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Impact of oviposition of shoot gall psylla, *Apsylla cistellata* Buckton on gall formation and panicle emergence in mango

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Abstract
The aim of this study was to determine the effects of shoot gall psylla, *Apsylla cistellata* oviposition on the galls formation and panicles emergence, which ultimately results in no fruiting. Results indicated that galls were not formed on the twigs (40 cm) without eggs, whereas, those with eggs found to bear varying number of galls (5.92 - 41.01 galls/twig). The maximum number of galls (41.01 and 40.11 galls/twig) were formed on the twigs carry eggs at their maximum (200 eggs/twig), during both the years of investigation. It was observed that as the number of eggs increased on the leaves of twig (40 cm), gall formation increased proportionately, however, panicles emergence decreased proportionately with the egg number. The maximum number of panicles emergence (3.25 and 3.15 panicles/ twig) was initiated on leaves without eggs (0.00 eggs/ twig), which further reduced in case of leaves with 10 eggs (1.65 and 2.14 panicles/twig), followed by leaves with 50 eggs (1.09 and 1.01 panicles/twig) and 0.45 and 0.50 panicles/twig were found in case of leaves with 100 eggs. Whereas, no panicle emergence (0.00 panicle/ twig) was found on the leaves with 200 eggs/ twig, during the year 2016 and 2017, respectively. Correlation analysis also revealed a positive significant relationship between the number of eggs and a total number of galls formed/twig (r = 0.923, 0.916), whereas, significant negative relationship (r= -0.885, -0.881) was found between eggs number and panicle emergence during both the years of experiment.

Keywords: *Apsylla cistellata,* correlation, gall formation, panicle emergence

Introduction

Mango shoot gall psylla, *Apsylla cistellata* Buckton (Psyllidae: Homoptera) is a severe pest of mango all over northern India, Nepal and Bangladesh (Singh, 2000) [9]. The malady instigated by mango shoot gall psylla has a restricted and fixed distribution in various regions of India. It is broadly present over many districts of Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, Uttarakhand and *Tarai* regions of Northern India (Buckton, 1896; Rahman *et al.*, 2007 and Rahman *et al.*, 2016) [1, 6, 5]. Mango shoot gall psylla infestation is usually known as *Ghundi* rog in Uttarakhand and it is familiar as the most harmful pest due to its ability to change reproductive and vegetative buds into galls, further leading to reduced to no fruit setting on affected plants (Kadam *et al.*, 2017) [3]. Among all the major mango producing belts of Uttarakhand *viz.*, Almora, Udham Singh Nagar, Nainital and Dehradun districts (approximately 3000 hectare area), shoot gall psylla has been found as the most frequently occurring pest, since the last 2-3 years, causing an annual loss of Rs 70-80 crores (Singh *et al.*, 2015 and Kadam *et al.*, 2017) [14, 3].

A. cistellata is a monophagous and monocyclic pest of mango. Adults once emerged from the galls, start laying eggs inside the midrib on the new flush of leaves in the month of March-April. The embryo develops slowly, constantly and distinctly, until eggs started hatching in the month of August. After egg hatching, 1st instar nymph starts feeding *in situ* inside ovipositional slits. The feeding of nymphs inside the slits leads to the formation of hard conical green shoot galls in place of axillary and apical buds, which directly interfere with the formation of inflorescence and further subsequent growth is arrested, resulting in no or low yields. Later, nymphs enter into these fully formed galls, where they grow and fed up to adulthood (Singh *et al.*, 1975; Singh and Mishra, 1978 and Kumar, 2004) [10, 11, 4]. It has been recognized that losses caused by mango shoot gall psylla depend on the number of eggs laid and a severely infested trees yield only 10-12 kg of fruits against a normal yield of 300 kg from a healthy tree (Singh *et al.*, 1975 and Singh, 2000) [10, 9].

Hence, the present study was conducted with a view to determine the impact of oviposition of shoot gall psylla on gall formation and panicle emergence on infested trees. Further, these studies will also help while implementing a successful management practice, as pest biology is changing frequently year by year due to several factors *viz.*, ecological factors *etc*.

