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INCIDENCE OF LEAF EATING INSECT PESTS OF MULBERRY IN KOLAR REGION (KARNATAKA, INDIA) AS IMPACTED BY AGRONOMIC PRACTICES

Sreenivasa B. [1], Noble Morrison M.[2], Manjunath, D.[1]

1. Department of Studies in Sericulture Science, University of Mysore, Mysuru-570 006, India.
2. Research Extension Centre, Central Sericulture Research and Training Institute, Central Silk Board, Madivala, Kolar District.

ABSTRACT: An effort has been made in the current investigation to document the effects of certain agronomic practices on the incidence of leaf eating insect pests in mulberry crop system in different seasons from 2013-14 to 2015-16 in farmers' gardens of Kolar District in the following combinations: a) tillage + closer spacing + organic inputs (T1), b) tillage + closer spacing + inorganic inputs (T2), c) tillage + closer spacing + organic inputs + inorganic inputs (T3), d) zero tillage + wider spacing + organic inputs (T4), e) zero tillage + wider spacing + inorganic inputs (T5), and f) zero tillage + wider spacing + organic inputs + inorganic inputs (T6). A great deal of fluctuation was noticed in the incidence of *Diaphaniapulverulentalis*, *Spilosomaobliqua*, and *Neorthacrisacuticepsnilgirensis* as influenced by the agronomic practices. Regardless of season and year of pest monitoring, the incidence was highest in T4 and least in T6. On the whole, the incidence was found decreased in the following order: T4, T2, T1, T5, T3, and T6 (i.e. T4>T2>T1>T5>T3>T6). A discussion has been elaborated on the results of the current study taking cognizance of the findings available elsewhere in other crop systems in general and mulberry in particular. The results assume considerable importance at such a time when there is dearth of information on the agronomic practice-based incidence of the key leaf eating insect pests in mulberry crop system so as enable us to select a suitable pest control measure(s) to keep the pest incidence in check.

KEYWORDS: Agronomic practices, mulberry gardens, pest monitoring, seasonal incidence

***Corresponding Author: Prof. D. Manjunath** Ph.D.
Department of Studies in Sericulture Science, University of Mysore, Mysuru-570 006, India
* Email Address: manjunath459l@yahoo.co.in

1. INTRODUCTION

There is an age-old association between the silkworm, *Bombyxmori* L., and its exclusive food plant, the mulberry, *Morus*spp. Association of similar nature also has been visualized between mulberry and a number of herbivorous insect pests, including the leaf eating ones. Being mostly sporadic in nature, at times, especially during rainy (July-October) and winter (November-February) seasons of South India, the populations of the leaf eating insect pests reach epidemic proportions, leading to considerable reduction in the mulberry leaf production with concomitant decline in the silkworm rearing capacity and in turn the production of cocoons. The important leaf eating pests of mulberry among others consist of 1) leaf roller (*Diaphaniapulverulentalis*Hampson), 2) Bihar hairy caterpillar (*Spilosomaobliqua* Walker),3) cutworm (*Spodopteralitura*Fabricius) and 4) wingless gra sshopper(*Neorthacrisacuticepsnilgirensis*Uvarov). Though man has taken cognizance of their occurrence in mulberry gardens and the extent of damage they inflict to foliage production, efforts to document these aspects as influenced by the agronomic practices, especially at farmers level, are either found wanting or are confined to recording the incidence of pests in one or two years/seasons/agro-climatic regions (Hemalatha, 2006; Balasaraswathi*et al*., 2014; Chakraborty *et al.*, 2015). However, there are clear indications that the incidence and abundance of these pests vary considerably with respect to season, agronomic practice employed (spacing, nutrient input, tillage practice, irrigation, crop rotation, etc.), mulberry variety planted, and extent of precipitation, and so on. Therefore, gathering adequate information regarding the role of agronomic practices on the incidence and abundance of insect pests in mulberry crop system based on systematic studies encompassing all the seasons extending over a period of three to four years is bound to help us to choose a need based management tactic to offset the problems posed by the pests. Elsewhere in other crop systems, as opposed to mulberry crop system, literature is replete with the information that the investigations have categorically proved that agronomic practices employed for raising a crop plant have a direct bearing on the incidence and abundance of various insect pests. Nevertheless, a comprehensive and worth mentioning account on these aspects, chiefly emphasizing the importance of soil fertility management on a sustainable basis through the application of organic matter to the soil, has been provided by Scriber (1984) and Altieri and Nicholls (2003) who have stated that soils that receive inorganic fertilizer application show elevated levels of pest incidence in crop plants, while those provided with organic inputs exhibit a great deal of resistance to pests with concomitant increase in production and productivity of a crop. They have also reported that increased level of nitrogen in the crop plants has been considered the principal factor for the elevated levels of pest incidence and abundance. The other researchers who have made concerted efforts to report the impact of agronomic practices on these scores include Culliney and Pimentel (1986), Eigenbrode and Pimentel (1988), Kajimura (1995), Phelan *et al.* (1995), Altieri*et al*. (1998), Morales *et al*. (2001), and Atijegbe*et al*. (2014) focusing on the role of fertilizer application (organic/inorganic), Willson and Eisley (1992) and Brust*et al*. (1985) working on tillage practices, and Hill (1989) and Kulagod*et al*. (2011) dealing with plant spacing (plant density/crop geometry). In the current investigation, efforts have been directed to document the effects of agronomic practices at sericulture farmers' level based on the field survey conducted during 2013-14, 2014-15, and 2015-16 in Kolar region (Karnataka) on the incidence of the leaf eating pests of mulberry in three taluks*viz*., Kolar, Bangarpet, and Malur, located 30-40 km from each other. The findings emanated from the investigation are discussed in the light of those in the available literature to arrive at a pertinent conclusion.

