following headings.

Incubation period: The incubation period of acarid mite, T. putrescentiae during the year 2017-18 was presented in the Table 1. The shortest incubation period was noticed on groundnut (2.45 \pm 0.51 days) and it was statistically at par with some other hosts like wheat $(2.64 \pm 0.49 \text{ days})$ and sorghum (2.68 \pm 0.81 days). The incubation period of T. putrescentiae was maximum on the broken grains of rice $(3.82 \pm 0.70 \text{ days})$. The incubation period of acarid mite during 2018-19 was shortest on broken grains of groundnut $(2.54 \pm 0.50 \text{ days})$, and was statistically at par with other food commodities viz., wheat (2.73 \pm 0.44 days), sorghum (2.82 \pm 0.70 days) and kabuli gram (2.86 \pm 0.49 days), respectively (Table 1). The incubation period of acarid mite T. putrescentiae was noticed 3.86 ± 0.75 days, when fed on broken grains of rice. The two years pooled over data on the incubation period of acarid mite clearly showed that the incubation period was shortest when fed upon the broken grains of groundnut (2.50 \pm 0.50 days) and was statistically at par with some other food commodities viz., wheat (2.68 \pm 0.47 days), sorghum (2.75 \pm 0.75 days) and kabuli gram (2.77 \pm 0.58 days), respectively.

Larval period: The data revealed that during 2017-18, the larval period was lowest when the larvae fed upon the broken groundnut $(3.04 \pm 0.83 \text{ days})$ and was statistically at par with other food materials viz., kabuli gram $(3.41 \pm 0.75 \text{ days})$ and wheat $(3.32 \pm 0.47 \text{ days})$. The maximum larval period of *T. putrescentiae* was recorded on broken grains of rice $(3.91 \pm 0.64 \text{ days})$, and was at par with other food materials viz., black gram $(3.59 \pm 0.50 \text{ days})$, pigeon pea $(3.64 \pm 0.49 \text{ days})$, white urd dal $(3.68 \pm 0.47 \text{ days})$ and green gram $(3.77 \pm 0.41 \text{ days})$, respectively. The larval period of acarid mite in 2018-19 was shortest *i.e.* 3.09 ± 0.79 days when fed on the broken groundnut and it was at par with other food commodities viz., wheat $(3.41 \pm 0.60 \text{ days})$ and kabuli gram $(3.45 \pm 0.60 \text{ days})$, respectively. The larval period was maximum on broken grain

of rice $(3.95 \pm 0.60 \text{ days})$. The two years pooled over data on larval period of acarid mite revealed that the larval period was shortest on the broken groundnut $(3.07 \pm 0.81 \text{ days})$. However, the maximum larval period were noticed in case of broken grains of rice $(3.93 \pm 0.62 \text{ days})$ and were statistically at par with other commodities like pigeon pea $(3.66 \pm 0.48 \text{ days})$, white urd dal $(3.70 \pm 6.52 \text{ days})$ and green gram $(3.80 \pm 0.55 \text{ days})$, respectively (Table 1). The present findings are more or less in accordance with the earlier work carried out by Mostafa *et al.* (2013) ^[9] from Egypt. They reported that groundnut and wheat were excellent food for larvae of *T. putrescentiae* as the larval period were shorter while the other food like milk powder, fish powder, sorghum and rice were least suitable because of longer larval period of *T. putrescentiae*.

Protonymph: During 2017-18 the protonymphal period of *T*. *putrescentiae* was lowest on groundnut (4.04 ± 0.39 days) and it was statistically at par with other food commodities viz., wheat $(4.45 \pm 0.51 \text{ days})$, kabuli gram $(4.50 \pm 0.51 \text{ days})$, sorghum (4.55 \pm 0.83 days) and bajra (4.59 \pm 0.60 days), respectively. The protonymphal period was maximum on broken grains of rice (5.55 \pm 0.89 days). The protonymphal period of T. putrescentiae during 2018-19 was shortest when reared on groundnut (4.09±0.72 days) and was statistically superior over rest of the food. The maximum protonymphal period of mite was recorded when reared on rice (5.59 ± 0.82) days) and was statistically at par with some other food commodities like white urd dal (5.18 \pm 0.70 days) and green gram (5.41±0.30 days), respectively. The two years pooled over data on protonymphal period of T. putrescentiae revealed that it was maximum when T. putrescentiae were reared on broken grains of rice $(5.57 \pm 0.85 \text{ days})$ and was statistically at par with green gram (5.39 \pm 0.55 days). The protonymphal period was shortest in case of broken groundnut (4.07 \pm 0.56 days) and it was followed by broken grains of wheat $(4.48 \pm 0.56 \text{ days})$, which were statistically at par with other food commodities like kabuli gram (4.52 \pm 0.51 days), sorghum (4.59 \pm 0.79 days) and bajra (4.61 \pm 0.55 days), respectively. In the present investigations, the protonymphal period of T. putrescentiae were shortest on broken groundnut and maximum on broken grains of rice (Table 1). Liu et al. (2006) [10] studied different developmental periods of T. putrescentiae on different hosts and found that the protonymphal period were shortest on groundnut and maize, while the same were maximum on barley, oat, sorghum, rice etc. Sarwar et al. (2010)^[12] also support the present findings as they found groundnut, wheat and sorghum as the most effective with a shorter protonymphal period, thus closely support the present findings.

Tritonymph: The tritonymphal period of *T. putrescentiae* during 2017-18 was shortest when reared on broken groundnut (5.27 ± 0.98 days) however, it was statistically at par with other food materials viz., wheat (5.59 ± 0.69 days), and kabuli gram (5.64 ± 0.82 days), while it was maximum on broken grains of rice (6.86 ± 0.79 days) and was statistically at par with green gram (6.77 ± 0.83 days). During the year 2018-19, the tritonymphal period of *T. putrescentiae* was maximum in case of broken grains of rice *i.e.* 6.91 ± 0.83 days and was found statistically at par with other food commodities viz., green gram (6.82 ± 0.52 days) and white urd dal (6.50 ± 0.60 days), while it was shortest when mite

fed on broken groundnut (5.41 \pm 0.50 days), however it was at par with other food commodities viz., wheat (5.64 \pm 0.60 days), kabuli gram (5.68 \pm 0.66 days) and sorghum (5.73 \pm 0.80 days), respectively. The two year pooled over data on tritonymphal period revealed that it was shortest when T. putrescentiae reared on broken groundnut (5.34 \pm 0.74 days), however it was statistically at par with other food commodities *i.e.*, broken grains of wheat $(5.61 \pm 0.64 \text{ days})$ and broken kabuli gram (5.66 \pm 0.74 days), respectively. The tritonymphal period was maximum when acarid mite fed upon rice $(6.89 \pm 0.81 \text{ days})$ and was statistically at par with broken grains of green gram (6.80 \pm 0.68 days) (Table 1). Similar results were noticed by Kheradmand et al. (2007)^[11], where they noticed that the tritonymphal period of T. putrescentiae was influenced by the different food and was highest in case of mushroom, groundnut and wheat, thus more or less in accordance with the present findings. Further, Sarwar et al. (2010) ^[12] also support the present findings as they found groundnut, wheat and sorghum as most effective with shorter tritonymphal period, thus closely support the present findings.

