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**MH Poornima**
Ph.D. Scholar, Department of Entomology, University of Horticultural Sciences, Bagalkot, Karnataka, India

**JB Gopali**
Professor, Department of Entomology, University of Horticultural Sciences, Bagalkot, Karnataka, India

**SI Athani**
Director of Student Welfare, University of Horticultural Sciences, Bagalkot, Karnataka, India

**Venkateshalu**
Professor and Head, Department of Entomology, University of Horticultural Sciences, Bagalkot, Karnataka, India

**Suvarna Patil**
Assistant Professor, Dept. of Entomology, University of Horticultural Sciences, Bagalkot, Karnataka, India

**Correspondence**
**MH Poornima**
Ph.D. Scholar, Department of Entomology, University of Horticultural Sciences, Bagalkot, Karnataka, India

# Impact of ultra high density, high density and conventional planting systems on major insect pests of mango

**MH Poornima, JB Gopali, SI Athani, Venkateshalu and Suvarna Patil**

**Abstract**
The experiment was conducted to study the influence of different planting densities on population dynamics of major insect pests of mango at Regional Horticultural Research and Extension Centre (RHREC), Dharwad during 2016-17 and 2017-18. The results revealed that among the different planting densities, ultra high density planting system (4.2 × 0.9 m, 4.2 × 1.2 m, 4.2 ×1.5 m, 4.2 ×1.5 and 2.5 × 2.5 m) and high density planting system (5.0 × 2.5 m, 5.0 × 5.0 m and 7.5 × 5.0 m) recorded higher incidence of leaf hopper and fruit fly damage as compared to conventional planting system 10 × 10 m. However, cost effectiveness of different planting density indicated that 5 × 5 m (400 plants/ha) had obtained maximum net returns (Rs. 213640 $ha^{-1}$) with highest B:C ratio (4.24) as compared to conventional planting of 10 × 10 m (100 plants/ha) suggesting that both from entomological and agronomical point of view, 5 × 5 m (400 plants/ha) spacing is optimum, economically viable, easily adoptable and practically acceptable by the farming community.

**Keywords:** Mango hoppers, fruit fly, ultra high density, high density, conventional

## 1. Introduction

Recently, area under high density and ultra high density is increasing so as to increase the production and productivity of mango. India is bestowed with rich diversity of mango cultivars and home for several mango accessions. In the country, mango is grown over an area of 2262.77 thousand ha (35% of total fruit-growing area) with an annual production of 19,687 thousand MT, which accounts for 60 per cent of the total world mango production with the productivity of 8.70 MT per hectare. In Karnataka, mango is cultivated in an area of 192.61 thousand hectares with an annual production of 1829.21 thousand MT and productivity of 9.49 MT per hectare during 2016-17 [1]. Under high density planting system (HDPS), to realize the higher productivity, one has to optimize the parameter of growth and minimize unproductive components of plants without sacrificing the overall health of the tree and quality of fruits. High density orcharding enables planting of more number of trees per unit area as compared to the traditional system of planting. However, this intense orchard system may impact arthropod diversity because of change in microclimate *viz.*, increased humidity and low light intensity due to increase in tree canopy, thus favouring the multiplication and build up of insect pests.

Mango hoppers (*Amritodus atkinsoni* Lethierry, *Ideoscopus niveosparsus* Lethierry and *Ideoscopus clypealis* Lethierry) are most destructive, monophagous and widespread insect pests with a potential to cause even complete loss of fruit yield owing to non-setting of flower and dropping of immature fruits. Both nymphs and adults cluster on the lower side of tender leaves and on inflorescence and suck the sap, resulting in drying of the entire inflorescence and even small fruits resulting in enormous yield loss. The maximum hopper population is found in varieties having dense inflorescence and orchards with closer spacing [2], which is a characteristic of HDPS of mango. Fruit flies (*Bactrocera* spp.) are economically important and polyphagous pests infesting more than 400 different fruits and vegetables especially in mango, guava, citrus, melon, papaya, peach, plum and apple [3]. Fruit flies are considered as high priority quarantine pests as they create major problem in the export of fresh mango fruits to foreign countries. Female flies puncture the skin of mature fruits with ovipositor and insert the eggs into the mesocarp in clusters. The maggots tunnel and feed on the pulp of the fruit. The enormous losses up to 80 per cent in mango, however losses due to *B. dorsalis* varies with season and region [4]. Considering the economic position of mango in Indian agriculture and increased area under HDPS and subsequent change in pest status, the investigation was undertaken on assessment of major insect pests of mango under different planting system in unprotected condition.