Materials and Methods

The present investigation was carried out during the year 2016 and 2017 at Horticulture Research Centre, Patharchatta, GBPUAT, Pantnagar to determine a relationship between a number of eggs laid by mango shoot gall psylla, *Apsylla cistellata* on leaves and number of galls formation and panicles emergence. A heavily infested 25 years old mango tree *var.* Dashehari with psylla eggs bearing leaves were selected for this experiment during the month of August. For this experiment 5 treatments *viz.*, 1) leaves with no egg/twig (40 cm length), 2) leaves with 10 eggs/twig, 3) leaves with 50 eggs/twig, 4) leaves with 100 eggs/twig, and 5) leaves with 200 eggs/twig, were taken for observation in the field. The egg-bearing leaves per 5 twigs were observed in each treatment and each treatment was replicated thrice in a completely randomized block design. Twigs were selected on the basis of varying natural egg infestation. A required number of eggs were counted on each leaf/ 5 twig (twig length 40 cm) and extra eggs were destroyed by piercing with the needle. Counting of eggs was done in the 1st week of August and observations on gall formation and panicle emergence was taken in the month of October and November.

Statistical Analysis

Pooled data was further analyzed statistically using ANOVA by SPSS software and OPSTAT (Sheoran, 2010) [8] for Duncan mean range test and test of significance at 0.05%, respectively. Reduction in panicle emergence among different treatments was calculated by the formula:

$$\text{Reduction in panicle emergence} = \frac{\text{Panicle emergence in twigs without eggs} - \text{Panicle emergence in twigs with eggs}}{\text{Panicle emergence in twigs without eggs}} \times 100$$

Further, correlation analysis was also done between the number of eggs on leaves/ twig with gall formation and panicle emergence using SPSS software.

(a) (b)

Fig 1: a) Egg hatching on the ventral surface of mango leaf b) Gall formation at axil and apical bud positions of the twig

Results and Discussions

On perusal of data presented in table 1 and figure 2, results indicated that during the year 2016, number of galls formed varies with the number of eggs on a leaves/twig (40 cm). It was found that galls were not formed (0.00 galls/ twig) on twig without eggs (0.00 eggs/twig). The number of galls/twig became proportionately higher as the number of eggs bearing leaves increased on a twig. It was observed that if all the leaves of twig carry eggs at their maximum number (200 eggs), the number of galls formed were maximum (41.01 galls/ twig), by converting all buds to galls. This was followed by leaves with 100 eggs/twig which gave rise to 30.45 galls/twig, leaves with 50 eggs/twig gave rise to 25.56 galls/twig, and minimum 5.92 galls were formed on leaves with 10 eggs/twig. Gall: egg ratio was further calculated and results indicated that the minimal ratio was recorded in case of leaves with 10 eggs (1 gall: 1.68 eggs), followed by leaves with 50 eggs/twig (1 gall: 1.96 eggs), leaves with 100 eggs (1 gall: 3.28 eggs) and the maximum ratio was obtained in 200 eggs (1 gall: 4.88 eggs). It clearly showed that as the number of eggs increased, the gall: egg ratio also increased proportionately per twig. However, as far as panicle emergence is concerned, it decreased proportionately as the number of eggs on leaves/twig increased. The maximum number of panicles initiation (3.25 panicles/twig) was recorded on twigs having no eggs bearing leaves (0.00 eggs/twig) which was followed by leaves with 10 eggs (1.65 panicles/twig), leaves with 50 eggs (1.09 panicles/twig) and the minimum was observed in case of leaves with 100 eggs (0.45 panicles/twig). However, panicle emergence was not initiated on leaves with 200 eggs/twig. Results indicated that in case of leaves with 10 eggs/twig panicle emergence reduced by 49.23 %, followed by leaves with 50 eggs (66.46%), leaves with 100 eggs (86.15%) and maximum reduction (100%) was found in case of leaves with 100 eggs/twig, over leaves without eggs/twig. On statistical analysis, all the observations (treatments) were found significantly different from each other pertaining to their effect on gall formation and panicle emergence.

