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Research Article

BIOLOGY OF RED SPIDER MITE, TETRANYCHUS MACFARLANEI BAKER AND PRITCHARD ON SOYBEAN

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Abstract- Studies on biology of red spider mite, *T. macfarlanei* on soybean was carried out at Department of Agricultural Entomology, College of Agriculture, Navile, Shivamogga. The total duration from egg to adult emergence or the total developmental period was less in male (10.62 ± 0.69 days) compared to female (11.92 ± 0.89 days). Adult longevity for male was 11.37 ± 0.69 days whereas, the adult female lived for 24.61 ± 0.57 days. Fecundity results indicated that mated females laid more eggs than unmated females. Mated and unmated females laid, on an average, 54.93 ± 8.08 and 31.87 ± 2.61 eggs, respectively. Correspondingly mated females laid 2.12 to 3.13 (2.69 ± 0.18) eggs per day and unmated females laid 1.36 to 1.59 (1.44 ± 0.12) eggs per day.

Keywords- Red spider mite, oilseed crops

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Introduction

Soybean is one of the most important oilseed crops of India. In India soybean has acquired third position among the oilseeds after groundnut and mustard. It is a unique crop with high nutritional value, contains 40 percent protein and 20 percent edible oil besides other minerals and vitamins. In India, in the year 2016-17, soybean cultivation extended to 11.33 million ha with record production of 11.00 million tonnes and an average yield of 970 kg per ha [1]. The exuberant crop growth, soft and succulent foliage attracts many insects and non insect pests and provides unlimited source of food, space and shelter for them. About 380 species of insects and non insect pests *viz*., one mite, two millipedes, ten vertebrates and one snail have been reported on soybean crop from many soybean growing countries around the world [2]. Among the non-insect pests, red spider mites are the notably notorious pests and gaining tremendous importance in recent years owing to their devastating nature and damage potential. *Tetranychus macfarlanei* Baker and Pritchard is a well known species, recorded in serious proportions on cotton, soybean, cucurbits, brinjal, okra, *etc* [3,4]. Soybean fields infested with spider mites during late vegetative and early reproductive growth have recorded yield reduction of 40-60 percent. The injury caused by spider mites in soybean results from perforation of lower epidermal cells. High infestation of these mites reduce the photosynthetic rate, damage the leaf mesophyll and cause closure of stomata. This leads to the formation a chlorotic spot [5]. At higher levels of damage by spider mites, the chlorophyll content decreases by 55.26 percent and the carotenoid content by 79.3 percent, ultimately it affects the yield and protein content in soybean [6]. For effective management of these tiny but most notorious pests, knowledge about their biology is a prime requisite.

Materials and Methods

Studies on biology of red spider mite, *T. macfarlanei* on soybean was carried out at Department of Agricultural Entomology, College of Agriculture, Navile, Shivamogga. Pure culture of red spider mite *T. macfarlanei* was initiated by collecting the mite infested leaves from soybean field at AHRS, Bavikere.

Collected mites were identified by Dr. C. Chinnamade Gowda, Junior Acarologist, All India Network Project (AINP), GKVK Bangalore. Mites from pure culture were used for mass multiplication in laboratory for further biology studies [Plate-1]. The mites were reared on soybean leaves following the technique of Rodriguez (1953) and Gilstrap (1977) with slight modification. The soybean leaves were kept on wet cotton wad with undersurface up in a petri dish (10 cm diameter) and they were used for rearing the mites. Water was added frequently to keep the cotton wad moist to maintain the leaves in turgid condition. Deteriorating leaves along with mites were carefully removed and kept on fresh leaves. The mites from the previous leaves (deteriorating leaves) migrated to the fresh leaves as the older leaves progressively dried. Twenty five gravid females were released on a fresh leaf in the petridish and allowed overnight in order to obtain the eggs. Next morning the eggs were lifted carefully with the help of a '0' number camel's hair brush and transferred to a previously prepared leaf discs at the rate of one egg per leaf disc per petri plate. Such thirty plates were maintained to study the biology. The observations on development of various stages of mites were observed twice a day with the help of stereoscopic binocular microscope. The observations on developmental periods *viz*., incubation period, duration of larva, protonymph, deutonymph, and quiescent stages (nymphochrysalis, deutochrysalis and teleiochyrsalis), pre-oviposition, oviposition and post- oviposition periods, fecundity and longevity of adults were recoreded. Whenever a change to next stage was observed, the midpoint between the two observations was considered as the time of moulting. But if moulting was taking place at the time of observations then it was taken as the time of moulting. When the mites reached adult stage, the opposite sex mite which developed on other leaf disc was released on this leaf disc to observe mating, pre-oviposition, oviposition and post-oviposition periods and also fecundity and longevity of the mites. For recording the fecundity, a pair of adult mites (male and female) was separately released after emergence on the petri dish having soybean leaf and the eggs laid by the female were recorded.

