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Seasonal impact on life-fertility table parameters of *Oligonychus sapienticolus* Gupta infesting banana under Gangetic Basin of West Bengal, India

S. Dey and K. Karmakar*

Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Nadia -741 252, India

***Corresponding Author Email :** acarikarmakar@rediffmail.com

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Abstract

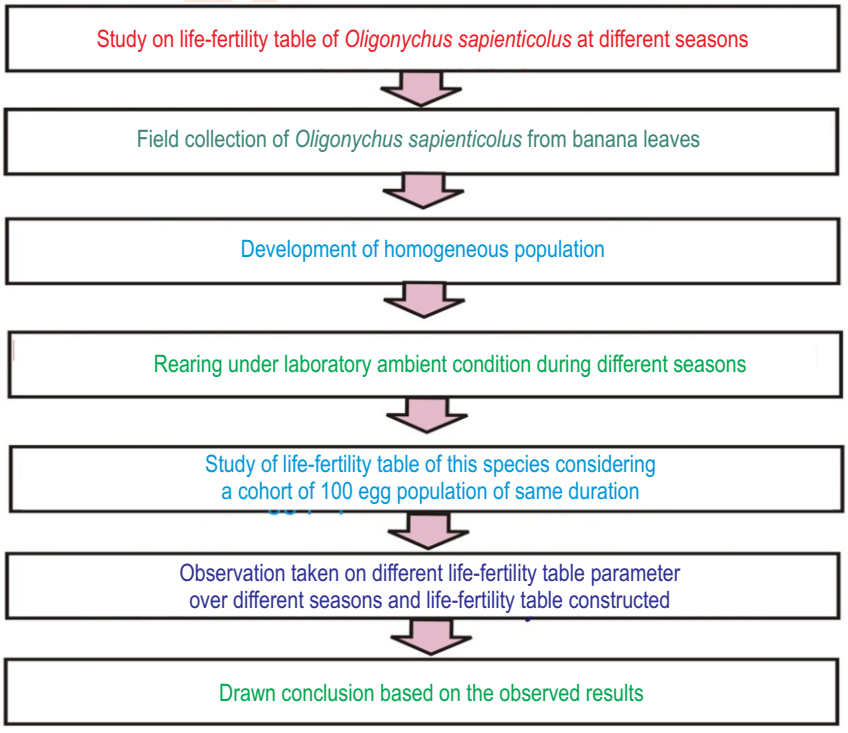
Aim : The aim of the present study was to investigate the impact of seasonal variation on life-fertility table of *Oligonychus sapienticolus* Gupta.

Methodology : Adult mite population were collected from infested banana leaves and reared under laboratory condition. A cohort of 100 eggs laid at a time by a population of 100 gravid females was considered for the experiment. This cohort was used for constructing of age specific life-fertility table. Seasonal impact on different life-fertility table parameters were studied by using different formulas.

Results : The perusal of data showed that the net reproductive rate, finite rate of increase and innate capacity for increase in number were highest during summer months, but mean generation time, doubling time and corrected generation time declined with increase in temperature.

Interpretation : The study concludes that this mite prefer hot and dry climatic condition for better growth and development. So, during this period appropriate management measures against this mite will avoid the chances of yield loss of banana plantation.

Key words: Banana, Life-fertility table, *Oligonychus sapienticolus,* Seasonal impact



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Introduction

Banana (*Musa* sp.; Family: Musacae) is one of the most important tropical fruit crops which is native to tropical Indo-Malaya and Australian region. It is the fourth most important food commodity in the world after rice, wheat and corn (Karmakar and Dey, 2004). This fruit crop was first domesticated in Papua New Guinea and it is now cultivated over 130 countries in tropical and subtropical world. India occupies leading position in banana production in the world followed by China and Philippines. In India, the total area under banana cultivation 858 thousand ha where West Bengal occupies 49 thousand ha (Anonymous, 2017). In West Bengal, banana is cultivated throughout the year, especially in Gangetic alluvial zone and Teesta-Terai zone (Chattopadhyay and Hassan, 1996). Banana is enriched with high carbohydrate low sodium, high potassium and essential nutrient elements along with medicinal properties containing 89 kcal of energy without any cholesterol (Morton, 1987; Chandler, 1995; Robinson, 1996; Sidhu and Zafar, 2018).