## 2. Material and Methods

To study the influence of different planting densities on population dynamics of major insect pests of mango, the field experiments were carried out in Randomized Block Design (RBD) with four replications. The mango orchard under the study was six years old with Alphonso variety. The other cultural operations such as weeding, mulching, pruning and training was performed as and when required especially after harvest of the crop during June and July months. For the experimentation, totally nine different planting densities were evaluated as nine treatments as mentioned in the Table 1. Four mango trees were selected for each treatment and each tree considered as one replication thus, four replications were maintained for each treatment. Unprotected condition was maintained to assess the abundance of insect pests under different planting densities.

**Table 1:** Details of planting densities of mango var. Alphonso for assessment of insect population

| Tree Spacing | | Planting density (Trees /ha) |
|---|---|---|
| **Ultra High Density Planting** | | |
| $T_1$ | 4.2 × 0.9 m | 2646 |
| $T_2$ | 4.2 × 1.2 m | 1984 |
| $T_3$ | 4.2 × 1.5 m | 1587 |
| $T_4$ | 4.2 × 1.8 m | 1323 |
| $T_5$ | 2.5 × 2.5 m | 1600 |
| **High Density Planting** | | |
| $T_6$ | 5.0 × 2.5 m | 800 |
| $T_7$ | 5.0 × 5.0 m | 400 |
| $T_8$ | 7.5 × 5.0 m | 286 |
| **Conventional Planting** | | |
| $T_9$ | 10 × 10 m | 100 |

### 2.1 Observations

The observations on the abundance of major insect pests of mango were recorded in different planting densities under unprotected condition. The observation on number of hoppers was recorded at 50 per cent flowering, 100 per cent flowering, fruit formation and fruit development stages in unprotected orchard. Observations on number of hoppers from five randomly selected panicles (inflorescences) per tree was counted and recorded during early morning hours during which hoppers were inactive and easy to count the population. For assessment of fruit fly damage in mango under unprotected condition at different planting densities, the observations were recorded at the time of harvesting. Soon after harvesting of mango, hundred fruits were chosen randomly from harvested lot and examined for oviposition injury on fruits. Further, such fruits were kept for observation to confirm the emergence of maggots from the fruits. The per cent fruit fly damage was worked out by adapting formula given below.

$$\text{Percent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

### 2.2 Yield and cost economics

The treatment-wise fruit yield per tree was recorded and computed to quintal per hectare basis. Further, cost economics was calculated for unprotected conditions based on total yield in quintal per hectare, other cost of cultivation and gross return based on market price at Rs. 40 per kg. The following formulae were used for calculation of B:C ratio.

1. Gross return = Yield x Market price of mango (Rs. 40/kg)
2. Net Returns = Gross Return - Total Cost
3. B: C ratio = Gross Return / Total Cost

## 3. Results and Discussion

The result of the first year (2016-17) indicated that the hopper population commenced from panicle initiation stage and then gradually increased with the advancement in peak flowering and thereafter declined towards development fruit stage. The hopper population in various treatments differed significantly. The mean data on hopper population from 50 per cent flowering stage to fruit development stage, significantly highest population of leaf hopper was recorded under ultra high density planting systems such as 4.2 × 0.9 m, 4.2 × 1.2 m, 4.2 ×1.5 m, 4.2 ×1.5 and 2.5 × 2.5 m with hopper population ranging from 52.50 to 58.75 hoppers per panicle which were on par with each other indicating no significant differences were observed among ultra high density planting systems. Whereas, high density planting systems such as 5.0 × 2.5 m, 5.0 × 5.0 m and 7.5 × 5.0 m recorded 32.50 to 51.77 hoppers/panicle which were at par with each other. While in conventional planting system (10 × 10 m) registered low hopper population (24.60 hoppers/panicle) as compared to all other planting densities under unprotected conditions. Regarding fruit fly infestation, significantly highest per cent fruit fly damage was noticed in ultra high density planting system *viz.*, 4.2 × 0.9 m (2646 trees/ha), 4.2 × 1.2 m (1984 trees/ha), 4.2 × 1.5 m (1581 trees/ha), 4.2 × 1.8 m (1323 trees/ha) and 2.5 × 2.5 m (1600 trees/ha) by recording 47.25 to 52.75 per cent which were on par with each other. However, planting density of 10 × 10 m (28.56%) and 7.5 × 5.0 m (30.96%) recorded lower incidence as compared to high density planting systems (Table 2).