2. MATERIALS AND METHODS

In as is where is condition at sericulture farmers' level, the agronomic practices employed by them such as spacing (crop geometry), organic inputs, inorganic inputs, and tillage operations were grouped in to the following combinations:

a) Gardens with tillage + closer spacing + organic inputs (T1),
b) Gardens with tillage + closer spacing + inorganic inputs (T2),
c) Gardens with tillage + closer spacing + organic inputs + inorganic inputs (T3),
d) Gardens with zero tillage + wider spacing + organic inputs (T4),
e) Gardens with zero tillage + wider spacing + inorganic inputs (T5), and
f) Gardens with zero tillage + wider spacing + organic inputs +inorganic inputs (T6).

The common conditions that the chosen gardens comprised were drip irrigation and Victory-1 (V-1) mulberry variety. In all, 120 sericulture farmers' gardens drawn from twenty-seven villages falling in three taluks each with nine clusters (three/cluster) were covered for the program. These gardens were distributed equally among the treatments (T1-T6), i.e. 20 per treatment. The selection of farmers' gardens was based on the fact that there was a considerable uniformity in terms of each of the agronomic components among the gardens falling in each of the treatments (T1-T6). Tillage operations were carried out employing power tiller, bullock ploughing, manual digging, and tractor ploughing (in gardens with wider spacing). Crop geometry consisted of closer spacing with 3' x 3' and less whereas that under wider spacing comprised the gardens with spacing in excess of 3' x 3' that varied from 3' x 2' + 5' to (8' x 2') x 8'. Application of organic inputs composed of compost and farmyard manure (16-20 MT/ha), green manure (sunhemp, dhaincha, horsegram, etc.), and mulches dumped in trenches, along with de-oiled cakes of neem/pongamia/groundnut. With regard to administration of chemical fertilizers, it chiefly consisted of urea, apart from NPK (15:15:15, 17:17:17, or 19:19:19) applied as per the recommendations of Central Sericulture Research and Training Institute (CSR&TI), Mysuru. The selected gardens under each of the treatments were monitored at monthly interval, starting from 15-20 days after pruning/shoot harvesting up to 65-70 days, for recording the incidence of *D. pulverulentalis, S. obliqua,* and *N. a. nilgirensis*as per the techniques/methods outlined by CSR&TI, Mysuru. The accrued data were analyzed statistically by one-way ANOVA using SPSS Package (version 21) (Sundarraj*et al*., 1972; Snedecor and Cochran, 1979).

3. RESULTS AND DISCUSSION

The mean data pertaining to the incidence of the leaf eating insect pests of mulberry monitored in summer, rainy and winter seasons during 2013-14, 2014-15 and 2015-16 are furnished in Tables1-3.