Banana is attacked by more than two hundred species of insects and non-insect pests, among them Rhizome weevil (*Cosmopolites sordidus* Germar), Pseudostem weevil (*Odoiporus longicollis* Olivier), leaf scarring beetle (*Nodostoma subcostatum* Jacoby and *N. viridipennis* Motsculsky) and Banana aphid (*Pentalonia nigronervosa* Coquerel) are important (Simmonds, 1966 and Singh, 1970). With respect to non-insect pests, majority goes to nematodes and mites. From India, 71 nematode species belonging thirty three genera have been reported from Banana and from West Bengal 17 species have been recorded (Mukherjee and Dasgupta, 1983). The number of phytophagous mite viz., *Tetranychus urticae* Koch (Colombo *et al.,* 1993), *T. neocaledonicus* Andre, *T. cinnabarinus* Boisduval, *Oligonychus sapienticolus* Gupta, *O. indicus* Pritchard and Baker, *O. mangiferus* Rahman and Sapra (Gupta, 1985), *T. gloveri* Banks (Simon, 1991;1993), *T. tumidus* Banks (Ramos and Rodriguez, 1995; Prez *et al.,* 2004), *T. lombardinii* Baker and Pritchard (Jones 1978), *T. lambi* Prtichard and Baker (Williams, 1990), *T. piercei* McGregor (Zhang and Fu, 2004), *Panonychus ulmi* Koch (Karmakar and Dey, 2004), *Brevipalpus phoenicis* Geijskes (Arbabi *et al.,* 2002), *Phyllocoptruta musae* Keifer (Mohanasundaram *et al.,* 1989) and *Raoiella indica* Hirst (Kane and Ochoa, 2012) species have been reported to infest banana causing damage.

Among the above mentioned mite pests, *O. sapienticolus* has been observed as one of the potential mite pest attacking banana plantation under Gangetic Basin of West Bengal, and colonize at the ventral surface of leaves along the parallel veins during hot and dry period of the year. Under congenial condition, this mite species increase its population in a profuse number and appears as potential pest of banana. Perusal of available literatures reveal that none of research work has been carried out till date for studying the life-fertility table of this mite and assess the yield loss. Although several experiments have been conducted on bio-ecology, life-fertility table parameter and management by using other species of spider mites but none of the information has been generated on this mite species. Keeping this in view, the objective of present research work was to study the life-fertility table parameters of *O. sapienticolus* in three different seasons (January-February, February-March and March-April) and to understand details of its biological cycle which may be useful in future for formulating management strategies against this potential mite pest of banana.

Materials and Methods

Adult gravid females and males specimens of *O. sapienticolus* were collected from infested banana leaves (Cultivar: Martaman) from the banana field, Monduri Farm of BCKV and reared under laboratory condition to start the culture. The experiment was conducted under laboratory ambient condition which differed widely season to season. The laboratory was equipped with a hygrometer for recording relative humidity and maximum-minimum thermometer for recording mean temperature of the three different seasons. The mean temperature in January-February was recorded as 17°C and relative humidity 60%; in February-March temperature was 22°C and relative humidity 65% and March-April it was 28°C and relative humidity 85%, respectively. A plastic tray (10"x8") was taken and a foam pad was placed in the tray. Water was added to maintain the moisture level. Matured banana leaves, which were preferred by this mite, were collected from field, cleaned with water and wiped with cloth. Clean leaves were cut into pieces (6"x3"), placed on the tray and then mites were released on the leaves for their further oviposition and colonization.

After 6 hrs, adults were shifted to another tray and the eggs obtained were considered as single cohort followed by 100 larval population based on which the life-fertility table was constructed. The mites passed through different developmental stages like egg, larva, protonymph, deutonymph and adult stage. Larval stage was characterized by the presence of three pairs of legs and then protonymphal, deutonymphal and adult stage were characterized by the presence of four pairs of legs. Food material was changed at two or three days interval. Duration from egg to adult and ovipositional periods was recorded.

The total number of eggs laid by gravid females was recorded daily and it was continued till post-ovipositional period. The number of gravid females which survived in each pivotal age (days) were also counted. Same process was followed during other seasons. Life-fertility tables were constructed by using different parameters, pivotal age in days (x), survival data of gravid female individuals in each pivotal age (lx), female offspring produced per female in each age class (mx), net reproductive rate (R_0), mean generation time (T_0), corrected generation time (T), innate capacity for increase in number (r_m), finite rate of increase (λ) and doubling time (D_t). All the above mentioned parameters were calculated following Birch (1948).

Result and Discussion

Among different mite species infesting banana crop, banana spider mite, *Oligonychus sapienticolus* has been observed as one of the most damaging mite pest causing whitish specks along the leaf veins. Under congenial condition this mite specie increase its population in a profuse number and appears as potential pest of banana. Adult gravid females, yellowish green with dorso-lateral black dots, colonize at ventral leaf surface along the parallel leaf veins. Males are smaller than the females, with posterior part tapering in the former. They are characterized by leg pretarsus with strong empodial claw provided with basal proximo-ventral hairs, genual setal number, dorsal striation pattern. Male adeagus is used for species level identification. The shaft of adeagus of this species is elongated with a middle sigmoid part terminated with upward pointed tip. It was observed that *O. sapienticolus* completed its generation (T_0) within 18.69 days in the month of March-April and 30.44 days in January-February.