During second year (2017-18) overall mean data of all stages of mango from panicle initiation to fruit development, lowest hopper population was recorded in conventional planting 10 × 10 m (15.41 hoppers/panicle) wherein plant population was 100 trees per hectare. Under high density 7.5 × 5.0 m (286 trees/ha), 5.0 × 5.0 m (400 trees/ha) and 5.0 × 2.5 m (800 trees/ha) recorded 21.43, 32.71 and 32.96 hoppers per panicle, respectively. Steadily the hopper population increased under ultra high density planting by recording 35.69, 33.68, 33.92, 32.90 and 36.57 hoppers per panicle in planting densities of 4.2 × 0.9 m (2646 trees/ha), 4.2 × 1.2 m (1587 trees/ha), 4.2 × 1.5 (1984 trees/ha) and 4.2 × 1.8 (1323 trees/ha) and 2.5 × 2.5 m (1600 trees/ha), respectively. Regarding fruit damage there was significant difference among the treatments and higher per cent damage was observed under ultra high density planting with spacing of 4.2 × 0.9 m (2646 trees/ha) (36.55%) and 4.2 × 1.2 m (1984 trees/ha) (34.11%), 4.2 × 1.5 m (1587 trees/ha) (32.89%), 4.2 × 1.8 m (29.33%) and 2.5 × 2.5 m (27.67%) which were on par with each other. Lower per cent fruit fly damage of 16.33, 18.33, 23.33 and 25.89 per cent was registered in spacing of 10 × 10 m (100 trees/ha), 7.5 × 5.0 m (286 trees/ha), 5.0 × 5.0 m (400 trees/ha) and 5.0 × 2.5 m (800 trees/ha), respectively under unprotected conditions (Table 3).

The pooled data confirmed similar trend as that of first (2016-17) and second year (2017-18) data. These observations suggested that both hopper population (Fig.1) and per cent fruit fly damage (Fig.2) were more pronounced under ultra high density and high density planting systems as compared to conventional planting system (Table 4) suggesting regular monitoring, surveillance, planning and intensive care with respect to plant protection measures under high density planting system. Present study illustrated that, as the planting density increases from conventional (10x10 m) to ultra high density (4.2x0.9 m), the insect population also increased proportionately. This could be attributed to closer spacing and dense crop canopy which might have of created microclimate such as increased humidity, low temperature and less light intensity in the orchard favouring multiplication of hoppers. Present finding are corroborated with the observations made by many workers on mango hoppers at different planting densities. Closer spacing between plants attracted higher incidence of hoppers as noted by [5,6]. The hopper population varied significantly under different plant densities [7], wherein planting density of 5×5 m had maximum hoppers and significantly varied from other plant densities of 7.5 × 7.5 m and 10 × 10 m. The hopper incidence was found to be highest in all planting densities, except in wider spacing of 10×10 m. Similar observation was noticed that more hoppers in 5 x 5 m spacing as compared to 10 x 5 m and 10 x 10 m [8].

Irrespective of planting density, the fruit fly damage depends on number of trees per unit area and availability of fruits per plant. Under high density planting system the distance between trees as well as between fruits within the tree is shorter as compared to conventional planting system where, size of the tree and spacing is wider. Thereby, damage was highest under high density planting system as fly gets more opportunity to visit more number of fruits per unit area and per unit time as compared to conventional planting system. As such, no documented information is available to support the present findings on fruit fly damage under high density planting system. However, among the *Bactrocera* species infesting mango, *B. dorsalis*, *B. zonata* [9] and *B. correcta* [10] were found to inflict significant economic damage to the fruits.