Total developmental period: The total developmental period of T. putrescentiae during 2017-18 showed that it was shortest on broken groundnut (14.86 \pm 1.69 days), and was statistically superior in comparison with others food materials viz., broken grains of wheat (15.91 \pm 0.94 days), bajra (16.68 \pm 1.19 days), sorghum (16.36 \pm 1.45 days) and kabuli gram (16.23 \pm 1.66 days), respectively. The total developmental period was longest when T. putrescentiae fed on the broken grains of rice $(20.18 \pm 1.46 \text{ days})$. During the year 2018-19, it was shortest on broken groundnut (15.09 \pm 1.14 days) and was statistically superior over rest of the other food sources. However, it was closely followed by broken grains of wheat (16.36 \pm 1.23 days), bajra (17.00 \pm 1.08 days), sorghum (16.59 \pm 1.66 days) and kabuli gram (16.55 \pm 1.28 days), respectively. The total developmental period was highest when the acarid mite fed on broken grains of rice $(20.36 \pm 1.63 \text{ days})$. The two years pooled over data on the total developmental period of T. putrescentiae on different broken grains showed that it was shortest when acarid mite fed on groundnut (14.98 \pm 1.42 days) and was statistically superior over rest of the food grains. However, it was closely followed by broken grains of wheat (16.14 \pm 1.09 days), sorghum (16.48 \pm 1.56 days) and kabuli gram (16.39 \pm 1.47 days), respectively. The total developmental period was maximum when T. putrescentiae fed upon broken grains of rice (20.27 ± 1.55 days), and it was followed by green gram (19.36 \pm 1.38 days) and white urd dal $(18.50 \pm 1.27 \text{ days})$, respectively. Mostafa *et al.* (2013)^[9] in Egypt also studied the biology of T. putrescentiae on different hosts and reported that when T. putrescentiae fed on hosts like groundnut, wheat and fish powder, its total post embryonic developmental period reduced as compared to other hosts having high carbohydrates contents like rice. These findings clearly support the present results. Further, Chmielewski (2000)^[13] reported more or less similar results on other species of acarid mite, Acarus siro, where the total developmental period was shorter on various oilseeds like groundnut and soyabean.

Pre oviposition period: The pre oviposition period of *T. putrescentiae* during 2017-18 was maximum when reared on broken grains of wheat $(3.41 \pm 0.60 \text{ days})$ (Table 1) and was statistically at par with other food commodities *i.e.* kabuli gram $(3.45 \pm 0.89 \text{ days})$ and groundnut $(3.91 \pm 0.88 \text{ days})$,

respectively. However, it was shortest when mite reared on broken grains of rice $(1.68 \pm 0.67 \text{ days})$ and green gram (1.77) \pm 0.55 days), respectively. The pre oviposition period of acarid mite during 2018-19, was longest on broken groundnut $(4.00 \pm 0.73 \text{ days})$ and was statistically superior over rest of the food materials (Table 1). The pre oviposition period was shortest *i.e.* 1.82 ± 0.70 days on broken grains of rice, and it was statistically at par with other food grains *i.e.* broken green gram (2.00 \pm 0.56 days). The pooled over data of two years on clearly revealed that the pre oviposition period was maximum when the acarid mite fed on broken groundnut $(3.95 \pm 0.80 \text{ days})$ however, it was followed by wheat $(3.45 \pm$ 0.60 days) and kabuli gram (3.48 \pm 0.75 days), respectively. The pre oviposition period was shortest when the acarid mite fed upon broken grains of rice $(1.75 \pm 0.68 \text{ days})$ and was statistically at par with green gram (1.89 \pm 0.56 days), respectively. In past, Mostafa et al. (2003) [9] in their investigation reported more or less similar results from Egypt. They also reported the longer pre oviposition period of T. putrescentiae when reared on carbohydrate food like rice and shorter pre ovipositional period on food stuffs like groundnut, wheat and fish powder, thus closely support the present findings. Further, Taha et al. (2010)^[14] also reported more or less similar results when they reared on other species of stored grain mite, Gohieria fusca (Oud.).

Oviposition period: The oviposition period of the female in 2017-18 was recorded maximum when fed on broken groundnut (18.73 \pm 2.05 days) and was statistically higher over rest of the food stuff treatments however, it was followed broken grains of wheat $(15.23 \pm 1.44 \text{ days})$. The oviposition period was shortest in case of broken rice grains (5.23 ± 0.64) days) and was statistically at par with green gram (6.00 ± 0.65 days), respectively. During year 2018-19, the oviposition period was highest when acarid mite fed upon broken groundnut (18.82 \pm 1.51 days) and was followed by broken grains of wheat (15.50 \pm 0.95 days). However, it was shortest on broken grains of rice $(5.41 \pm 0.69 \text{ days})$ and was followed by sorghum (13.41 \pm 0.99 days) and kabuli gram (13.59 \pm 1.23 days), respectively (Table 1). The two years pooled over data on the ovipositional period of T. putrescentiae clearly showed that it was maximum *i.e.* 18.77 ± 1.78 days on broken groundnut and it was followed by broken grains of wheat $(15.36 \pm 1.19 \text{ days})$. The oviposition period was shortest when T. putrescentiae was reared on broken grains of rice $(5.32 \pm$ 0.66 days) and was closely followed by green gram (6.07 \pm 0.78 days) (Table 1). The present findings are closely supported by Mostafa et al. (2013)^[9] who also reported that when the acarid mite, T. putrescentiae reared on groundnut have longer ovipositional period. Further, Chmielewski (1999) ^[13] also showed that groundnut was accepted by T. putrescentiae and it had longer ovipositional period under laboratory conditions, the present findings who also closely supported by Thomas et al. (2015) [15] who also recorded longer ovipositional period of T. putrescentiae when reared on groundnut based food materials.

Post oviposition period: The post ovipositional period of *T. putrescentiae* during 2018-19 showed that the post oviposition period was maximum on broken groundnut (3.68 \pm 0.81 days), and was statistically at par with other food stuffs like broken grains of wheat (3.77 \pm 1.29 days) and kabuli gram (4.05 \pm 1.08 days) and it was shortest on broken grains of rice (1.45 \pm 0.51 days) and was followed by broken grains

green gram (2.00 \pm 0.56 days), pigeon pea (2.27 \pm 0.79 days) and white urd dal (2.27 ±0.57 days), respectively. During 2018-19, the post oviposition period revealed that it was maximum when mite were reared on kabuli gram (4.14 \pm 0.81 days) and was statistically at par with broken grains of wheat $(3.82 \pm 0.81 \text{ days})$ and groundnut $(3.86 \pm 0.88 \text{ days})$. However, it was shortest on broken grains of rice (1.50 ± 0.51) days). The two years pooled over data on post ovipositional period revealed that it was highest when fed upon kabuli garm $(4.09 \pm 0.94 \text{ days})$ and were statistically at par with other food stuffs viz., groundnut (3.77 \pm 0.84 days) and wheat (3.80 \pm 1.05 days), respectively. The post oviposition period was shortest when the acarid mite was reared on broken grains of rice $(1.48 \pm 0.51 \text{ days})$ and, it was followed by other food stuffs viz., broken grains of green gram (2.09 \pm 0.66 days), white urd dal (2.34 \pm 0.70 days) and pigeon pea 2.36 \pm 0.84 days, respectively. In the present study the post ovipositional period of T. putrescentiae were higher on kabuli gram, groundnut and wheat as compared to other food materials. In past, Mostafa et al. (2013) [9] reported the longer post oviposition period of T. putrescentiae when reared on groundnut, wheat and fish powder, thus more or less in close conformity with the present findings. Further, Taha et al. (2010)^[14] from Egypt also reported the similar trends on other stored grain mite, G. fusca. Sanchez-Ramos et al. (2007)^[16] also reported more or less similar results when they reared on another species of acarid mite, T. neiswanderi on food stuffs like groundnut, soyabean, wheat, buckwheat, dog's food and reported more or less results.