The population size was doubled in 4.33 days during March-April and in 9.90 days during January-February. The net reproductive rate (R_0) was 23.73 in March-April which was higher than other two seasons. Both innate capacity for increase in number (r_m) and finite rate of increase in number (λ), showed maximum values during summer. The details of life-fertility table parameters and seasonal impact on life fertility table parameters are presented in Table 1.

The perusal of data revealed that the fastest development of *Oligonychus sapienticolus* occurred during hot and dry weather of March-April, however, reverse phenomena was observed during January-February due to low temperature. Several researches conducted on life-fertility table parameters on spider mites are in accordance with the results of the present study. It was reported that higher temperature coupled with low humidity level was found favourable for rapid development while duration of developmental stages of two agriculturally important phytophagous mite genera *viz. Oligonychus* and *Tetranychus* reduced significantly (Abou-Awad *et al.,* 2011). Net reproductive rate (R_0) of *O. sapienticolus* was highest during March-April (23.73) due to prevailing hot and dry situation which accelerated the growth and development.

Congdon and Logan (1983) reported the highest net reproductive rate at 31°C and lowest at 19°C in *Oligonychus pratensis*. Net reproductive rate showed positive correlation with temperature and it was reflected in *Oligonychus mangiferus* (Abou-Awad *et al.,* 2011; Lin, 2013) and *Oligonychus afrasiaticus* (El-Halawany, 2013). The mean length of generation (T_0) is normally reduced with increase in temperature because hot weather accelerates the growth and development and reduce the

Table 1: Life-fertility table parameters of *Oligonychus sapienticolus* during winter season (January-February) under ambient laboratory conditions

Host	Winter season	x	lx	mx	lx*mx	x*lx*mx
		0-25	0.59	Including immature stages and pre oviposition period		
Banana leaf	Jan-Feb	26	0.59	0.25	0.14	3.64
		27	0.59	1.75	1.03	27.81
		28	0.59	3.25	1.91	53.48
		29	0.59	3.67	2.16	62.64
		30	0.49	2.11	1.03	30.90
		31	0.49	1.75	0.85	26.35
		32	0.41	1.65	0.67	21.44
		33	0.39	1.09	0.42	13.86
		34	0.39	0.93	0.36	12.24
		35	0.31	0.79	0.24	8.40
		36	0.31	0.71	0.22	7.92
		37	0.28	0.63	0.17	6.29
		38	0.25	0.52	0.13	4.94
		39	0.21	0.42	0.08	3.12
		40	0.20	0.39	0.07	2.80
		41	0.19	0.35	0.06	2.72
		42	0.18	0.29	0.05	2.1
		43	0.16	0.21	0.03	1.29
		44	0.12	0.15	0.01	0.44
		45	0.09	0.11	0.009	0.44
		46	0.08	0.10	0.008	0.36
		47	0.08	0.08	0.006	0.28
		48	0.06	0.07	0.004	0.19
		49	0.04	0.06	0.002	0.09
		50	0.02	0	0	0

Table 2: Life-fertility table parameters of *Oligonychus sapienticolus* during pre-summer season (February-March) under laboratory ambient condition

Host	Pre-summer season	x	lx	mx	lx*mx	x*lx*mx
		0-18	0.59	Including immature stages and pre oviposition period		
Banana leaf	Feb-March	19	0.59	0.60	0.35	6.65
		20	0.59	2.00	1.18	23.60
		21	0.59	3.80	2.24	47.04
		22	0.59	5.00	2.95	64.90
		23	0.43	5.40	2.32	53.36
		24	0.37	4.89	1.80	43.20
		25	0.31	4.67	1.44	36.00
		26	0.29	4.22	1.22	31.72
		27	0.27	3.87	1.04	28.08
		28	0.24	3.47	0.83	23.24
		29	0.21	3.19	0.66	19.14
		30	0.19	3.00	0.57	17.10
		31	0.16	2.17	0.34	10.54
		32	0.12	1.51	0.18	5.76
		33	0.10	1.07	0.10	3.30
		34	0.08	0.70	0.05	1.70
		35	0.06	0.10	0.006	0.21
		36	0.04	0	0	0

Table 3: Life-fertility table parameters of *Oligonychus sapienticolus* during summer season (March-April) under laboratory ambient condition