### 3.1 Effect on fruit yield (q/ha) and cost economics

There was significant variation in yield levels among the different planting densities. Ultra high planting density recorded highest yield (88.10 to 93.73 q/ha). While, high density planting systems recorded moderate yield levels (55.77 to 80.92 q/ha). Whereas, conventional planting system recorded lower yield (42.11 q/ha). However, cost effectiveness of different planting density indicated that 5 × 5 m (400 plants/ha) had obtained maximum net returns (Rs. 213640/ha) with highest B:C ratio (4.24) as compared to conventional planting of 10 × 10 m (100 plants/ha) suggesting that 5x5 m spacing is profitable both from entomological and agronomical point of view (Table 5). Higher yield levels under ultra-HDPS is mainly because of more number of trees per unit area gave higher fruit yield per hectare despite of higher incidence of hoppers and fruit fly damage. Although, this system of planting was not profitable as apparent from low B:C ratio due to higher incidence of hoppers and fruit fly damage which might be responsible reduction in yield levels. Further, high density planting systems requires more intensive care with respect to plant protection and canopy management. Thus, low monitory return in ultra-HDPS was resulted from increased cost of cultivation due to more number of plants per unit area. The cost towards agronomic practices, agrochemicals and farm labours may increase with increase in number of plants per unit area under ultra-HDPS as compared to high density and conventional planting system. From the foregoing discussion it can be concluded that planting density should be neither too high nor too low. Hence, both from entomological and agronomical point of view, 5 × 5 m (400 plants/ha) spacing is optimum, economically viable, easily adoptable and practically acceptable by the farming community.

**Table 2:** Impact of planting densities on mango hoppers and fruit fly damage under unprotected conditions during first year (2016-17)

| Treatments | | Plant density (Trees/ha) | Number of leaf hoppers per panicle | | | | | Percent fruit fly damage * |
|---|---|---|---|---|---|---|---|---|
| | | | 50% Flowering | 100% flowering | Fruit formation stage | Fruit devt. stage | Mean | |
| $T_1$ | 4.2 × 0.9 m | 2646 | 44.83 (6.73)$^{c}$ | 84.33 (9.19)$^{c}$ | 58.00 (7.63)$^{dc}$ | 32.58 (5.75)$^{c}$ | 54.94 (7.45)$^{c}$ | 52.75 (46.61)$^{e}$ |
| $T_2$ | 4.2 × 1.2 m | 1984 | 43.50 (6.61)$^{c}$ | 81.42 (9.02)$^{c}$ | 57.17 (7.57)$^{cd}$ | 28.42 (5.38)$^{b}$ | 52.63 (7.26)$^{cd}$ | 50.95 (45.57)$^{de}$ |
| $T_3$ | 4.2 × 1.5 m | 1587 | 43.58 (6.60)$^{c}$ | 80.25 (8.93)$^{c}$ | 54.25 (7.35)$^{cd}$ | 29.58 (5.45)$^{c}$ | 51.92 (7.19)$^{cd}$ | 49.56 (44.79)$^{de}$ |
| $T_4$ | 4.2 × 1.8 m | 1323 | 42.42 (6.51)$^{c}$ | 80.75 (8.96)$^{c}$ | 52.50 (7.23)$^{cd}$ | 27.92 (5.30)$^{b}$ | 50.90 (7.12)$^{c}$ | 47.25 (43.42)$^{de}$ |
| $T_5$ | 2.5 × 2.5 m | 1600 | 45.25 (6.75)$^{c}$ | 83.00 (9.12)$^{c}$ | 58.75 (7.68)$^{d}$ | 32.92 (5.78)$^{c}$ | 54.98 (7.43)$^{d}$ | 45.65 (42.49)$^{cd}$ |
| $T_6$ | 5.0 × 2.5 m | 800 | 43.58 (6.64)$^{c}$ | 80.58 (8.99)$^{c}$ | 55.42 (7.46)$^{cd}$ | 27.48 (95.29)$^{b}$ | 51.77 (7.23)$^{cd}$ | 40.23 (39.34)$^{bc}$ |
| $T_7$ | 5.0 × 5.0 m | 400 | 43.25 (6.56)$^{c}$ | 78.92 (8.84)$^{c}$ | 50.58 (7.09)$^{c}$ | 25.92 (5.10)$^{b}$ | 49.67 (7.02)$^{c}$ | 38.22 (38.02)$^{b}$ |
| $T_8$ | 7.5× 5.0 m | 286 | 30.50 (5.55)$^{b}$ | 46.50 (6.83)$^{b}$ | 36.67 (6.08)$^{b}$ | 16.33 (4.10)$^{a}$ | 32.50(5.74)$^{b}$ | 30.96 (33.74)$^{a}$ |
| $T_9$ | 10 × 10 m | 100 | 20.08 (4.54)$^{a}$ | 35.75 (6.01)$^{a}$ | 28.67 (5.39)$^{a}$ | 13.91 (3.80)$^{a}$ | 24.60 (5.01)$^{a}$ | 28.56 (32.27)$^{a}$ |
| S. Em ± | | | 0.14 | 0.20 | 0.17 | 0.12 | 0.08 | 1.33 |
| C.D. at 5% | | | 0.45 | 0.61 | 0.51 | 0.35 | 0.25 | 4.00 |