A more or less similar trend was also observed during the year 2017. As summarized in table 2 and figure 3, results revealed that the number of galls formed on twig varies with the number of eggs on leaves/twig. Leaves without eggs (0.00 egg/twig) gave rise to almost negligible gall formation (0.00 galls/twig), whereas those with eggs found to bear varying number of galls. It was found that if all the leaves carry maximum eggs (200 eggs /twig), later galls formed were maximum (40.11 galls/twig) by converting all the buds into galls, which further reduced on leaves with 100 eggs (35.09 galls/twig), followed by leaves with 50 eggs gave rise to 22.26 galls/twig and leaves with 10 eggs gave rise to 8.17 galls/twig. Gall: egg ratio was further calculated and results indicated that the minimal ratio was found in case of leaves with 10 eggs (1 gall: 1.22 eggs), followed by leaves with 50 eggs/twig (1 gall: 2.25 eggs), leaves with 100 eggs (1 gall: 2.85 eggs) and the maximum ratio was obtained in case of 200 eggs (1 gall: 4.99 eggs). It clearly showed that as the number of eggs increased, the gall: egg ratio also increased proportionately. However, the panicle emergence decreased proportionately with a number of eggs on leaves/twig. It was found that maximum panicle emergence (3.15 panicle/twig) was initiated on leaves with 0.00 eggs/twig, which was followed by leaves with 10 eggs (2.14 panicle/twig), leaves with 50 eggs initiated 1.01 panicles/twig, leaves with 100 eggs initiated 0.50 panicles/twig, however, no panicle emergence (0.00 panicle/twig) was recorded on leaves with 200 eggs/twig. Further, observations were taken on reduction in panicle emergence and results indicated that 32.06% reduction was observed in case of leaves with 10 eggs/twig, over twig without egg-bearing leaves. This was followed by leaves with 50 eggs (67.94%) and leaves with 100 eggs (84.13%). Whereas, the maximum reduction in panicle emergence was recorded in case of leaves with 200 eggs/twig (100%). On statistical analysis, all the observations were found significantly different from each other in relevance to their impact on gall formation and panicle emergence.

Results pertaining to correlation analysis recorded in table 3, during the year 2016, revealed that a number of eggs on leaves/twig was found positively correlated to an average number of galls formed/twig (r= 0.923) at 0.05 level of significance. That means if the number of eggs were increasing on twigs, gall formation was also found later increasing in the same manner. Whereas, eggs bearing leaves/twig were found negatively correlated to panicles emergence (r= -0.885) at 0.05 level of significance. That means as the number of eggs/twig was increasing, panicle emergence was decreasing proportionately. The same trend was also recorded during the year 2017, egg-bearing leaves /twig were found significantly positively correlated to gall formation (r= 0.916) at 0.05% and significantly negatively correlated to panicle emergence (r= -0.881), at 0.05% level of significance.

Studies conducted by earlier workers *viz.*, Gupta and Haq (1958) [2] and Singh (1959) [13] recorded that galls were not formed on branches without eggs, whereas those with eggs were found to bear a varying number of galls, which is in agreement with the present investigation. Singh and Mishra (1978) [11] gave an arbitrary relationship that 10 eggs present on one leaf gave rise to 3 galls and 20 eggs initiated 6 galls, which somehow found contrary to the present observation. Singh (1980) [12] stated that 10 eggs gave rise to 5.06 galls and 500 eggs gave rise to 52.58 galls. Whereas, in the present investigation, leaves with 10 eggs were recorded with 5-8 galls/twig and leaves with 200 eggs/twig were recorded with less than 50 galls/twig. Studies conducted by Sharma (2008) [7], stated that the mean number of galls formed increased with the number of eggs on a twig (30 cm). He also observed that if all the leaves of twig carry eggs at their maximum (150), the number of galls formed were more than 50 by converting all buds to galls. The number of nymphs per gall were also found proportional to the number of eggs laid by shoot gall psylla. However, in the present studies, galls formed were lesser than 50, in case of leaves with 200 eggs/twig, which does not support the present investigation completely.