Total life span of female: The total life span of female acarid mite, T. putrescentiae during the year 2017-18 was presented in Table 1 clearly showed that the total life span of female acarid mite was highest (41.05 \pm 2.99 days) when fed upon broken groundnut and was followed by broken grains of wheat (38.32 \pm 2.81 days) and kabuli gram (37.14 \pm 2.61 days). However, the total life span of female T. putrescentiae was shortest on broken grains of rice (28.45 \pm 1.61 days) and it was statistically at par with green gram (29.00 \pm 1.72 days). The total life spans of female T. putrescentiae in year 2018-19 was highest on broken groundnut (41.95 \pm 2.89 days) and was closely followed by broken grains of wheat (39.23 ± 2.03) days) and kabuli gram (37.64 \pm 2.05 days). The life span of female were shortest when it was reared on broken grains of rice (29.09 \pm 2.25 days) however, it was at par with broken grains of green gram (29.86 \pm 2.37 days) and white urd dal $(30.68 \pm 2.06 \text{ days})$, respectively. The two years pooled over data on total life span of female T. putrescentiae revealed that it was maximum on broken groundnut (41.50 \pm 2.94 days) and was statistically higher over rest of the food stuff and followed by broken grains of wheat (38.80 \pm 2.33 days). The total life span of female acarid mite was shortest on broken grains of rice (28.77 \pm 1.93 days) and was at par with green gram (29.43 \pm 2.04days). The present findings were closely supported by the earlier work carried out by Sanchez-Ramos et al. $(2007)^{[16]}$, who also reported that when T. putrescentiae females reared on groundnut based food the female life span was significantly higher in comparison to other food stuffs. The present results were also closely supported by Taha et al. (2010)^[14] when they reared stored mite, G. fusca on different hosts and recorded higher female life period on groundnut and wheat. Thus, closely support the present findings.

Total life span of male: The total life span of male mite during the year 2017-18 showed that the maximum life span of male $(36.91 \pm 1.92 \text{ days})$ were noticed when fed on broken groundnut and was followed by broken grains of wheat (32.32 \pm 2.56 days). The total life span of male mite was shortest on broken grains of rice $(20.41 \pm 1.98 \text{ days})$. However, it was followed by black gram (24.09 \pm 1.86 days), green gram $(23.18 \pm 1.36 \text{ days})$ and white urd dal $(24.00 \pm 2.37 \text{ days})$, respectively. The total life span of male acarid mite was maximum on broken groundnut $(34.41 \pm 2.35 \text{ days})$ and followed by broken grains of wheat $(33.59 \pm 1.19 \text{ days})$ during 2018-19. The total life span of male acarid mite was shortest on broken grains of rice $(21.05 \pm 1.41 \text{ days})$ and was followed by green gram (22.91 \pm 1.89 days) (Table 1). The two year pooled over data on total life span of male was longest when they were reared on broken groundnut (36.66 \pm 2.13 days) and was followed by broken grains of wheat (32.95 ± 1.87) days) and kabuli gram (31.45 ± 2.55 days), respectively. The total life span of male T. putrescentiae was shortest when it was reared on broken grains of rice $(20.73 \pm 1.70 \text{ days})$ and was closely followed by green gram (23.05 \pm 1.63 days). The present findings were closely supported by earlier work carried out by Sanchez-Ramos *et al.* (2007) ^[16], who reported that when T. putrescentiae males reared on groundnut based food, the male life span was significantly higher in comparison to other food stuffs.

Fecundity: The data on number of eggs laid by a single female T. putrescentiae during the year 2017-18 revealed that females reared on groundnut lay maximum number of eggs $(107.23 \pm 4.87 \text{ eggs /female})$ and was significantly higher over rest of the food stuff and was followed by broken grains of wheat $(73.05 \pm 2.96 \text{ eggs} / \text{female})$. Further, the lowest numbers of eggs were laid by those females reared on broken grains of rice $(27.23 \pm 0.94 \text{ eggs /female})$. During 2018-19, the highest number of eggs were laid by those females reared on broken groundnut (95.32 \pm 1.82 eggs /female) and was significantly higher over rest of the food stuff treatments and closely followed by broken grains of wheat (74.23 ± 3.10) eggs /females). The females who reared on broken grains of rice laid lowest number of eggs (28.25 ± 2.67 eggs /female) under the laboratory conditions. The two year pooled over data on fecundity of T. putrescentiae clearly revealed that the highest number of eggs were laid by the females reared on broken groundnut (106.71 ± 5.49 eggs /female) and was followed broken grains of wheat (73.64 \pm 3.03 eggs /female). The lowest number of eggs were laid by those females reared on broken grains of rice $(27.74 \pm 2.30 \text{ eggs /female})$ and was followed by green gram $(33.52 \pm 1.61 \text{ eggs /female})$ and white urd dal (38.77 \pm 2.63 eggs /female), respectively. The present findings were closely supported by Chmielewski (2000) ^[13] who also recorded higher fecundity when acarid mite, T. putrescentiae were reared on groundnut based food products under laboratory condition. Further, Mostafa et al. (2013) ^[9] also reported that when the when females of T. putrescentiae reared on groundnut, wheat and fish powder, laid higher number of eggs in comparison to other food including rice, thus closely support the present findings. Liu et al. (2006)^[10] also reported more or less similar results in case of groundnut, maize and yeast.

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Table 1.	Biological	narameters of	acari mite	1	nutrescentiae or	Various	broken	orains
Table I.	Diological	purumeters or	acuir mite,		punescenniae of	various	oronen	Siamo