Figures in the parentheses are $\sqrt{x+0.5}$ transformed values *Figures in the parentheses are arc sine transformed values
In a column, means followed by same alphabet(s) do not differ significantly by DMRT (P=0.05)

**Table 3:** Impact of planting densities on mango hoppers and fruit fly damage under unprotected conditions during second year (2017-18)

| Treatments | | Plant density (Trees/ha) | Number of leaf hoppers per panicle | | | | | Percent fruit fly damage * |
|---|---|---|---|---|---|---|---|---|
| | | | 50% Flowering | 100% flowering | Fruit formation stage | Fruit devt. stage | Mean | |
| $T_1$ | 4.2 × 0.9 m | 2646 | 28.89 (5.42)$^{c}$ | 53.83 (7.35)$^{c}$ | 39.81 (6.33)$^{b}$ | 20.22 (4.54)$^{de}$ | 35.69 (6.00)$^{c}$ | 36.55 (37.15)$^{e}$ |
| $T_2$ | 4.2 × 1.2 m | 1984 | 27.72 (5.31)$^{c}$ | 50.78 (7.14)$^{c}$ | 37.89 (6.18)$^{b}$ | 18.33 (4.34)$^{cd}$ | 33.68 (5.83)$^{c}$ | 34.11 (35.67)$^{e}$ |
| $T_3$ | 4.2 × 1.5 m | 1587 | 27.57 (5.26)$^{c}$ | 50.95 (7.13)$^{c}$ | 38.11 (6.17)$^{b}$ | 19.05 (4.39)$^{cde}$ | 33.92 (5.87)$^{c}$ | 32.89 (34.86)$^{de}$ |
| $T_4$ | 4.2 × 1.8 m | 1323 | 26.50 (5.16)$^{c}$ | 50.55 (7.10)$^{c}$ | 36.81 (6.07)$^{b}$ | 17.71 (4.24)$^{cd}$ | 32.90 (5.74)$^{c}$ | 29.33 (32.66)$^{cd}$ |
| $T_5$ | 2.5 × 2.5 m | 1600 | 29.72 (5.50)$^{c}$ | 54.17 (7.39)$^{c}$ | 41.45 (6.46)$^{b}$ | 20.95 (4.63)$^{e}$ | 36.57 (6.09)$^{c}$ | 27.67 (31.69)$^{c}$ |
| $T_6$ | 5.0 × 2.5 m | 800 | 27.05 (5.25)$^{c}$ | 49.05 (7.04)$^{c}$ | 37.83 (6.19)$^{b}$ | 17.89 (4.29)$^{cd}$ | 32.96 (5.78)$^{c}$ | 25.89 (30.54)$^{bc}$ |
| $T_7$ | 5.0 × 5.0 m | 400 | 26.61 (5.17)$^{c}$ | 48.78 (6.96)$^{c}$ | 38.39 (6.24)$^{b}$ | 17.05 (4.16)$^{c}$ | 32.71 (5.72)$^{c}$ | 23.33 (28.69)$^{b}$ |
| $T_8$ | 7.5× 5.0 m | 286 | 18.11 (4.31)$^{b}$ | 33.11 (5.78)$^{b}$ | 23.72 (4.92)$^{a}$ | 10.78 (3.36)$^{b}$ | 21.43 (4.68)$^{b}$ | 18.33 (25.28)$^{a}$ |
| $T_9$ | 10 × 10 m | 100 | 13.17 (3.70)$^{a}$ | 20.39 (4.57)$^{a}$ | 19.72 (4.49)$^{a}$ | 8.35 (2.97)$^{a}$ | 15.41 (3.99)$^{a}$ | 16.33 (23.80)$^{a}$ |
| S. Em ± | | | 0.11 | 0.16 | 0.13 | 0.09 | 0.13 | 0.87 |
| C.D. at 5% | | | 0.36 | 0.49 | 0.41 | 0.29 | 0.39 | 2.63 |

Figures in the parentheses are $\sqrt{x+0.5}$ transformed values *Figures in the parentheses are arc sine transformed values
In a column, means followed by same alphabet(s) do not differ significantly by DMRT (P=0.05)