Table 1: Relationship between the number of eggs, gall formation and panicle emergence during 2016

Treatments (Eggs/twig)	Mean number of galls formed/ twig*	Gall: egg ratio	Mean number of panicles emerged/twig*	Per cent reduction in panicle emergence
0 eggs	0.00 ± 0.00[a]	0:0.00	3.25 ±0.05[a]	0.00
10 eggs	5.92 ± 0.08[b]	1: 1.69	1.65± 0.00[b]	49.23
50 eggs	25.56 ± 0.03[c]	1: 1.96	1.09 ±0.02[c]	66.46
100 eggs	30.45 ± 0.59[d]	1: 3.28	0.45± 0.01[d]	86.15
200 eggs	41.01 ± 0.49[e]	1: 4.88	0.00 ± 0.00[e]	100.00
C.D (0.05)	1.098		0.074	
S.E (±M)	0.344		0.023	
F-test	**		**	

*Mean of 3 replications, each replication containing 5 twigs
** F-test is significant
In a column, means followed by same letters are not significantly different by DMRT

Table 2: Relationship between the number of eggs, gall formation and panicle emergence during 2017

Treatments (Eggs/twig)	Mean number of galls formed/ twig*	Gall: egg ratio	Mean number of Panicles emerged/ twig*	Per cent reduction in panicle emergence
0 eggs	0.00 ± 0.00[a]	0:0.00	3.15 ± 0.04[a]	0.00
10 eggs	8.17 ± 0.04[b]	1: 1.22	2.14 ± 0.04[b]	32.06
50 eggs	22.26 ± 0.50[c]	1: 2.25	1.01 ± 0.01[c]	67.94
100 eggs	35.09 ± 0.02[d]	1: 2.85	0.50 ± 0.01[d]	84.13
200 eggs	40.11 ± 0.52[e]	1: 4.99	0.00 ± 0.00[e]	100.00
C.D	1.032		0.081	
S.E (±M)	0.323		0.026	
F-test	**		**	

*Mean of 3 replications, each replication containing 5 twigs
** F-test is significant
In a column, means followed by same letters are not significantly different by DMRT

Table 3: Correlation analysis between the number of eggs, gall formation, and panicle emergence during 2016 and 2017.

Year	Mean number of galls formed/ twig*	Mean number of panicles emerged/twig*
2016	0.923*	-0.885*
2017	0.916*	-0.881*

* Correlation is significant at the 0.05 level of significance (2-tailed)