Includation period 2017-18 2.45±0.51c 2.45±0.51c 3.22±0.70c 2.82±0.70c 2.82±0.70c 3.00±0.79bc 2.68±0.74g 3.7±0.44b 3.09±0.79bc Includation period 2.00±02 2.54±0.50c 2.73±0.44d 3.8±0.75a 2.95±0.65cd 2.75±0.75dc 2.98±0.62cd 3.01±0.75bc 2.71±0.75bc 3.22±0.47b 3.14±0.67bc Includation 3.04±0.78a 3.23±0.47dc 3.31±0.67a 3.52±0.51bc 3.64±0.49abc 3.64±0.49abc 3.44±0.67bc 3.72±0.52abc Protein 3.04±0.78abc 3.52±0.51cf 3.48±0.51bcl 3.64±0.49abc 3.64±0.47abc 3.45±0.67cd 3.25±0.75ab 3.72±0.52abc Protein 3.04±0.72bc 4.45±0.51cf 5.5±0.89a 4.59±0.67cd 4.8±0.72cd 4.9±0.85cd 4.5±0.51cf 5.3±0.78ab 3.72±0.72b 5.8±0.89dc 6.8±0.77cd 4.5±0.51cf 5.3±0.78ab 3.72±0.72b 5.8±0.58dc 6.8±0.77cd 4.5±0.51cf 5.3±0.58ab 5.4±0.58dc 6.8±0.75ab 5.2±0.58bb 4.5±0.51cf 5.3±0.57ab 5.4±0.52dc 5.5±0.85bb 5.5±0.85bb 5.5±0.85	Particulars	Year	Groundnut	Wheat	Rice	Bajra	Sorghum	Blackgram	Pigonpea	Kabuligram	Green gram	Urd dal
Inclusion period 218+19 2.54±0.50e 2.7±0.44e 3.8±0.75a 2.95±0.69ed 2.8±0.70bc 3.09±0.45bcd 2.8±0.45bcd 3.3±0.47bc 3.1±0.70bc Protect 2017-18 3.0±0.80e 2.3±0.47de 3.8±0.75a 2.8±0.65cd 2.75±0.75de 2.97±0.58de 3.3±0.47b 3.1±0.64a 3.5±0.51bcd 3.6±0.47bcd 3.6±0.47bcd 3.4±0.70bcd 3.7±0.57abc Protomproph period 3.00±0.7081 3.4±0.60bcd 3.5±0.51bcd 3.5±0.51bcd 3.6±0.47bbd 3.6±0.47bbd 3.8±0.55bd 3.7±0.57abc Protomympi 2017-18 4.0±0.50cd 4.4±0.50cd 3.5±0.51bcd 3.6±0.67abd 4.8±0.70cd 4.5±0.51cd 5.4±0.70ab 5.8±0.70ab 5.8±0.70ab 4.8±0.70cd 4.9±0.72ab 4.8±0.70ab 5.8±0.504d 4.8±0.70ab 4.5±0.51bcd 4.8±0.70ab 4.8±0.70ab 4.8±0.70ab 4.8±0.70ab 4.5±0.72ab 4.8±0.70ab 4.8±0.70ab 4.8±0.70ab 4.8±0.72ab	Incubation period	2017-18	2.45±0.51e	2.64±0.49de	3.82±0.70a	2.82±0.62cde	2.68±0.81de	2.95±0.51bcd	3.05±0.69bc	2.68±0.67de	3.27±0.44b	3.09±0.64bc
period Pooled 2.50e.050e 2.68±0.47de 3.84±0.72a 2.89±0.65cd 3.75±0.67be 2.89±0.62cd 3.07±0.57be 2.77±0.58de 3.74±0.67be Laradi 2018-19 3.04±0.83e 3.3±0.47de 3.91±0.64bc 3.55±0.51bc 3.54±0.51bc 3.64±0.49bc 3.45±0.60d 3.8±0.70a 3.73±0.57bc Protomph 2017-18 3.04±0.83e 4.31±0.60bc 3.55±0.60a 3.52±0.51bc 3.64±0.49bc 3.68±0.47bc 3.45±0.60d 3.8±0.70a 3.73±0.57bc Protomph 2017-18 4.04±0.39c 4.45±0.51c 5.5±0.83a 4.84±0.77cd 4.84±0.77cd 4.55±0.51c 5.41±0.50ab 5.8±0.73b 5.7±0.58c 5.8±0.73b 5.7±0.78c 5.8±0.72b 5.8±0.73b 5.7±0.78c 5.7±0.78c 5.7±0.78c 5.7±0.78c 5.7±0.78c 5.8±0.72b		2018-19	2.54±0.50e	2.73±0.44de	3.86±0.75a	2.95±0.69cd	2.82±0.70de	3.00±0.73bcd	3.09±0.45bcd	2.86±0.49cde	3.36±0.49b	3.18±0.70bc
1 2017-18 3.040-088 3.220.47a 3.910.643 5.90.018 3.540.07bcdl 3.540.07bcdl 3.740.41a 3.849.07abc 1018-19 3.000.7018 3.320.07bl 3.540.07bc 3.540.07bcl 3.640.94bcd 3.640.94bcl 3.640.94bcl 3.640.07bcl 3.840.07bcl 3.640.07bcl 3.840.07bcl 3.640.94bcl 3.640.07bcl 3.840.07bcl 3.640.07bcl 3.840.07bcl 3.640.07bcl 3.840.07bcl 3.640.07bcl 3.840.07bcl 4.540.07bcl 4.840.07bcl 4.840.07bcl 4.840.07bcl 4.950.07bcl 4.550.01bcl 5.840.07bcl 4.550.01bcl 5.840.07bcl 4.550.01bcl 5.840.07bcl 5.84		Pooled	2.50±0.50e	2.68±0.47de	3.84±0.72a	2.89±0.65cd	2.75±0.75de	2.98±0.62cd	3.07±0.57bc	2.77±0.58de	3.32±0.47b	$3.14{\pm}0.67bc$
Larva 2018-19 3.09±0.79d 3.41±0.60bcd 3.95±0.60a 3.55±0.51bc 3.50±0.51cl 3.64±0.49abc 3.68±0.47abc 3.43±0.60dd 3.82±0.70ab 3.73±0.57abc Protomppind period 3.07±0.73bc 4.45±0.51cf 5.55±0.89a 4.59±0.60de 4.55±0.81d 4.82±0.77cd 4.91±0.85cd 4.50±0.51d 5.61±0.60ab 5.09±0.72ac Protomppind period 4.09±0.72t 4.09±0.02t 4.45±0.51ef 5.59±0.82a 4.64±0.75de 4.84±0.72de 4.89±0.77cd 4.52±0.51ef 5.39±0.52a 5.14±0.70bc 5.41±0.50bc Titompind 2017-18 5.27±0.98t 5.69±0.69df 6.86±0.79a 5.77±0.70de 5.68±0.59def 6.18±0.70cd 6.32±0.47c 5.64±0.82tf 6.41±0.50bc Total 2017-18 1.48±61.40bf 1.59±1.04f 1.63±1.13e 16.34±1.14e 16.34±1.40df 1.63±1.45e 1.74±1.40dd 1.63±1.45e 1.74±1.45e 1.63±1.45e 1.74±1.45e 1.63±1.45e 1.74±1.45e 1.63±1.45e 1.74±1.45e 1.63±1.45e 1.74±1.45e 1.63±1.45e 1.74±1.45e 1.63±1.45e 1.43±1.4	Larval period	2017-18	3.04±0.83e	3.32±0.47de	3.91±0.64a	3.50±0.51bcd	3.45±0.51bcd	3.59±0.50abcd	3.64±0.49abcd	3.41±0.75cde	3.77±0.41ab	3.68±0.47abc
prinu Pooled 3.07±0.81e 3.34±0.54d 3.34±0.63d 5.34±0.63d 5.05±0.82a 4.44±0.40de 4.44±0.70de 4.34±0.77de 4.59±0.59bcd 4.55±0.51c 5.14±0.71bc 5.34±0.70de 5.34±0.70de 5.34±0.70de 5.34±0.70de 5.34±0.70de 5.34±0.70de 5.34±0.70de 5.44±0.50bc 5.45		2018-19	3.09±0.79d	3.41±0.60bcd	3.95±0.60a	3.55±0.51bc	3.50±0.51bc	3.64±0.49abc	3.68±0.47abc	3.45±0.60cd	3.82±0.70ab	3.73±0.57abc