D. pulverulentalis

Irrespective of season, the pest showed maximum incidence in T4 and minimum in T6 during the period of survey from 2013-14 to 2015-16. The values of mean incidence of *P. mori*during 2013-14 ranged from 4.79 ± 0.17 to 2.53 ± 0.15, from 7.39 ± 0.58 to 2.23 ± 0.40, and from 9.55 ± 0.29 to 2.40 ± 0.20 % in summer, rainy, and winter seasons, respectively. During 2014-15, the corresponding values varied from 2.50 ± 0.09 to 0.90 ± 0.06, from 6.80 ± 0.31 to 1.51 ± 0.20, and from 5.38 ± 0.21 to 1.33 ± 0.14 %. With regard to 2015-16, the pest incidence fluctuated from 3.15 ± 0.10 to 1.61 ± 0.08, from 7.30 ± 0.32 to 2.04 ± 0.24, and from 6.53 ± 0.37 to 1.30 ± 0.28 %, respectively in summer, rainy, and winter seasons. By taking the pooled data (the mean values for all the seasons together) too in to consideration, T4 was the highest and T6 the lowest in the pest incidence. The highest and least mean data for these treatments during 2013-14, 2014-15, and 2015-16 were 7.24 ± 0.29 & 2.38 ± 0.18, 5.38 ± 0.21 & 1.33 ± 0.14, and 5.66 ± 0.23 & 1.65 ± 0.17 %, respectively (Table 1).

S. obliqua

Whereas T4 exhibited the greatest incidence of *S. obliqua,* T6 showed the least regardless of the season and period of the pest monitoring. The highest and lowest incidence of the pest in summer, rainy, and winter seasons of 2013-14 respectively varied from 1.98 ± 0.15 to 0.70 ± 0.07, from 3.21 ± 0.19 to 1.56 ± 0.18, and from 4.13 ± 0.15 to 1.29 ± 0.13 %. During 2014-15, the greatest values for summer, rainy, and winter seasons stood at 1.21 ± 0.08, 3.28 ± 0.18, and 3.84 ± 0.18 % , while the corresponding least values were 0.83 ± 0.09 (T5), 2.03 ± 0.29, and 1.59 ± 0.17 %. The maximum and minimum values for mean incidence of the pest during 2015-16 for summer, rainy, and winter remained at 1.31 ± 0.08 and 0.63 ± 0.09, 3.70 ± 0.11 and 1.66 ± 0.16, and 2.55 ± 0.08 and 1.18 ± 0.10 %. Based on the pooled data too, maximum incidence of the pest was noticeable in T4 and minimum in T6 during the entire period of monitoring. The mean results in this regard stood at 3.10 ± 0.08 (T4) and 1.18 ± 0.08 (T6) (2013-14), 3.84 ± 0.18 (T4) and 1.59 ± 0.17 (2014-15), and 2.55 ± 0.08 (T4) and 1.18 ± 0.10 % (T6) (2015-16) (Table 2).

N. a. nilgirensis

Regardless of the year and season of the pest survey, T4 scored the highest incidence as against T6 with least incidence. The highest mean values during 2013-14 were 2.73 ± 0.10 for summer, 4.04 ± 0.24 for rainy and 3.51 ± 0.18 % winter seasons. The corresponding least data stood at 0.81 ± 0.13, 1.36 ± 0.19 and 1.08 ± 0.15 %. With regard to 2014-15, the greatest and least mean values scored were 1.76 ± 0.13 and 0.74 ± 0.10 for summer, 3.16 ± 0.15 and 1.35 ± 0.25 for rainy, and 2.01 ± 0.07

and 0.69 ± 0.08 % for winter seasons. Looking at 2015-16, while the maximum mean results for summer, rainy, and winter seasons were 2.01 ± 0.07, 3.58 ± 0.09, and 2.95 ± 0.25 % as against the minimum values of 0.69 ± 0.08, 1.39 ± 0.17, and 1.10 ± 0.25 %, respectively. T4 being the greatest and T6 the least too was observed when the pooled data were looked into. The values were 3.43 ± 0.13 (T4) and 1.08 ± 0.14 (T6), 2.85 ± 0.08 (T4) and 1.17 ± 0.16 (T6), and 2.85 ± 0.08 (T4) and 1.06 ± 0.12 % (T6), respectively during 2013-14, 2014-15, and 2015-16 (Table 3).
Statistical analysis of the mean data documented for different treatments during 2013-14 to 2015-16 revealed significant variations ($P \leq 0.01$) among most treatments.