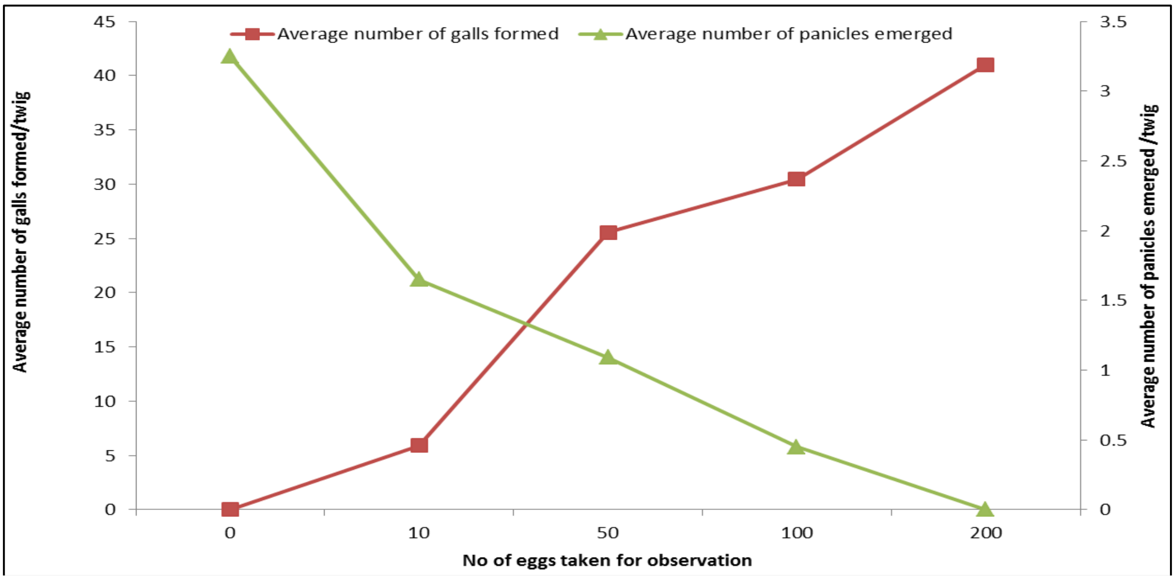

Fig 2: Relationship between the number of eggs, gall formation and panicle emergence during 2016

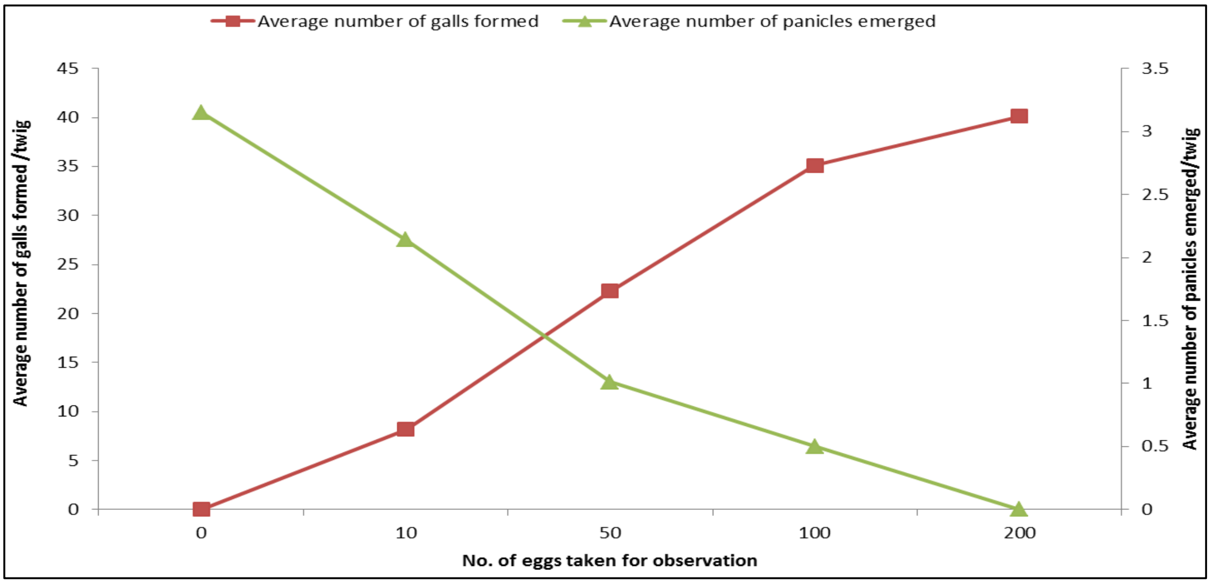

Fig 3: Relationship between the number of eggs, gall formation and panicle emergence during 2017

Conclusion

Hence, it can be concluded from the results that 10 eggs of shoot gall psylla gave rise to 6 to 9 galls and reduced panicle emergence by 32 to 49% as compared to twigs without eggs. A significant and positive correlation was found between the number of eggs laid by *A. cistellata* and gall formation, that means a higher number of buds converted into galls, as the number of eggs bearing leaves increased on a twig. However, panicle emergence decreased proportionately with the number of eggs on leaves/twig.

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