Protonymp period 2017-18 4.04±0.39 4.45±0.51ef 5.55±0.89a 4.59±0.60de 4.55±0.83de 4.82±0.77cde 4.91±0.85cd 4.50±0.51e 5.41±0.50ab 5.18±0.70abc Proled 4.07±0.55g 4.84±0.56f 5.57±0.85a 4.64±0.70abc 4.85±0.70abc 4.52±0.51e 5.41±0.50ab 5.14±0.71bc Proled 4.07±0.55g 4.84±0.56f 5.57±0.85a 4.61±0.55ef 4.85±0.72ab 6.32±0.47c 5.64±0.82ef 6.77±0.83ab 6.41±0.50bc Proled 5.34±0.70ef 5.64±0.60ef 6.91±0.83a 5.86±0.70bd 6.14±0.71c 6.32±0.75b 5.68±0.66ef 6.82±0.52ab 6.50±0.60abc Color 5.34±0.60f 15.91±0.94e 201.81±1.46a 16.68±1.19de 16.36±1.45e 17.4±1.90de 17.91±1.59c 16.23±1.66e 18.9±1.45a 16.48±1.05de 15.9±1.47ef 19.36±1.33b 18.50±1.27c Pro- 2017±18 1.9.9±0.88a 3.41±0.00a 1.84±0.136 16.48±1.56ef 17.5±1.24d 18.0±1.14a 18.50±1.27c Oriposition 2017±18 3.91±0.88a 3.31±0.00a <td>Pooled</td> <td>3.07±0.81e</td> <td>3.36±0.54d</td> <td>3.93±0.62a</td> <td>3.52±0.51cd</td> <td>3.48±0.51cd</td> <td>3.61±0.50bcd</td> <td>3.66±0.48abc</td> <td>3.43±0.68d</td> <td>3.80±0.55ab</td> <td>3.70±0.52abc</td>		Pooled	3.07±0.81e	3.36±0.54d	3.93±0.62a	3.52±0.51cd	3.48±0.51cd	3.61±0.50bcd	3.66±0.48abc	3.43±0.68d	3.80±0.55ab	3.70±0.52abc
Protompring 2018-19 4.09±0.72f 4.50±0.60e 5.59±0.82a 4.64±0.73de 4.66±0.67cde 5.05±0.69bcd 4.55±0.51e 5.14±0.70bc 5.34±0.7abc 5.64±0.60ac 6.32±0.47c 5.44±0.7bc 5.64±0.60ac 6.32±0.47c 5.64±0.61bc 5.64±0.62bc 6.32±0.47c 6.32±0.47c 6.34±0.7bc 6.84±0.50bc 6.82±0.52ab 6.50±0.60abc 6.82±0.52ab 6.50±0.60abc 6.82±0.52bc 3.44±0.7bc 6.84±0.50bc 6.32±0.47c 6.32±0.47c 6.34±0.7bc 6.63±0.7bc 6.84±0.50bc 6.82±0.52bc 6.82±0.52bc 6.82±0.52bc 6.82±0.52bc 6.82±0.57bc 8.32±1.45c 6.50±0.60b 8.2±0.72c 8.50±1.27c 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.85c 7.8±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.84bc 7.02±0.85c 7.8±0.85bc 7.8±0.85bc 7.8±0.85bc	Protonymph period	2017-18	4.04±0.39e	4.45±0.51ef	5.55±0.89a	4.59±0.60de	4.55±0.83de	4.82±0.77cde	4.91±0.85cd	4.50±0.51de	5.36±0.60ab	5.09±0.72bc
pendu Pooled 4.07±0.56g 4.48±0.56f 5.57±0.85a 4.61±0.55ef 4.59±0.79ef 4.84±0.72de 4.98±0.77cd 4.52±0.51ef 5.39±0.55a 5.14±0.71b Tritonymp period 2017-18 5.27±0.981 5.59±0.69ef 6.66±0.79a 5.77±0.72a 5.68±0.50ef 6.92±0.72c 6.32±0.71c 5.64±0.82ef 6.72±0.83ab 6.14±0.71c 6.34±0.61b 5.68±0.74ab 6.82±0.72ab 6.59±0.66ab 6.82±0.72ab 6.59±0.66ab 6.82±0.72ab 6.59±0.66ab 6.82±0.72ab 6.59±0.66ab 6.82±0.72ab 6.59±0.67ab 6.34±0.61b 5.66±0.74ab 6.89±0.72ab 6.85±0.75b 18.3±1.45c Total 2017-18 14.84±1.69f 15.91±0.942 20.8±1.42a 16.64±1.13e 16.48±1.56ef 17.5±1.24d 18.07±1.63cd 16.39±1.47ef 19.3±1.43b 18.8±1.09b 18.9±0.70c 2.9±0.50b 3.4±0.50b 1.29±1.45c 14.4±0.97b 2.4±0.50e 1.5±1.45c 1.7±0.55d 2.27±0.4c 12.9±0.37b 3.4±0.50c 1.5±1.45c 1.7±0.55d 2.27±0.50c 3.4±0.50b 3.4±0.50c 1.5±1.45c 1.7±0.5±1.35b		2018-19	4.09±0.72f	4.50±0.60e	5.59±0.82a	4.64±0.49de	4.64±0.75de	4.86±0.67cde	5.05±0.69bcd	4.55±0.51e	5.41±0.50ab	5.18±0.70abc
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Pooled	4.07±0.56g	4.48±0.56f	5.57±0.85a	4.61±0.55ef	4.59±0.79ef	4.84±0.72de	4.98±0.77cd	4.52±0.51ef	5.39±0.55ab	5.14±0.71bc
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Tritonymph period	2017-18	5.27±0.98f	5.59±0.69ef	6.86±0.79a	5.77±0.72de	5.68±0.59def	6.09±0.72cd	6.32±0.47c	5.64±0.82ef	6.77±0.83ab	$6.41 \pm 0.50 bc$
period 5.34±0.74e 5.61±0.64de 6.89±0.81a 5.82±0.76d 5.70±0.69d 6.14±0.71c 6.34±0.61bc 5.66±0.74de 6.80±0.68a 6.45±0.55b Total 2017-18 14.86±1.69f 15.91±0.94e 20.8±1.46a 16.68±1.104e 16.36±1.45c 17.74±1.00cd 17.91±1.55c 16.23±1.66e 19.72±1.37b 18.32±1.45c developme Pooled 14.98±1.42g 16.34±1.00f 20.27±1.53a 16.84±1.13e 16.48±1.56ef 17.58±1.49de 18.23±1.68cd 16.59±1.28f 19.35±1.38b 18.50±1.07c Pre- 2017-18 3.91±0.88a 3.41±0.00f 2.08±0.70g 2.95±0.51cd 3.14±1.07b 2.45±0.51e 2.45±0.50b 3.45±0.00b 1.07±0.56f 2.27±0.44c Oviposition Pooled 3.95±0.80a 3.45±0.00b 1.82±0.70g 2.95±0.51cd 3.14±1.07b 2.41±0.50e 2.61±0.59de 3.48±0.75b 7.40±0.65f <td>2018-19</td> <td>5.41±0.50f</td> <td>5.64±0.60ef</td> <td>6.91±0.83a</td> <td>5.86±0.81de</td> <td>5.73±0.80ef</td> <td>6.18±0.70cd</td> <td>6.36±0.75bc</td> <td>5.68±0.66ef</td> <td>6.82±0.52ab</td> <td>6.50±0.60abc</td>		2018-19	5.41±0.50f	5.64±0.60ef	6.91±0.83a	5.86±0.81de	5.73±0.80ef	6.18±0.70cd	6.36±0.75bc	5.68±0.66ef	6.82±0.52ab	6.50±0.60abc
Total developend tal period 2017-18 14.86±1.69f 15.91±0.94 20.81±1.46a 16.68±1.19b 16.36±1.42b 17.45±1.00cd 17.91±1.50c 16.23±1.66c 19.27±1.37b 18.32±1.45c developend tal period 15.09±1.14g 16.36±1.23f 20.36±1.63a 17.00±1.08f 16.84±1.69f 17.78±1.49d 18.23±1.68cd 16.59±1.68f 19.29±1.08cd 16.39±1.47cg 19.45±1.39b 18.68±1.09bc Prev 2017-18 3.91±0.88a 3.41±0.60a 1.68±0.67d 2.86±0.75b 3.05±0.79b 2.36±0.49c 2.64±0.68d 3.50±0.60b 2.02±1.05c 2.41±0.50c Oviposition 108-91 4.00±0.73a 3.50±0.60b 1.82±0.70g 2.95±0.51cd 3.14±0.70c 2.45±0.51c 2.64±0.68d 3.50±0.60b 2.02±0.50c 2.41±0.50c 2.01±0.50c 2.01±0.50c 2.01±0.50c 3.48±0.75b 1.89±0.56f 2.74±0.50c 020000 18.82±1.51a 15.02±0.95b 5.41±0.69b 12.71±1.74c 13.41±0.90*2 13.42±0.8c 3.62±0.76c 2.41±0.50c 5.65±0.51c 2.72±0.75c 4.05±1.08a 2.00±0.65c 2.		Pooled	5.34±0.74e	5.61±0.64de	6.89±0.81a	5.82±0.76d	5.70±0.69d	6.14±0.71c	6.34±0.61bc	5.66±0.74de	6.80±0.68a	6.45±0.55b