DISCUSSION

When the mean/pooled data were perused, the following general observations become cognizable: a) there was no appreciable variation in the incidence of each of the pests over a period of three years, b) highest pest incidence was noticed in the treatment involving zero tillage + wider spacing + organic inputs (T4), c) the pest incidence was least in the treatment consisting of zero tillage + wider spacing + organic inputs + inorganic inputs (T6), d) the pest incidence was considerably low and somewhat comparable in treatments with T3 and T6, e) the incidence of the pests was by and large comparable among most treatments involving T1, T2, and T5, f) regardless of the year and season of pest monitoring, the incidence was mostly found decreased in the following order: T4, T2, T1, T5, T3, and T6 (i.e. T4>T2>T1>T5>T3>T6). Further, the trends emerging from seasonal data as well as from pooled data (for all the seasons put together) for different years of pest monitoring are comparable with each other. In order to render silkworm rearing a successful and profitable venture, concerted efforts have been made over the years by researchers to ensure that nutritional quality of mulberry foliage matches with nutritional requirement of silkworm. As such, there is a dire need to accomplish this goal by adopting appropriate agronomic practices/packages for cultivation of mulberry. Suitable packages have been evolved and recommended from time to time by sericulture research institutes for exploitation at sericulture farmers' level, so that foliage produced would be optimum in quality and quantity. Despite this, a great deal of variation in quality and quantity of leaf produced is noticed chiefly as a consequence of varied agronomic practices (spacing, application of nutrient element, irrigation, method of pruning/harvesting of foliage, tillage operation, mulberry variety planted and so on) employed with concomitant variation in pest incidence and abundance. Of course, the impact of seasons on these pest-related parameters cannot be underestimated. Obviously, the pest incidence and abundance would be the consequences of interplay between agronomic practices and environmental factors. Though we have information that pest incidence and abundance are influenced by agronomic as well as seasonal factors, the same is not adequate enough to precisely understand and decide as to what pest control measure(s) to be chosen/implemented in accordance with magnitude of pest problem as influenced by agronomic practices and environmental factors. Further, it may be understood that the sericulture farmers of Kolar District are constrained to employ varied agronomic packages due to certain compelling circumstances. In light of this, investigations dealing with the effects of agronomic practices on the incidence of the leaf eating insect pests in mulberry crop system assume great significance, more so in Kolar region which has earned the dubious distinction for producing the superior quality silkworm cocoons in the state of Karnataka. The current investigation spanning over a period of three years from 2013 to 2015 and encompassing all seasons has led to generation of useful information pertaining to the role of agronomic practices employed at farmers' level in Kolar District on the incidence of *D. pulverulentalis*, *S. obliqua*, and *N. a. nilgirensis*, the three key polyphagous insect pests accounting for a sizeable reduction in the production of mulberry leaf and in turn silkworm cocoon. With regard to the incidence of these pests, it is not possible to single out the impact of an independent agronomic practice. Further, whatever the effect that has been realized would undoubtedly be due to the combined action of these practices coupled with environmental factors. It was noticed that the incidence of the pests was least when the gardens were subjected to the agronomic practices such as the combination of zero tillage, wider spacing, organic inputs, and