Similarly, eggs laid by unmated females were also recorded by releasing the adult females separately on the petri dish with soybean leaf. As the sex ratio was found to be 1: 9.6, the number of eggs laid by the individual female was divided by 9.6 to get the number of female births. Similarly, the number of eggs laid by mated and unmated females were also recorded. The morphometric measurements of different mite stages were taken from ocular micrometer fitted to stereo binocular microscope.

Results and Discussion

Incubation period

The eggs were laid singly on the lower surface of the leaves as well as on the webbings [Plate-2]. The freshly laid eggs were smooth, spherical in shape, translucent white and they gradually turned brown and then creamy pink towards the end of the incubation period. The incubation period ranged from 3.16 to 4.43 days with an average of 3.57 ± 0.38 days for males and for females the incubation period ranged between 3.51 and 4.50 days with an average of 3.88 ± 0.33 days [Table-1]. The egg measured 0.13 ± 0.01 mm in diameter [Table-3].

Table-1 Developmental periods of life stages of *Tetranychus macfarlanei* on soybean

Stage	Sex	Range	Duration in Days (Mean ± SD)
Incubation	Male	3.16-4.43	3.57 ± 0.38
	Female	3.51-4.50	3.88 ± 0.33
Larva	Male	2.00-2.92	2.18 ± 0.17
	Female	2.21-3.00	2.36 ± 0.19
Nymphochrysalis	Male	0.55-0.71	0.62 ± 0.05
	Female	0.59-0.83	0.77 ± 0.06
Protonymph	Male	1.62-1.94	1.79 ± 0.11
	Female	1.64-2.20	1.95 ± 0.16
Deutochrysalis	Male	0.49-0.67	0.57 ± 0.06
	Female	0.53-0.89	0.77 ± 0.10
Deutonymph	Male	1.03-1.32	1.16 ± 0.07
	Female	1.08-1.36	1.27 ± 0.09
Teliochrysalis	Male	0.55-0.87	0.73 ± 0.11
	Female	0.59-1.03	0.92 ± 0.10
Total Developmental Period	Male	9.23-11.71	10.62 ± 0.69
	Female	10.42-12.05	11.92 ± 0.89

Sample size n=30

Table-2 Ovipositional period, fecundity and longevity of *Tetranychus macfarlanei* on soybean

Period	Sex	Range	Duration in Days (Mean ± SD)
Preoviposition	Mated Female	1.05-1.68	1.52 ± 0.15
	Unmated Female	0.96-1.33	1.21 ± 0.12
Oviposition	Mated Female	18.64-22.28	20.39 ± 1.27
	Unmated Female	19.30-24.17	22.17 ± 1.30
Post oviposition	Mated Female	1.96-2.93	2.70 ± 0.20
	Unmated Female	2.12-2.98	2.50 ± 0.28
Adult Longevity	Male	10.69-12.18	11.37 ± 0.69
	Female	22.37-25.69	24.61 ± 0.57
Fecundity	Mated Female	41.62-68.83	54.93 ± 8.08
	Unmated Female	28.19-38.47	31.87 ± 2.61
No. of eggs / Day/Female	Mated Female	2.12-3.13	2.69 ± 0.18
	Unmated Female	1.36-1.59	1.44 ± 0.12
Total Life Cycle	Male	20.72-23.36	21.99 ± 1.86
	Female	35.12-37.79	36.53 ± 2.14