development 2018-19 15.09±1.14g 16.36±1.23f 20.36±1.63a 17.00±1.08ef 16.59±1.66f 17.68±1.49de 18.23±1.68d 16.55±1.28f 19.45±1.39b 18.68±1.09bc tal period 2001cl 14.98±1.42g 16.14±1.09f 20.27±1.55a 16.84±1.13e 16.48±1.56ef 17.57±1.24d 18.07±1.63cd 16.39±1.47ef 19.36±1.38b 18.50±1.27c Pre- 2017-18 3.91±0.88a 3.41±0.00g 1.68±0.70g 2.86±0.70g 3.05±0.70b 2.36±0.49c 2.59±0.50c 3.45±0.03b 1.77±0.55d 2.27±0.44c Oviposition 2018-19 4.00±0.73a 3.50±0.60b 1.82±0.70g 2.95±0.51d 3.14±1.07bc 2.41±0.50d 2.64±0.68d 3.50±0.05b 2.41±0.50f 2.41±0.50d 2.41±0.50d 3.45±0.51g 3.09±0.56f 2.34±0.47c 3.24±0.71a 3.84±0.75b	Total	2017-18	$14.86{\pm}1.69f$	15.91±0.94e	20.18±1.46a	16.68±1.19de	16.36±1.45e	17.45±1.00cd	17.91±1.59c	16.23±1.66e	19.27±1.37b	18.32±1.45c
Independent Pooled 14.98±1.42g 16.14±1.09g 20.27±1.55a 16.84±1.13e 16.48±1.56e 17.57±1.24d 18.07±1.63cd 16.93±1.47e 19.36±1.38b 18.50±1.27c Pre- Oviposition period 2017-18 3.91±0.88a 3.41±0.00a 1.68±0.67d 2.86±0.75b 3.05±0.79b 2.36±0.49c 2.59±0.50bc 3.45±0.89a 1.77±0.55d 2.27±0.44c Oviposition period Pooled 3.95±0.80a 3.45±0.00b 1.82±0.70g 2.95±0.51c 2.41±0.50c 2.64±0.68de 3.50±0.0bb 2.02±0.51cg 2.41±0.50c 2.61±0.59de 3.48±0.75b 1.89±0.55c 2.14±0.50c Oviposition period 16.82±1.51a 15.50±0.95b 5.41±0.69h 12.77±1.47d 13.41±0.99cd 10.23±1.16e 7.91±1.35f 13.59±1.23c 6.14±0.91h 7.18±0.93g Pooled 18.77±1.78a 15.36±1.19b 5.32±0.66i 12.68±1.37d 13.34±0.98c 10.27±1.71e 7.95±1.03f 13.52±1.14c 6.07±0.78h 7.11±1.13g Post 2017-18 3.68±0.81a 3.77±1.29a 1.45±0.51g 3.09±0.94d 3.24±0.82b	developmen	2018-19	15.09±1.14g	16.36±1.23f	20.36±1.63a	17.00±1.08ef	16.59±1.66f	17.68±1.49de	$18.23{\pm}1.68cd$	16.55±1.28f	19.45±1.39b	18.68±1.09bc
Pre- Oviposition period 2017-18 3.91±0.88a 3.41±0.60a 1.68±0.67d 2.86±0.75b 3.05±0.79b 2.36±0.49c 2.59±0.50bc 3.45±0.89a 1.77±0.55d 2.27±0.44c Oviposition period 2018-19 4.00±0.73a 3.50±0.60b 1.82±0.70g 2.95±0.51cd 3.14±1.07bc 2.45±0.51e 2.64±0.68de 3.50±0.60b 2.04±0.56f 2.34±0.47c Oviposition period 2017-18 18.73±2.05a 15.23±1.44b 5.23±1.64b 12.59±1.27d 13.27±0.97cd 10.32±1.81e 8.00±0.92f 13.59±1.32c 6.04±0.91b 7.05±1.32g Oviposition period 18.82±1.51a 15.50±0.95b 5.41±0.69b1 12.71±1.47d 13.34±0.98c 10.27±1.71e 7.95±1.03f 13.52±1.14c 6.07±0.78b 7.11±1.13g Pooled 18.77±1.78a 15.36±1.19b 5.32±0.66i 12.68±1.37d 13.34±0.98c 10.27±1.71e 7.95±1.03f 13.52±1.14c 6.07±0.78b 7.11±1.13g Pooled 3.77±1.84a 3.80±0.51e 3.14±0.88b 3.6±1.07b 2.95±0.60c 2.36±0.88d 4.14±0.81a 2.18±0.77d 2.14±0.82	tal period	Pooled	14.98±1.42g	16.14±1.09f	20.27±1.55a	16.84±1.13e	16.48±1.56ef	17.57±1.24d	18.07±1.63cd	16.39±1.47ef	19.36±1.38b	18.50±1.27c
Oviposition period 2018-19 4.00±0.73a 3.50±0.6bb 1.82±0.70g 2.95±0.51cd 3.14±1.07bc 2.45±0.51e 2.64±0.68de 3.50±0.6bb 2.00±0.56g 2.41±0.50e Period 90oled 3.95±0.80a 3.45±0.6bb 1.75±0.68f 2.91±0.63cd 3.09±0.93c 2.41±0.50e 2.61±0.59d 3.48±0.75b 1.89±0.56f 2.34±0.47e Ovipositio period 18.73±2.05a 15.23±1.44b 5.23±0.44b 12.59±1.27d 13.27±0.97cd 10.32±1.61e 7.91±1.15f 13.45±1.05c 6.00±0.65b 7.05±1.32g Ovipositio period 18.82±1.51a 15.50±0.95b 5.41±0.6bi 12.72±1.47d 13.41±0.99cd 10.32±1.81e 8.00±0.92f 13.59±1.23c 6.14±0.91b 7.11±1.33g Post 2017-18 3.68±0.81a 3.71±1.29a 14.25±0.51g 3.09±0.94cd 3.27±1.20b 2.25±0.51c 2.24±0.79d 4.14±0.81a 2.18±0.77d 2.14±0.77d 2.41±0.82d Oviposition 2017-18 3.68±0.81a 3.82±1.81a 1.50±0.51a 3.18±0.81 2.34±0.42b 2.41±0.82d 2.09±0.66d 2.34±	Pre-	2017-18	3.91±0.88a	3.41±0.60a	1.68±0.67d	2.86±0.75b	3.05±0.79b	2.36±0.49c	2.59±0.50bc	3.45±0.89a	1.77±0.55d	2.27±0.44c
period Pooled 3.95±0.80a 3.45±0.60b 1.75±0.68f 2.91±0.63cd 3.09±0.92c 2.41±0.50e 2.61±0.59de 3.48±0.75b 1.89±0.56f 2.34±0.47e Ovipoin period 18.73±2.05a 15.23±1.44b 5.23±0.44b 12.59±1.27d 13.27±0.97cd 10.23±1.61e 7.91±1.15f 13.45±1.05c 6.00±0.65b 7.05±1.32g Ovipoin period 18.82±1.51a 15.05±0.95b 5.41±0.69b 12.77±1.47d 13.41±0.99cd 10.32±1.81e 8.00±0.92f 13.59±1.32c 6.14±0.91b 7.11±1.13g Pooled 18.77±1.78a 15.36±1.19b 5.32±0.66i 12.68±1.37d 13.34±0.98c 10.27±1.01e 7.95±1.03f 13.52±1.14c 6.07±0.78b 7.11±1.13g Post 2017-18 3.68±0.81ab 3.77±1.29a 1.45±0.51g 3.09±0.94c 3.25±0.51de 2.27±0.79ef 4.05±1.08a 2.09±0.56d 2.41±0.82a Oviposino period 2018-19 3.86±0.88ab 3.82±0.81a 1.50±0.51e 3.14±0.88a 3.61±0.7b 2.59±0.60c 2.64±0.68d 4.09±0.94a 2.09±0.56d 2.34±0.70cd	Oviposition period	2018-19	4.00±0.73a	3.50±0.60b	1.82±0.70g	2.95±0.51cd	3.14±1.07bc	2.45±0.51e	2.64±0.68de	3.50±0.60b	2.00±0.56fg	2.41±0.50ef