inorganic inputs (T6) as opposed to those with other combinations of agronomic practices (T1, T2, T3, T4, and T5) where the treatment involving zero tillage, wider spacing, and organic inputs (T4) showed the highest incidence of these leaf eating pests. Interestingly, each of the pests showed almost a similar level of incidence over a period of three years with respect to a particular treatment, probably due to similarities in the nutritional components of foliage, which supported their persistence and proliferation, as well as environmental factors. The observations on the impact of the treatment combinations (T1-T6) on the pest incidence cannot be entirely compared with that elsewhere in other crop systems where combined action of agronomic practices like the ones in the current study are seldom adopted/considered. Nevertheless, significantly reduced pest incidence in the mulberry gardens with tillage and closer spacing receiving organic inputs (T1) corroborate the findings elsewhere in other crop systems administered with organic nutrients (Eigenbrode and Pimentel, 1988; Altieri and Nicholls, 2003; Adilakshmi *et al*., 2007; Zehnder*et al.*, 2007; Atijegbe*et al*., 2013). Even the gardens with tillage and closer spacing as well as those with zero tillage and wider spacing, receiving both organic and inorganic inputs (T3 & T6), revealed the declined level of pest incidence. In contrast, the gardens with tillage and wider spacing, treated with organic nutrients (T4), revealed distinctly deviated results with higher incidence of the pests, probably due to reduced levels of soil microbial biomass and soil dehydrogenase activity as evidenced by the findings of a separate study conducted by us (unpublished data). In this regard, it is highly pertinent to record the well-established fact that the soils exhibiting higher densities of micro-fauna (microbial community) would be rich in a host of chemical substances that improve plant health and confer resistance to it against pests and diseases (Altieri and Nicholls, 2003).With regard to impact of tillage practices observed in the current study, it is pertinent to mention at this juncture that tillage greatly alters the physical characteristics of soil (Neher and Barbercheck, 1999; Alam *et al*., 2014) and the matrixsupporting growth of the microbial population (Kennedy, 1999) and this may indirectly have an impact on plant resistance against pests and diseases. It is also reported that various methods of tillage can have important effects on insect pests (Smutny*et al*., 2008) who have reported that reduced soil tillage led to increase in the incidence of *Dasineurabrassicae*and *Ostrinianubilalis*. No impact of tillage on the incidence of foliar arthropods has been reported by Whealen *et al.* (2007), Teague *et al.* (2008), and Mante Jr. (2016). Admittedly, with regard to tillage practice employed along with other practices, it may not go out of place to mention here that this practice wherever applied might have contributed to reduction in the incidence of the pests in question through the following actions: 1) caused mechanical damage/destruction to soil inhabiting stages of the life cycle such as pupa (leaf roller and Bihar hairy caterpillar) and ootheca of wingless grasshopper, 2) mortality of the soil inhabiting stages due to desiccation following exposure to scorching sun (high temperature), and 3) predation of soil inhabiting stages by birds when soil is tilled as reported by Butter *et al*. (1992), Baskaran*et al*. (1993), and Brar*et al*. (1996). Planting density and spacing are also reported to influence the pest incidence in a significant way. In this regard, Hill (1989) reported that close spacing brings about effects such as colonization of natural enemies of pests and wider spacing attracts insect pests when the plant density is low. In paddy (*Oryza sativa* L.), Kulagod*et al*. (2011) have come out with the observation that close planting aggravating the pest problem.