**Table 4:** Impact of planting densities on mango hoppers and fruit fly damage under unprotected condition (Pooled data)

| Treatments | | Plant density (Trees/ha) | Number of leaf hoppers per panicle | | | | | Per cent fruit fly damage * |
|---|---|---|---|---|---|---|---|---|
| | | | 50% Flowering | 100% flowering | Fruit formation Stage | Fruit devt. stage | Mean | |
| $T_1$ | 4.2 × 0.9 m | 2646 | 37.86 (6.11)$^{c}$ | 69.08 (8.34)$^{c}$ | 48.91 (7.01)$^{c}$ | 26.40 (5.19)$^{de}$ | 45.31 (6.77)$^{c}$ | 44.65 (41.91)$^{f}$ |
| $T_2$ | 4.2 × 1.2 m | 1984 | 35.61 (6.01)$^{c}$ | 66.10 (8.13)$^{c}$ | 47.53 (6.91)$^{c}$ | 23.38 (4.89)$^{cd}$ | 43.15 (6.61)$^{c}$ | 42.53 (40.67)$^{ef}$ |
| $T_3$ | 4.2 × 1.5 m | 1587 | 35.57 (6.01)$^{b}$ | 65.60 (8.08)$^{c}$ | 46.18 (6.79)$^{c}$ | 24.32 (4.98)$^{cde}$ | 42.92 (6.59)$^{c}$ | 41.23 (39.87)$^{efd}$ |
| $T_4$ | 4.2 × 1.8 m | 1323 | 34.46 (5.91)$^{c}$ | 65.65 (8.13)$^{c}$ | 44.66 (6.68)$^{c}$ | 22.82 (4.83)$^{c}$ | 41.90 (6.51)$^{c}$ | 38.29 (38.13)$^{ed}$ |
| $T_5$ | 2.5 × 2.5 m | 1600 | 37.49 (6.16)$^{c}$ | 68.58 (8.31)$^{c}$ | 50.10 (7.11)$^{c}$ | 26.93 (5.24)$^{e}$ | 45.78 (6.80)$^{c}$ | 36.66 (37.23)$^{cd}$ |
| $T_6$ | 5.0 × 2.5 m | 800 | 35.32 (5.98)$^{c}$ | 64.82 (8.08)$^{c}$ | 46.63 (6.86)$^{c}$ | 22.68 (4.81)$^{c}$ | 42.36 (6.55)$^{c}$ | 33.06 (35.06)$^{bc}$ |
| $T_7$ | 5.0 × 5.0 m | 400 | 34.93 (5.95)$^{c}$ | 63.85 (7.96)$^{c}$ | 44.48 (6.71)$^{c}$ | 21.49 (4.69)$^{c}$ | 41.19 (6.46)$^{c}$ | 30.78 (33.50)$^{b}$ |
| $T_8$ | 7.5× 5.0 m | 286 | 24.31 (4.98)$^{b}$ | 39.81 (6.33)$^{b}$ | 30.20 (5.54)$^{b}$ | 13.56 (3.75)$^{b}$ | 26.97 (5.24)$^{b}$ | 24.65 (29.69)$^{a}$ |
| $T_9$ | 10 × 10 m | 100 | 16.62 (4.14)$^{a}$ | 28.07 (5.34)$^{a}$ | 24.20 (4.97)$^{a}$ | 11.13 (3.41)$^{a}$ | 20.00 (4.53)$^{a}$ | 22.45 (28.24)$^{a}$ |
| S. Em ± | | | 0.13 | 0.18 | 0.15 | 0.11 | 0.14 | 1.01 |
| C.D. at 5% | | | 0.41 | 0.55 | 0.46 | 0.33 | 0.43 | 3.04 |

Figures in the parentheses are $\sqrt{x+0.5}$ transformed values *Figures in the parentheses are arc sine transformed values
In a column, means followed by same alphabet(s) do not differ significantly by DMRT (P=0.05)