Larva

The newly emerged hexapod larva was almost spherical or slightly oval in shape with two bright prominent red spots which were present on the sides of the dorsal propodosomal region [Plate-2]. The larva initially crawled around for some time and settled at a place to feed on the cell sap. Initially the larva was creamy white in colour and it turned green upon feeding and finally it turned dark green after feeding for some time with dark specks appearing dorsolaterally. The larval period for male ranged from 2.00 to 2.92 days with an average of 2.18 ± 0.17 days. Whereas, the female larval period ranged between 2.21 and 3.00 days with an average of 2.36 ± 0.19 days [Table-1]. The larva measured 0.19 ± 0.02 mm in length and 0.14 ± 0.02 mm in width [Table-3].

Table-3 Morphometric differences of various stages of the red spider mite, *Tetranychus macfarlanei*

Stage	Length (mm)	Width(mm)
Egg(diameter)	0.13 ± 0.01	
Larva	0.19 ± 0.02	0.14 ± 0.01
Nymphochrysalis	0.23 ± 0.01	0.14 ± 0.02
Protonymph	0.35 ± 0.03	0.20 ± 0.03
Deutochrysalis	0.32 ± 0.05	0.16 ± 0.04
Deutonymph	0.38 ± 0.03	0.24 ± 0.02
Teliochrysalis	0.37 ± 0.02	0.26 ± 0.04
Adult Male	0.34 ± 0.02	0.16 ± 0.01
Adult Female	0.50 ± 0.04	0.28 ± 0.03

Sample size n=30

Nymphochrysalis

The matured larva entered the quiescent stage I by anchoring itself to the leaf surface and assumed a characteristic pose by bending the first tarsi underneath the legs and the second and third pair of legs were stretched backwards and held close to the sides of opisthosoma [Plate-2]. The colour in this stage was dark green. This quiescent stage ranged from 0.55 to 0.71 days and 0.59 to 0.83 days, for male and female, respectively. This stage lasted for 0.62 ± 0.05 days in case of male and 0.77 ± 0.06 days for females [Table-1]. The nymphochrysalis stage measured 0.23 ± 0.01 mm in length and 0.14 ± 0.02 mm in width [Table-3].

Protonymph

The nymphochrysalis moulted to protonymph which was oval in shape with four pair of legs. Initially it was dark green in colour and turned to amber colour later in the stage [Plate-2]. The duration of protonymphal stage ranged from 1.62 to 1.94 days for male and 1.64 to 2.20 days for female with an average of 1.79 ± 0.11 days for male and 1.95 ± 0.16 days for female [Table-1). The protonymph measured 0.35 ± 0.03 mm in length and 0.20 ± 0.03 mm in width [Table-3].

Deutochrysalis

The matured protonymph entered the quiescent stage II known as deutochrysalis [Plate-2]. At this stage the mite became inactive by suspending all the activities such as feeding and remained anchored to the leaf surface. This quiescent stage ranged between 0.49 and 0.67 days for male and 0.53 to 0.89 days for female with an average of 0.57 ± 0.06 and 0.77 ± 0.10 days for male and female, respectively [Table-1]. It measured 0.32 ± 0.05 mm in length and 0.16 ± 0.04 mm in width [Table-3].

Deutonymph

The deutonymph which emerged from deutochrysalis was carmine red in colour [Plate-2]. Sex determination was possible in this stage as the male was elongated and smaller in size whereas, the female was broader and large. This stage ranged from 1.03 to 1.32 days for male and the female ranged between 1.08 and 1.36 days. The average duration of deutonymph was 1.16 ± 0.07 days for male and 1.27 ± 0.09 days for male [Table-1]. It measured 0.38 ± 0.03 mm in length and 0.24 ± 0.02 mm in width [Table-3].