4. CONCLUSION

The culmination of the current study undertaken at farmers' level has led us to understand as follows: the agronomic practices under consideration have perceptible impact on the incidence of *D. pulverulentalis*, *S. obliqua*, and *N. a. nilgirensis*in mulberry gardens. The incidence differs in accordance with the combination of agronomic practices employed. However, the impact of an independent agronomic practice cannot be singled out. As such, efforts directed in this regard would become useful in generating information on the effect of an independent agronomic variable so as to arrive at a decision to select a suitable control measure to offset the pest problem posed by these leaf eating insect pests in mulberry crop system.

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Table 1: Incidence (%) of leaf roller (*Diaphaniapulverulentais*) in mulberry gardens subjected to different agronomic practices during 2013-14 to 2015-16 in Kolar District

	2013-14				**2014-15**				**2015-16**			
Treatment	**Summer**	**Rainy**	**Winter**	**Pooled**	**Summer**	**Rainy**	**Winter**	**Pooled**	**Summer**	**Rainy**	**Winter**	**Pooled**
T1	3.988 ± 0.17^{b}	6.013 ± 0.46^{ab}	7.825 ± 0.26^{c}	5.942 ± 0.21^{b}	2.013 ± 0.10^{b}	4.800 ± 0.31^{c}	4.825 ± 0.30^{c}	3.879 ± 0.22^{c}	2.513 ± 0.12^{bc}	5.300 ± 0.32^{c}	4.525 ± 0.37^{c}	4.112 ± 0.24^{c}
T2	4.300 ± 0.17^{ab}	6.613 ± 0.51^{a}	8.725 ± 0.27^{b}	6.546 ± 0.24^{b}	2.163 ± 0.10^{b}	5.800 ± 0.31^{b}	5.825 ± 0.30^{b}	4.596 ± 0.22^{b}	2.788 ± 0.09^{b}	6.300 ± 0.32^{b}	5.525 ± 0.37^{b}	4.871 ± 0.24^{b}
T3	3.025 ± 0.15^{c}	3.163 ± 0.47^{c}	3.325 ± 0.20^{e}	3.171 ± 0.19^{d}	1.275 ± 0.08^{d}	2.550 ± 0.22^{e}	2.575 ± 0.21^{e}	2.133 ± 0.15^{e}	1.925 ± 0.10^{c}	3.088 ± 0.26^{e}	2.275 ± 0.29^{e}	2.429 ± 0.19^{e}
T4	4.788 ± 0.17^{a}	7.388 ± 0.58^{a}	9.550 ± 0.32^{a}	7.242 ± 0.29^{a}	2.500 ± 0.09^{a}	6.800 ± 0.31^{a}	6.825 ± 0.30^{a}	5.375 ± 0.21^{a}	3.150 ± 0.10^{a}	7.300 ± 0.32^{a}	6.525 ± 0.37^{a}	5.658 ± 0.23^{a}
T5	4.000 ± 0.22^{b}	5.013 ± 0.46^{b}	6.825 ± 0.26^{d}	5.279 ± 0.22^{c}	1.625 ± 0.11^{c}	3.800 ± 0.31^{d}	3.825 ± 0.30^{d}	3.083 ± 0.23^{d}	2.263 ± 0.11^{c}	4.300 ± 0.32^{d}	3.525 ± 0.37^{d}	3.363 ± 0.23^{d}
T6	2.525 ± 0.15^{d}	2.225 ± 0.40^{c}	2.400 ± 0.20^{f}	2.383 ± 0.18^{e}	0.900 ± 0.06^{e}	1.513 ± 0.20^{f}	1.575 ± 0.21^{f}	1.329 ± 0.14^{f}	1.613 ± 0.08^{d}	2.038 ± 0.24^{f}	1.300 ± 0.28^{d}	1.650 ± 0.17^{f}
Mean	**3.771**	**5.069**	**6.442**	**5.094**	**1.746**	**4.210**	**4.242**	**3.399**	**2.375**	**4.721**	**3.946**	**3.681**
F-value	**23.18 ** **	**17.41 ** **	**131.0 ** **	**72.91 ** **	**41.67 ** **	**50.81 ** **	**52.66 ** **	**57.84 ** **	**31.25 ** **	**43.38 ** **	**32.50 ** **	**48.47 ** **

T1 = Gardens with tillage + closer spacing + organic inputs; T2 = Gardens with tillage + closer spacing + inorganic inputs;

T3 = Gardens with tillage + closer spacing + organic inputs + inorganic inputs; T4 = Gardens with zero tillage + wider spacing + organic inputs;

T5 = Gardens with zero tillage + wider spacing + inorganic inputs; T6 = Gardens with zero tillage + wider spacing + organic inputs +inorganic inputs.

Data were collected at monthly interval from 20 mulberry gardens for each of the treatments and are expressed as mean ± Standard error (M ± SE).

Seasons: Summer (March-June), rainy (July-October) and winter (November-February)

Mean values followed by same superscript are not significantly different from each other;** Indicate highly significant (P≤0.01) (one-way ANOVA).