**Table 5:** Influence of different planting densities on mango yield and cost economics due to hoppers and fruit fly damage under unprotected condition

| Treatments | | Plant density (Trees/ha) | Yield (q/ ha) | | | Other production cost (Rs/ha) | *Gross returns (Rs/ha) | Net returns (Rs/ha) | B:C Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2016-17 | 2017-18 | Pooled | | | | |
| $T_1$ | 4.2 × 0.9 m | 2646 | 88.56$^{a}$ | 98.89$^{a}$ | 93.73$^{a}$ | 189344 | 374900 | 185556 | 1.98 |
| $T_2$ | 4.2 × 1.2 m | 1984 | 83.03$^{abc}$ | 93.52$^{ab}$ | 88.28$^{ab}$ | 159864 | 353100 | 193236 | 2.21 |
| $T_3$ | 4.2 × 1.5 m | 1587 | 80.96$^{bc}$ | 95.23$^{ab}$ | 88.10$^{ab}$ | 143373 | 352380 | 209007 | 2.46 |
| $T_4$ | 4.2 × 1.8 m | 1323 | 88.25$^{ab}$ | 96.16$^{ab}$ | 92.21$^{a}$ | 124340 | 368820 | 244480 | 2.97 |
| $T_5$ | 2.5 × 2.5 m | 1600 | 80.89$^{bc}$ | 97.65$^{ab}$ | 89.27$^{ab}$ | 141700 | 357080 | 215380 | 2.52 |
| $T_6$ | 5.0 × 2.5 m | 800 | 77.26$^{c}$ | 84.58$^{b}$ | 80.92$^{b}$ | 92300 | 323680 | 231380 | 3.51 |
| $T_7$ | 5.0 × 5.0 m | 400 | 66.56$^{d}$ | 73.26$^{c}$ | 69.91$^{c}$ | 66000 | 279640 | 213640 | 4.24 |
| $T_8$ | 7.5× 5.0 m | 286 | 41.23$^{e}$ | 50.31$^{d}$ | 45.77$^{d}$ | 65050 | 183080 | 118030 | 2.81 |
| $T_9$ | 10 × 10 m | 100 | 37.96$^{e}$ | 46.25$^{d}$ | 42.11$^{d}$ | 53700 | 168420 | 114720 | 3.14 |
| S. Em ± | | | 2.46 | 3.27 | 2.84 | | | | |
| C. D. at 5% | | | 7.42 | 9.81 | 8.52 | | | | |

In a column, means followed by same alphabet(s) do not differ significantly by DMRT (P=0.05) * Market price of mango = Rs. 40 /kg