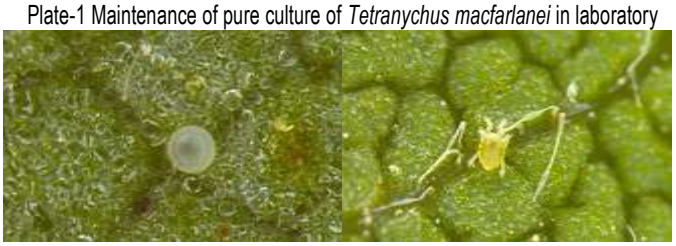
Teliochrysalis

The matured deutonymph entered the quiescent stage III known as teliochrysalis [Plate-2]. The body of the mite shrank and it was light carmine in colour. The teliochrysalis stage ranged from 0.55 to 0.87 days for male and 0.59 to 1.03 days for female. This stage lasted for 0.73 ± 0.11 and 0.92 ± 0.10 days for male and female, respectively [Table-1]. The teliochrysalis stage measured 0.37 ± 0.02 mm in length and 0.26 ± 0.04 mm in width [Table-3].

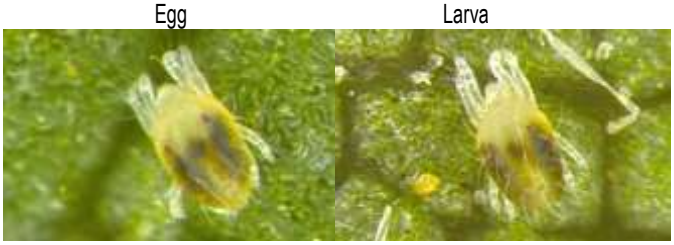
Total developmental period

The total duration from egg to adult for male ranged from 9.23 to 11.71 days with an average of 10.62 ± 0.69 days. Whereas, for female the range was between 10.42 and 12.05 days, on an average the total duration from egg to adult for female was 11.92 ± 0.89 days. The total developmental period for male was less compared to female [Table-1].

Plate-1 Maintenance of pure culture of *Tetranychus macfarlanei* in laboratory



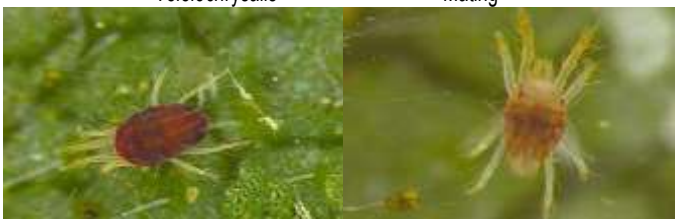
Egg Larva



Nymphochrysalis Protonymph

Deutochrysalis Deutonymph

Teleiochrysalis Mating



Adult female Adult male

Plate-2 Life stages of *Tetranychus macfarlanei*

Adult

The adults emerged from the skin of teliochrysalis by splitting it dorsally and their activities immediately. Sexual dimorphism was clearly visible at this stage.

Male

The males had narrow body with distinctly pointed abdomen and they were smaller than females. There were two red spots corresponding to the simple eyes and they were clearly visible. Initially the body colour was reddish green and later it turned to pinkish in colour. The first pair of legs was longer than the fourth pair of legs whereas, the second and third pair of legs were similar in size [Plate-2]. After emergence they were found wandering or waiting over the female quiescent stage i.e., female teliochrysalis for mating. The adult longevity of male ranged from 10.69 to 12.18 days with an average of 11.37 ± 0.69 days [Table-2]. The adult male measured 0.34 ± 0.02 mm in length and 0.16 ± 0.01 mm in width [Table-3].

Female

Soon after the emergence the females were bright red and later turned to deep red or brick red in colour. The simple eyes were located on the sides of dorsal propodosomal region. The females were bigger than males with rounded or oval abdomen [Plate-2]. The adult lifespan of female ranged from 22.37 to 25.69 days with an average of 24.61 ± 0.57 days [Table-2]. The adult female measured 0.50 ± 0.04 mm in length and 0.28 ± 0.03 mm in width [Table-3].

Mating

Always the males emerged little earlier than the females and wandered in search of quiescent female deutonymph (teliochrysalis). After finding the quiescent female deutonymph it placed the anterior pair of legs on female and waited for its emergence in order to mate immediately after the emergence [Plate-2]. Sometimes there was competition between three or four males. In many case males helped the females for emerging out of deutonymphal skin by pulling the ecdysial skin. Soon after the emergence the male slide underneath the female with its hysterosoma upturned while the female raised its posterior abdomen to accommodate the male for mating. The male held the female by its front two pairs of legs in the process of coupling. Mating lasted for a brief period of one to three minutes. Usually the female mated only once but the male was observed mating with several females.