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Pooled	3.95±0.80a	3.45±0.60b	1.75±0.68f	2.91±0.63cd	3.09±0.93c	2.41±0.50e	2.61±0.59de	3.48±0.75b	1.89±0.56f	2.34±0.47e
Odysition period 2018-19 18.82±1.51a 15.50±0.95b 5.41±0.69h 12.77±1.47d 13.41±0.99cd 10.32±1.81e 8.00±0.92f 13.59±1.23c 6.14±0.91h 7.18±0.93g Pooled 18.77±1.78a 15.36±1.19b 5.32±0.66i 12.68±1.37d 13.34±0.98c 10.27±1.71e 7.95±1.03f 13.52±1.14c 6.07±0.78h 7.11±1.13g Post - 2017-18 3.68±0.81ab 3.77±1.29a 1.45±0.51g 3.09±0.94cd 3.27±1.20bc 2.55±0.51de 2.27±0.79ef 4.05±1.08a 2.00±0.56f 2.27±0.57ef oviposition 2018-19 3.86±0.88ab 3.82±0.81ab 1.50±0.51e 3.18±0.81c 3.45±0.94bc 2.64±0.68d 2.45±0.89d 4.14±0.81a 2.18±0.77d 2.41±0.82d period Pooled 3.77±0.84a 3.80±1.05a 1.48±0.51e 3.14±0.85b 3.56±1.07b 2.59±0.60c 2.36±0.84cd 4.09±0.94a 2.09±0.66d 2.34±0.70cd 2017-18 41.05±2.99a 38.32±2.81b 28.45±1.61h 35.14±1.95d 3.55±1.75d 3.05±1.37e 31.74±2.61bc 29.09±0.62g 30.54±1.92g <td>0</td> <td>2017-18</td> <td>18.73±2.05a</td> <td>15.23±1.44b</td> <td>$5.23\pm0.64h$</td> <td>12.59±1.27d</td> <td>13.27±0.97cd</td> <td>10.23±1.61e</td> <td>7.91±1.15f</td> <td>13.45±1.05c</td> <td>6.00±0.65h</td> <td>7.05±1.32g</td>	0	2017-18	18.73±2.05a	15.23±1.44b	$5.23\pm0.64h$	12.59±1.27d	13.27±0.97cd	10.23±1.61e	7.91±1.15f	13.45±1.05c	6.00±0.65h	7.05±1.32g
Period Pooled 18.77±1.78a 15.36±1.19b 5.32±0.66i 12.68±1.37d 13.34±0.98c 10.27±1.71e 7.95±1.03f 13.52±1.14c 6.07±0.78h 7.11±1.13g Post - 2017-18 3.68±0.81ab 3.77±1.29a 1.45±0.51g 3.09±0.94cd 3.27±1.20b 2.55±0.51de 2.27±0.79f 4.05±1.08a 2.00±0.56f 2.27±0.57e oviposition 2018-19 3.86±0.88ab 3.82±0.81ab 1.50±0.51e 3.18±0.81c 3.45±0.94bc 2.64±0.68d 2.45±0.89d 4.14±0.81a 2.18±0.77d 2.41±0.82d period Pooled 3.77±0.84a 3.80±1.05a 1.48±0.51e 3.14±0.88b 3.65±1.07b 2.59±0.60c 2.36±0.84d 4.09±0.94a 2.09±0.66d 2.41±0.82d Pooled 3.77±0.84a 3.80±1.05a 1.48±0.51e 3.14±0.84b 3.05±1.07b 2.59±0.60c 2.36±0.84d 4.09±0.94a 2.09±0.64d 2.49±0.72d 2.94±0.72d 2.94	period	2018-19	18.82±1.51a	15.50±0.95b	$5.41\pm0.69h$	12.77±1.47d	13.41±0.99cd	10.32±1.81e	8.00±0.92f	13.59±1.23c	6.14±0.91h	7.18±0.93g
$ \begin{array}{c} \mbox{Post-} \\ \mbox{Post-} \\ \mbox{Poise} \\ \mbox{Post-} $		Pooled	18.77±1.78a	15.36±1.19b	5.32±0.66i	12.68±1.37d	13.34±0.98c	10.27±1.71e	7.95±1.03f	13.52±1.14c	6.07±0.78h	7.11±1.13g
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Post - oviposition	2017-18	$3.68{\pm}0.81ab$	3.77±1.29a	1.45±0.51g	3.09±0.94cd	3.27±1.20bc	2.55±0.51de	2.27±0.79ef	4.05±1.08a	2.00±0.56f	2.27±0.57ef
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		2018-19	$3.86{\pm}0.88ab$	3.82±0.81ab	1.50±0.51e	3.18±0.81c	3.45±0.94bc	2.64±0.68d	2.45±0.89d	4.14±0.81a	2.18±0.77d	2.41±0.82d
Note 2017-18 41.05±2.99a 38.32±2.81b 28.45±1.61h 35.14±1.95d 35.82±2.27cd 32.50±1.93e 30.86±2.55f 37.14±2.61bc 29.00±1.72bf 29.05±1.92fg 2018-19 41.05±2.99a 39.23±2.03b 29.09±2.5g 35.82±1.80d 36.45±3.14cd 33.05±3.19e 31.27±3.15f 37.64±2.05b 29.69±2.37g 30.68±2.07g Poole 41.50±2.94a 38.80±2.22b 28.77±1.93b 35.48±1.88d 36.14±2.70d 32.77±2.56e 31.07±2.84f 37.39±2.33c 29.43±2.04g 30.22±1.99fg Poole 41.50±2.94a 38.80±2.22b 28.77±1.93b 29.43±1.41b 29.09±2.48cd 24.09±1.86f 26.32±0.04c 30.77±2.8c 29.43±0.4g 30.32±1.99fg Poole 36.64±2.13a 35.9±1.19b 21.05±1.41b 28.23±3.10d 29.09±2.81d 25.09±2.00fg 27.09±1.54c 31.45±2.55c 23.18±1.36f 24.00±2.37f Poole 36.66±2.13a 35.9±1.87b 20.73±1.70b 28.73±2.44d 29.30±2.65d 24.59±1.93f 26.66±1.79c 31.45±2.55c 23.05±1.63g 24.59±1.83f 24.59±1.83f	period	Pooled	3.77±0.84a	3.80±1.05a	1.48±0.51e	3.14±0.88b	3.36±1.07b	2.59±0.60c	2.36±0.84cd	4.09±0.94a	2.09±0.66d	$2.34{\pm}0.70$ cd
$ \begin{array}{c} 104 \text{ mm} \\ \text{span fem} \\ \begin{array}{c} 2018 - 19 & 41.95 \pm 2.89 & 39.23 \pm 2.03 & 29.09 \pm 2.5 & 35.82 \pm 1.80 & 36.45 \pm 3.14c & 33.05 \pm 3.19 & 31.27 \pm 3.15 & 37.64 \pm 2.05 & 29.86 \pm 2.37 & 30.68 \pm 2.06 & 30.25 \pm 1.90 & 30.84 \pm 1.80 & 36.14 \pm 2.70 & 32.77 \pm 2.56 & 31.07 \pm 2.81 & 37.39 \pm 2.33 & 29.43 \pm 2.04 & 30.32 \pm 1.99 & 30.22 \pm 1.99 & 30.42 \pm 1.99 &$	Total life span female	2017-18	$41.05 \pm 2.99a$	38.32±2.81b	28.45±1.61h	35.14±1.95d	35.82±2.27cd	32.50±1.93e	30.86±2.53f	37.14±2.61bc	29.00±1.72gh	29.95±1.92fg