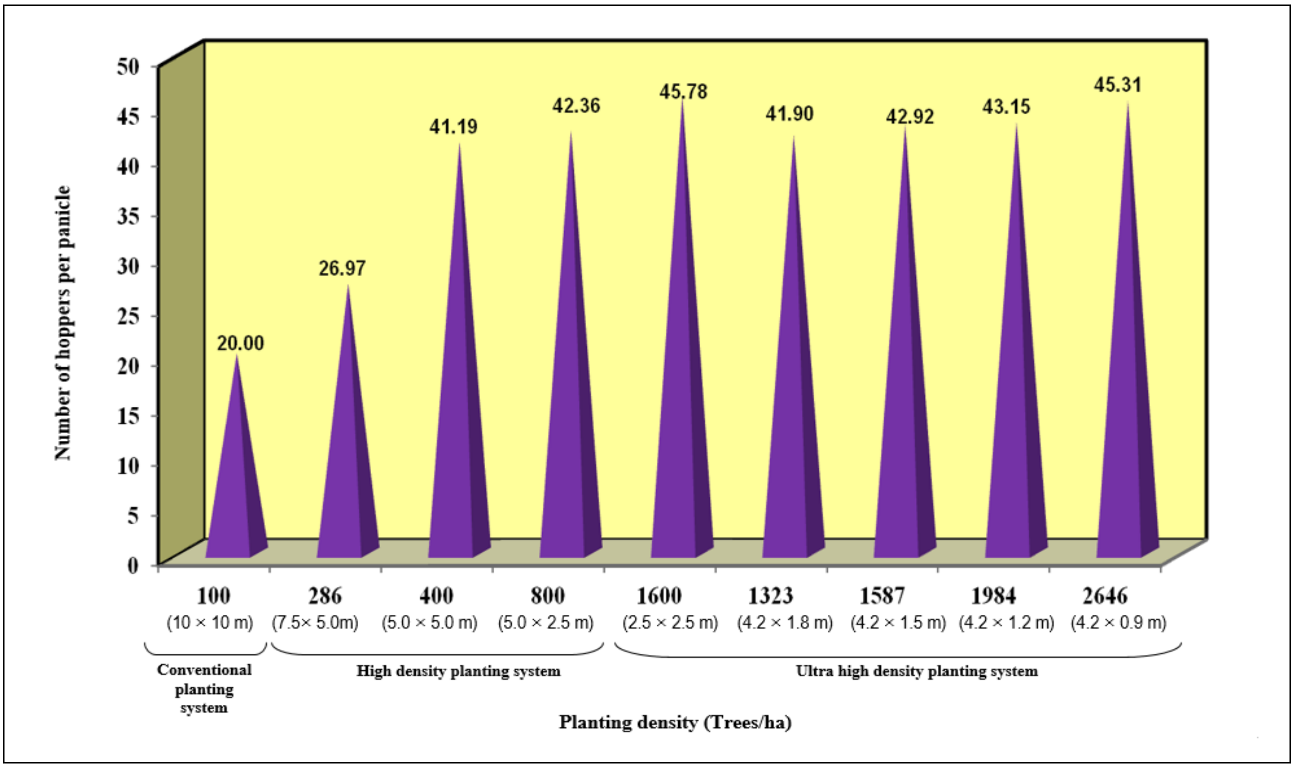


**Fig 1:** Relationship between planting density and hopper population in mango under unprotected condition

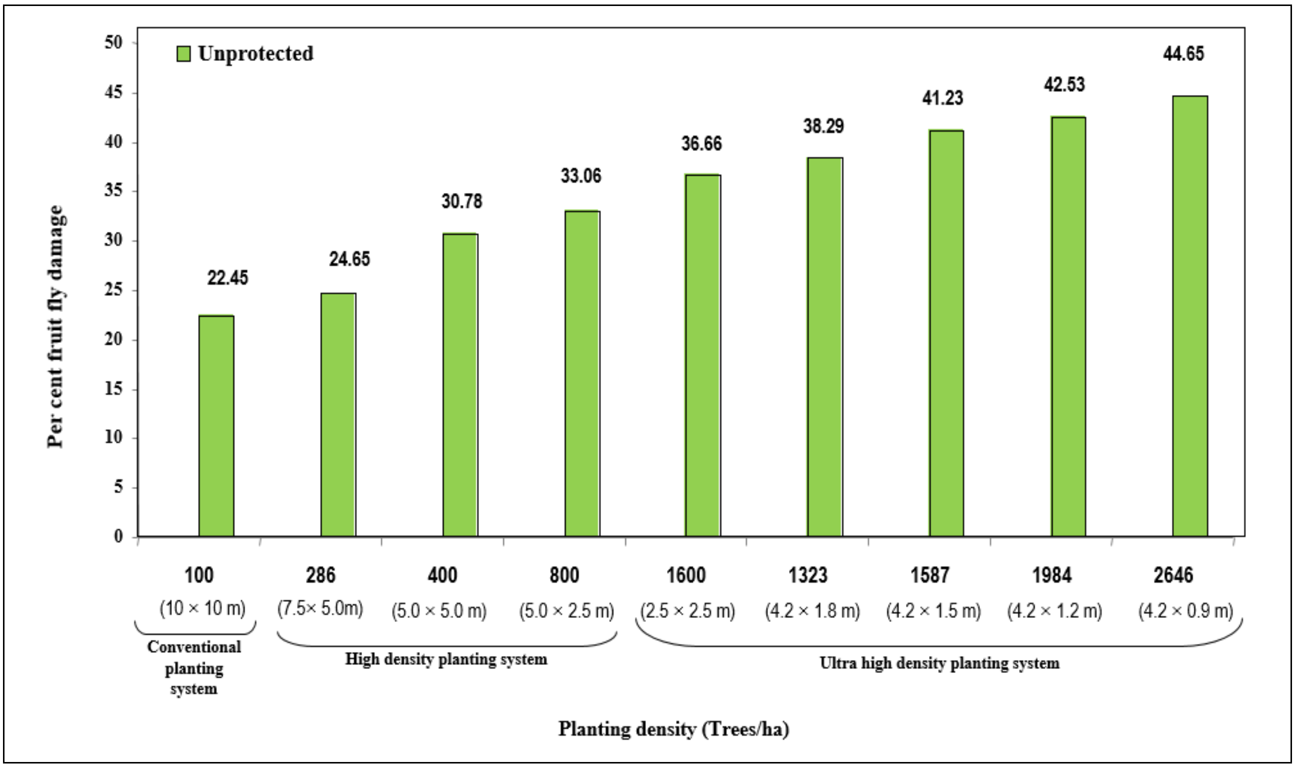


**Fig 2:** Fruit fly damage in mango under unprotected condition at different planting density

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