Table 2: Incidence (%) of Bihar hairy caterpillar (*Spilosomaobliqua*) in mulberry gardens subjected to different agronomic practices during 2013-14 to 2015-16 in Kolar District

	2013-14				**2014-15**				**2015-16**			
Treatment	**Summer**	**Rainy**	**Winter**	**Pooled**	**Summer**	**Rainy**	**Winter**	**Pooled**	**Summer**	**Rainy**	**Winter**	**Pooled**
T1	1.350 ± 0.11^{b}	2.925 ± 0.20^{a}	2.463 ± 0.15^{c}	2.246 ± 0.13^{c}	0.975 ± 0.10a^{b}	3.375 ± 0.27^{a}	2.000 ± 0.17^{cd}	2.117 ± 0.12^{bc}	0.838 ± 0.07^{b}	2.088 ± 0.13^{c}	2.150 ± 0.20^{a}	1.692 ± 0.07^{c}
T2	1.663 ± 0.14^{b}	3.213 ± 0.21^{a}	3.325 ± 0.10^{b}	2.733 ± 0.11^{b}	1.225 ± 0.08^{a}	2.588 ± 0.20^{b}	3.138 ± 0.15^{b}	2.317 ± 0.10^{b}	0.788 ± 0.06^{b}	2.888 ± 0.14^{b}	2.500 ± 0.20^{a}	2.058 ± 0.08^{b}
T3	0.850 ± 0.08^{c}	2.050 ± 0.21^{b}	1.663 ± 0.14^{e}	1.521 ± 0.09^{d}	0.913 ± 0.11^{b}	2.400 ± 0.24^{b}	2.188 ± 0.23^{c}	1.833 ± 0.15^{cd}	0.742 ± 0.09^{b}	1.838 ± 0.13^{cd}	2.150 ± 0.26^{a}	1.577 ± 0.12^{c}
T4	1.975 ± 0.15^{a}	3.213 ± 0.19^{a}	4.125 ± 0.15^{a}	3.104 ± 0.08^{a}	1.213 ± 0.08^{a}	3.275 ± 0.18^{a}	3.838 ± 0.18^{a}	2.775 ± 0.10^{a}	1.313 ± 0.08^{a}	3.700 ± 0.11^{a}	2.650 ± 0.22^{a}	2.554 ± 0.08^{a}
T5	1.450 ± 0.08^{b}	3.038 ± 0.23^{a}	2.038 ± 0.12^{d}	2.175 ± 0.10^{c}	0.833 ± 0.09^{b}	2.475 ± 0.17^{b}	2.288 ± 0.17^{c}	1.865 ± 0.10^{c}	0.825 ± 0.07^{b}	2.200 ± 0.12^{c}	2.100 ± 0.19^{a}	1.708 ± 0.09^{c}
T6	0.700 ± 0.07^{c}	1.563 ± 0.18^{b}	1.288 ± 0.13^{f}	1.183 ± 0.08^{e}	0.850 ± 0.11^{b}	2.025 ± 0.29^{b}	1.588 ± 0.17^{d}	1.487 ± 0.15^{d}	0.625 ± 0.09^{b}	1.663 ± 0.16^{d}	1.250 ± 0.23^{b}	1.179 ± 0.10^{d}
Mean	**1.331**	**2.667**	**2.483**	**2.160**	**1.001**	**2.690**	**2.506**	**2.066**	**0.855**	**2.396**	**2.133**	**1.795**
F-value	**19.54 ****	**11.57 ****	**63.92 ****	**51.12 ****	**3.347 ****	**5.366 ****	**21.51 ****	**12.92 ****	**8.968 ****	**32.19 ****	**4.987 ****	**25.84 ****

T1 = Gardens with tillage + closer spacing + organic inputs; T2 = Gardens with tillage + closer spacing + inorganic inputs;

T3 = Gardens with tillage + closer spacing + organic inputs + inorganic inputs; T4 = Gardens with zero tillage + wider spacing + organic inputs;

T5 = Gardens with zero tillage + wider spacing + inorganic inputs; T6 = Gardens with zero tillage + wider spacing + organic inputs +inorganic inputs.

Data were collected at monthly interval from 20 mulberry gardens for each of the treatments and are expressed as mean ±Standard error (M ± SE).

Seasons: Summer (March-June), rainy (July-October) and winter (November-February)

Mean values followed by same superscript are not significantly different from each other;** Indicate highly significant ($P \leq 0.01$) (one-way ANOVA).