Sex ratio

Mated females produced both male and female progenies whereas; the unmated females produced only male progenies. The male to female ratio of sexually reproduced population of *T. macfarlanei* was worked out as 1: 9.6.

Pre oviposition period

The females laid eggs only after a lapse of certain period and this period lasted for 1.05 to 1.68 (1.52 ± 0.15) days for mated females and 0.96 to 1.33 (1.21 ± 0.12) days for unmated females. Since, the females were fertilized soon after emergence the pre copulation period was negligible in mated females [Table-2].

Oviposition period

Oviposition period ranged from 18.64 to 22.28 days for mated females and 19.30 to 24.17 days for unmated females with an average of 20.39 ± 1.27 and 22.17 ± 1.30 days for mated and unmated females, respectively [Table-2].

Fecundity

Fecundity data revealed that an average of 54.93 ± 8.08 (41.62 – 68.83) and 31.87 ± 2.61 (28.19 – 38.47) eggs were laid by mated and unmated females, respectively. No. of eggs per day per female for mated female was 2.69 ± 0.18 (2.12 – 3.13) eggs whereas, unmated females laid 1.44 ± 0.12 (1.36 – 1.59) eggs per day [Table-2].

Post oviposition period

Post oviposition period lasted for 2.12 to 2.98 (2.70 ± 0.20) days for mated female and 1.96 to 2.93 (2.50 ± 0.28) days for unmated female [Table-2].

Total life cycle

Males completed their life cycle in 21.99 ± 1.86 (20.72 – 23.36) days Whereas, females took 36.53 ± 2.14 (35.12 – 37.79) days to complete their life cycle. It was clear from the results that males took less time than females to complete their life cycle [Table-2]. These results are in line with the earlier workers. The total duration from egg to adult emergence or the total developmental period was less in male (10.62 ± 0.69 days) compared to female (11.92 ± 0.89 days). These results agree with the findings of Sitharama (2010) who reported that the average developmental period in *T. macfarlanei* was 10.67 ± 0.55 days and 11.93 ± 0.51 days for male and female, respectively. Adult longevity for male was 11.37 ± 0.69 days whereas, the adult female lived for 24.61 ± 0.57 days. These findings are in line with the findings of Jose and Shah (1989) who reported that adult longevity for male was 11.46 ± 1.06 days and 19.84 ± 1.46 days for female.

Fecundity data revealed that mated females laid more eggs than unmated females. Mated and unmated females laid, on an average, 54.93 ± 8.08 and 31.87 ± 2.61 eggs, respectively. Correspondingly mated females laid 2.12 to 3.13 (2.69 ± 0.18) eggs per day and unmated females laid 1.36 to 1.59 (1.44 ± 0.12) eggs per day. These results are comparable with [7]. Higher fecundity in *T. macfarlanei* was reported by [8] who observed 137 eggs per female on cotton. It was observed that the males (21.99 ± 1.86 days) completed their life cycle earlier than females (36.53 ± 2.14 days). These results are comparable with [3] who reported that male lived for 19.90 ± 2.86 days and female lived for 39.13 ± 5.93 days on cotton. Male to female ratio of sexually reproduced population of *T. macfarlanei* was worked out as 1: 9.6. This phenomenon of preponderance of female over male has already been documented by earlier workers. The percent viability of eggs (89-96.5 percent) was similar to that observed by [8].

Conclusion

Spider mites are one of the most important agricultural pests throughout the world due to their polyphagous nature, high reproductive rate and short life cycle which contributes to resistance development to acaricides (Hildebrand et al., 1986). Thus, to overcome these problems the study on biology of *T. macfarlanei* on soybean was undertaken. Biology of *T. macfarlanei* revealed that male had less developmental period and adult longevity compared to female. Unmated females laid fewer eggs than that of mated females.

Application of research: Now a day's Red spider mite is becoming a major problem in almost all crops so as in Soybean. Biology of this pest varies from place to place as well in different crop ecosystems. The present study aimed at the biology of red spider mite in Soybean ecosystem will help the pest managers in understanding its life cycle and advising suitable control measures against this pest.

Research Category: Biology of Red Spider Mite

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