Spannen Pooled 41.50±2.94a 38.80±2.22b 28.77±1.93h 35.48±1.88d 36.14±2.70d 32.77±2.56e 31.07±2.84f 37.39±2.33c 29.43±2.04gh 30.32±1.99fg Total life span mah 2017-18 36.91±1.92a 32.32±2.56b 20.41±1.98g 29.23±1.77d 29.59±2.48cd 24.09±1.86f 26.32±0.04c 30.77±2.78c 23.18±1.36f 24.00±2.37f 2018-19 36.41±2.35a 33.59±1.19b 21.05±1.41h 28.23±3.10d 29.00±2.81d 25.09±2.00f 27.00±1.54c 32.14±2.32c 22.91±1.89g 25.18±1.35f Pooled 36.66±2.13a 32.95±1.87b 20.73±1.70h 28.73±2.44d 29.30±2.65d 24.59±1.93f 26.66±1.79c 31.45±2.55c 23.05±1.63g 24.59±1.86f Fecundity 107.23±4.87a 73.05±2.96b 27.3±0.94i 61.27±1.21c 64.55±1.50d 56.27±1.25f 54.27±2.48f 67.50±6.34c 32.95±1.52h 38.50±2.57k Fecundity 95.32±1.82a 74.23±3.10b 28.25±2.67i 62.50±1.28c 66.09±1.80d 56.55±1.15f 55.68±0.99f 68.09±5.15c 34.09±1.69h		2018-19	$41.95{\pm}2.89a$	$39.23{\pm}2.03b$	29.09±2.25g	$35.82{\pm}1.80d$	36.45±3.14cd	33.05±3.19e	31.27±3.15f	37.64±2.05bc	29.86±2.37g	30.68±2.06fg
2017-18 36.91±1.92a 32.32±2.56b 20.41±1.98g 29.23±1.77d 29.59±2.48cd 24.09±1.86f 26.32±0.4b 30.77±2.78c 23.18±1.36f 24.00±2.37f 2018-19 36.41±2.32a 33.59±1.19b 21.05±1.41h 28.23±3.10d 29.09±2.48cd 25.09±2.00f 27.00±1.54c 32.14±2.32c 29.91±1.89g 25.18±1.35f Poole 36.66±2.13a 32.95±1.87b 20.73±1.70h 28.73±2.44d 29.30±2.65d 24.59±1.93f 26.66±1.79c 31.45±2.55c 23.05±1.63g 24.59±1.84f Poole 107.23±4.87a 73.05±2.96b 27.3±0.94i 61.7±1.21c 64.55±1.50d 56.27±1.25f 54.27±2.48f 67.50±6.34c 29.9±1.54f 38.50±2.57g Poole 106.7±5.49a 74.23±3.10b 28.25±2.67i 62.50±1.28c 66.09±1.80d 56.55±1.15f 55.68±0.99f 68.09±5.15c 34.09±1.69h 39.05±2.72g Pooled 106.7±5.49a 73.64±3.03b 27.74±2.30j 61.89±1.24c 56.32±1.65d 56.41±1.20f 54.98±1.73g 67.80±5.74c 35.2±1.61i 38.77±2.63h		Pooled	41.50±2 .94a	$38.80{\pm}2.22b$	28.77±1.93h	$35.48{\pm}1.88d$	$36.14{\pm}2.70d$	32.77±2.56e	31.07±2.84f	37.39±2.33c	29.43±2.04gh	30.32±1.99fg
$ \begin{array}{c} 104 \\ \text{span mah} \end{array} \left\{ \begin{array}{c} 2018-19 \\ \text{sol} 36.41\pm2.35 \\ \text{sol} 36.59\pm1.19b \\ 21.05\pm1.41b \\$	Total life span male	2017-18	36.91±1.92a	$32.32 \pm 2.56b$	20.41±1.98g	29.23±1.77d	29.59±2.48cd	24.09±1.86f	26.32±2.04e	30.77±2.78c	$23.18{\pm}1.36f$	$24.00{\pm}2.37f$
Span mark Pooled 36.66±2.13a 32.95±1.87b 20.73±1.70b 28.73±2.44d 29.30±2.65d 24.59±1.93f 26.66±1.70e 31.45±2.55c 23.05±1.63g 24.59±1.87b 2017-18 107.23±4.87a 73.05±2.96b 27.23±0.94i 61.27±1.21e 64.55±1.50d 56.27±1.25f 54.27±2.48f 67.50±6.34c 32.95±1.52b 38.50±2.54g Fecundity 95.32±1.82a 74.23±3.10b 28.25±2.67i 62.50±1.28e 66.09±1.80d 56.55±1.15f 55.68±0.99f 68.09±5.15c 34.09±1.69b 39.05±2.72g Pooled 106.71±5.49a 73.64±3.03b 27.74±2.30j 61.89±1.24e 65.32±1.65d 56.41±1.20f 54.98±1.73g 67.80±5.74c 33.52±1.61i 38.77±2.63h		2018-19	36.41±2.35a	33.59±1.19b	21.05±1.41h	28.23±3.10d	29.00±2.81d	25.09±2.00f	27.00±1.54e	32.14±2.32c	22.91±1.89g	$25.18{\pm}1.35f$
2017-18 107.23±4.87a 73.05±2.96b 27.23±0.94i 61.27±1.21e 64.55±1.50d 56.27±1.25f 54.27±2.48f 67.50±6.34c 32.95±1.52b 38.50±2.54g Fecundity 95.32±1.82a 74.23±3.10b 28.25±2.67i 62.50±1.28e 66.09±1.80d 56.55±1.15f 55.68±0.99f 68.09±5.15c 34.09±1.69h 39.05±2.72g Pooled 106.71±5.49a 73.64±3.03b 27.74±2.30j 61.89±1.24e 65.32±1.65d 56.41±1.20f 54.98±1.73g 67.80±5.74c 33.52±1.61i 38.77±2.63h		Pooled	36.66±2.13a	32.95±1.87b	20.73±1.70h	28.73±2.44d	29.30±2.65d	24.59±1.93f	26.66±1.79e	31.45±2.55c	23.05±1.63g	$24.59{\pm}1.86f$
Pecundity 2018-19 95.32±1.82a 74.23±3.10b 28.25±2.67i 62.50±1.28e 66.09±1.80d 56.55±1.15f 55.68±0.99f 68.09±5.15c 34.09±1.69h 39.05±2.72g Pooled 106.71±5.49a 73.64±3.03b 27.74±2.30j 61.89±1.24e 65.32±1.65d 56.41±1.20f 54.98±1.73g 67.80±5.74c 33.52±1.61i 38.77±2.63h	Fecundity	2017-18	107.23±4.87a	73.05±2.96b	27.23±0.94i	61.27±1.21e	64.55±1.50d	56.27±1.25f	54.27±2.48f	67.50±6.34c	32.95±1.52h	38.50±2.54g
$Pooled \ 106.71 \pm 5.49a \ 73.64 \pm 3.03b \ 27.74 \pm 2.30j \ 61.89 \pm 1.24e \ 65.32 \pm 1.65d \ 56.41 \pm 1.20f \ 54.98 \pm 1.73g \ 67.80 \pm 5.74c \ 33.52 \pm 1.61i \ 38.77 \pm 2.63h \ 56.95 \pm 1.73g \ 67.80 \pm 5.74c \ 54.98 \pm 1.73g \ 67.80 \pm 5.74c \ 54.98 \pm 1.73g \ 54$		2018-19	95.32±1.82a	74.23±3.10b	28.25±2.67i	62.50±1.28e	66.09±1.80d	56.55±1.15f	55.68±0.99f	68.09±5.15c	34.09±1.69h	39.05±2.72g
		Pooled	106.71±5.49a	73.64±3.03b	27.74±2.30j	61.89±1.24e	65.32±1.65d	56.41±1.20f	54.98±1.73g	67.80±5.74c	33.52±1.61i	$38.77 \pm 2.63 h$

Number of observations=20; Figures showing the same alphabets are non-significant with each others

Conclusion

The investigation on the biology of stored grain mite *T. putrescentiae* was carried out on ten different broken grains. The total developmental period of mite was shortest on groundnut with longer ovipositional period and it was followed by wheat. The female longevity and fecundity was maximum on broken groundnut. Thus, from the present study it can be concluded that among all the hosts groundnut was most preferred host for mite *T. putrescentiae* and utmost care should be taken during its storage.

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