Table 3: Incidence (%) of wingless grasshopper (*Neorthacrisacuticepsnilgirensis*) in mulberry gardens subjected to different agronomic practices during 2013-14 to 2015-16 in Kolar District

	2013-14				2014-15				2015-16			
Treatment	**Summer**	**Rainy**	**Winter**	**Pooled**	**Summer**	**Rainy**	**Winter**	**Pooled**	**Summer**	**Rainy**	**Winter**	**Pooled**
T1	1.613 ± 0.14^{c}	2.300 ± 0.24^{c}	2.275 ± 0.18^{b}	2.063 ± 0.16^{b}	1.325 ± 0.09^{b}	2.350 ± 0.26^{b}	2.013 ± 0.17^{b}	1.896 ± 0.13^{b}	0.975 ± 0.12^{b}	1.863 ± 0.11^{bc}	2.650 ± 0.30^{a}	1.829 ± 0.11^{b}
T2	2.188 ± 0.11^{b}	2.288 ± 0.24^{c}	2.200 ± 0.16^{b}	2.225 ± 0.13^{b}	1.125 ± 0.10^{bc}	1.875 ± 0.17^{bc}	1.650 ± 0.10^{bc}	1.550 ± 0.08^{b}	0.988 ± 0.09^{b}	2.100 ± 0.13^{b}	2.750 ± 0.27^{a}	1.946 ± 0.10^{b}
T3	1.100 ± 0.12^{d}	2.100 ± 0.18c	1.363 ± 0.13^{c}	1.521 ± 0.12^{c}	0.900 ± 0.10^{cd}	2.125 ± 0.25^{b}	1.858 ± 0.19^{bc}	1.628 ± 0.15^{b}	0.925 ± 0.11^{bc}	1.575 ± 0.13^{cd}	1.700 ± 0.18^{b}	1.400 ± 0.09^{c}
T4	2.725 ± 0.10^{a}	4.038 ± 0.24^{a}	3.513 ± 0.18^{a}	3.425 ± 0.13^{a}	1.763 ± 0.13^{a}	3.163 ± 0.15^{a}	3.625 ± 0.11^{a}	2.850 ± 0.08^{a}	2.013 ± 0.07^{a}	3.575 ± 0.09^{a}	2.950 ± 0.25^{a}	2.846 ± 0.08^{a}
T5	1.600 ± 0.14^{c}	3.075 ± 0.18^{b}	2.263 ± 0.13^{b}	2.313 ± 0.12^{b}	0.963 ± 0.10^{cd}	2.163 ± 0.16^{b}	2.025 ± 0.24^{b}	1.717 ± 0.13^{b}	1.000 ± 0.10^{b}	1.825 ± 0.11^{bc}	2.700 ± 0.18^{a}	1.842 ± 0.09^{b}
T6	0.813 ± 0.13^{d}	1.363 ± 0.19^{d}	1.075 ± 0.15^{c}	1.083 ± 0.14^{d}	0.738 ± 0.10^{d}	1.350 ± 0.25^{c}	1.425 ± 0.21^{c}	1.171 ± 0.16^{c}	0.688 ± 0.08^{c}	1.388 ± 0.17^{d}	1.100 ± 0.25^{b}	1.058 ± 0.12^{d}
Mean	**1.673**	**2.527**	**2.115**	**2.105**	**1.135**	**2.171**	**2.099**	**1.802**	**1.098**	**2.054**	**2.308**	**1.820**
F-value	**31.14 ****	**18.28 ****	**30.10 ****	**35.33 ****	**12.02 ****	**7.950 ****	**19.44 ****	**20.89 ****	**22.62 ****	**37.98 ****	**9.250 ****	**37.04 ****

T1 = Gardens with tillage + closer spacing + organic inputs; T2 = Gardens with tillage + closer spacing + inorganic inputs;

T3 = Gardens with tillage + closer spacing + organic inputs + inorganic inputs; T4 = Gardens with zero tillage + wider spacing + organic inputs;

T5 = Gardens with zero tillage + wider spacing + inorganic inputs; T6 = Gardens with zero tillage + wider spacing + organic inputs + inorganic inputs.

Data were collected at monthly interval from 20 mulberry gardens for each of the treatments and are expressed as mean ± Standard error (M ± SE).

Seasons: Summer (March-June), rainy (July-October) and winter (November-February)

Mean values followed by same superscript are not significantly different from each other;** Indicate highly significant ($P \leq 0.01$)(one-way ANOVA).