Host	Summer season	x	lx	mx	lx*mx	x*lx*mx
		0-13	0.65	Including immature stages and pre oviposition period		
Banana leaf	Mar-April	14	0.65	0.67	0.43	6.02
		15	0.65	1.69	1.09	16.35
		16	0.65	5.07	3.29	52.64
		17	0.65	6.89	4.47	75.99
		18	0.59	6.76	3.98	71.64
		19	0.59	4.61	2.71	51.49
		20	0.59	4.23	2.49	49.80
		21	0.53	3.46	1.83	38.43
		22	0.53	3.11	1.64	36.08
		23	0.35	1.52	0.53	12.19
		24	0.35	1.20	0.42	10.08
		25	0.35	0.92	0.32	8.00
		26	0.29	0.61	0.17	4.42
		27	0.29	0.46	0.13	3.51
		28	0.23	0.36	0.08	2.24
		29	0.23	0.24	0.05	1.45
		30	0.20	0.21	0.04	1.20
		31	0.20	0.16	0.03	0.93
		32	0.20	0.14	0.02	0.64
		33	0.14	0.09	0.01	0.33
		34	0.11	0.06	0.066	0.20
		35	0.11	0	0	0

In January-February: Σ lx*mx= 9.64 and Σ x*lx*mx= 293.75; In February-March: Σ lx*mx= 17.27 and Σ x*lx*mx= 415.54 and In March-April: Σ lx*mx= 23.73 and Σ x*lx*mx= 443.63

Table 4: Results of net reproductive rate (R_0), mean length of generation (T_0), innate capacity for increase in number (r_m), corrected generation time (T), finite rate of increase in number (λ) and doubling time (D_t)

Life-fertility table parameter	January-February	February-March-	March-April
R0 = Σ (lx*mx)	9.65	17.27	23.73
T0 = Σ (x*lx*mx) / Σ(lx*mx)	30.44 days	24.06 days	18.69 days
rm = ln (R0) / T	0.07	0.11	0.16
T = ln (R0) / rm	32.38 days	25.81 days	19.79 days
λ = erm	1.07	1.11	1.17
Dt = ln (2) / rm	9.90 days	6.30 days	4.33 days

time for completion of generation (Abou-Awad *et al.* 2011). The findings of the present study are in confirmation with the above statement where the lowest mean length of generation (T_0) of *O. sapienticolus* was 18.69 days during March-April and the highest mean length of generation was 30.44 days during January-February. The mean length of generation time of spider mites decreased with increase in temperature as the mite took only 10.63 days to complete its generation time at 31°C and 31.14 days at 19°C whereas in case of *Oligonychus persae* the shortest generation time was 18.38 days at 30°C and longest generation time was 62.73 days at 15°C, respectively. (Aponte and McMurty, 1997; Congdon and Logan, 1983).

The mango spider mite, *Oligonychus mangiferus* completed their life cycle within 12.98 days at 31°C and 65% relative humidity in contrast to 31.79 days at 15°C and 75% relative humidity (Abou-Awad *et al.,* 2011). The study conducted over three different seasons confirmed that low temperature prolongs developmental stages and generation time, while reduces the net reproductive rate whereas high temperature showed reverse trend. Abu-shosha *et al.* (2017) stated that the mean length of generation time of *O. mangiferus* was minimum (17.87 days) at 31°C and maximum (20.12 days) at 25°C. The innate capacity of increase in number (r_m) normally describes the population growth potential of a specie under specific environmental conditions. According to Southwood, (1978), r_m normally depicts the overall effect of temperature and food on growth and development, reproduction and survival of a specie. In the present study, r_m was maximum (0.16) during hot weather (30°C) and minimum (0.07) during cold weather (17°C) which was very close to the r_m value of 0.17 during summer and 0.05 during winter (Hoque *et al.,* 2008) in *Tetranychus urticae* .

The estimated r_m values of *Oligonychus ranged* from 0.18 to 0.29 at 25°C, and particularly in case of *O. coffeae* it was 0.215 at 30°C; *O. pratensis* 0.36 at 31°C and *O. gossypii* 0.21 at 31°C (Bonato *et al.,* 1995; Congdon and Logan, 1983; Gotoh and Nagata, 2001; Perring *et al.,* 1984; Saito, 1979). It was also estimated that higher rm value is related to shorter developmental and generation times (Tanigoshi *et al.,* 1975; Sabelis 1981) which are in confirmation with the present findings. The finite rate of increase in number (λ) followed similar trend of r_m. Doubling time (D_t) was inversely proportional to temperature and the maximum value was during March-April and lowest during January-February. Sakunwarin *et al.* (2003) studied the life-fertility table of *T. truncates* Ehara and reported maximum value of λ is maximum (1.378) at 31°C and lowest (1.143) at 20°C. The study of life-fertility table parameters of Oligonychus sepianticolus has been conducted first time considering its economic importance. It is a potential mite pest of banana crop therefore; it may outbreak during its congenial condition and thereafter may cause substantial yield loss and the results of this study may be useful for making decision towards management of these potential mite pests in banana cultivation.

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