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# Performance of Different Varieties of Mango in North Gujarat Condition under Different Plant Spacing

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The study was conducted to evaluate the performance of different varieties of Mango in North Gujarat condition under different plant spacing during 2008-2023 at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. Accordingly, Kesar, Totapuri, Dashehari, Mallika and Amrapali varieties were planted in year 2008 at spacing of 4 m x 4 m, 5 m x 5 m, 6 m x 6 m and 7 m x 7 m. The experiment was laid out in factorial randomized block design with three replications and twenty treatment combinations. The different growth and yield parameters were recorded in terms of plant spread, plant height, plant stem girth, fruit yield plant$^{-1}$ and fruit yield hectare$^{-1}$ as observations. The experimental results revealed that, individually, Dashehari variety recorded maximum plant spread (E-W and N-S) (7.05 m and 7.17 m respectively), stem girth (91.92 cm) and Kesar variety recorded maximum plant height (7.54 m), while in case of planting spacing 7 m x 7 m recorded maximum plant spread (E-W and N-S) (7.53 m and 7.55 m respectively), plant height

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(7.01 m) and stem girth (90.07 cm) after 15th year of planting. With regard to yield parameters, Kesar variety planted at 4 m x 4 m spacing found superior and reported highest fruit yield hectare$^{-1}$ (11875.00 kg) whereas, highest fruit yield plant$^{-1}$ (32.73 kg) was observed with 7 m x 7 m spacing after 15th year of planting. Hence, kesar variety planted at 4 m x 4 m spacing found suitable for North Gujarat condition.

*Keywords: Mangifera indica; fruit yield; plant stem girth; Kesar.*

## 1. INTRODUCTION

Mango (*Mangifera indica* L.), which belongs to the family anacardiaceae, has immense adaptability and grows well in an extensive compass of climatic and soil conditions, making it the best of Indian table fruits (Chakraborti et al., 2022). Mango is cultivated over an area of 2316.8 thousand ha with an annual production of 20386 thousand MT with 8.8 MT/ha productivity in India (Anonymous, 2021). Gujarat is one of the important mango growing states of India and occupies an area of 163.78 thousand ha with production of 997.83 thousand MT with a productivity of 6.09 MT/ha (Anonymous, 2021). The most important mango grown cultivars in Western India are Kesar, Alphonso, Totapuri, Rajapuri, Vanraj, Dashehari, Jamadar, Langra, Neelum, Badami, Amrapali, Mallika, Dadamio and Sardar (Patel et al, 2022). Mango is high in vitamins, minerals and antioxidants and has been associated with a variety of health advantages, including potential anticancer effects, increased immunity, digestive health and eye health. (Anand et al., 2024). Owing to its importance and popularity, now a day several mango varieties are grown in Banaskantha, Sabarkantha and Kutch district of North Gujarat. Despite of higher producer of mango, India is still far behind in productivity. The main reason for low productivity can be attributed to poor orchard management including water and nutrient management, wider tree spacing with dense canopies, experiencing poor sunlight interception, lack of proper ventilation encouraging more pest and disease incidences (Soman et al., 2024). In addition to that, availability of arable land for extending mango cultivation has been a limitation over the years. Hence, intensification of mango production system is the necessity in the coming years. Increasing productivity of mango is possible by establishing high density orchards maximizing the resource use efficiency resulting in at least 2-3 times higher fruit yields than widely spaced orchards (Singh et al., 2001, Dalvi et al., 2010, Chaudhari and Singh, 2019, Kumar et al., 2019, Vidyashree et al., 2021, Soman et al., 2024). A great benefit of this system is the ability to carry out novel manipulations, which are largely impractical in conventional planting system such as ability to easily remove malformed inflorescences, ease in harvest and inter cultural operations (Raj et al., 2017, Oosthuyse et al., 2018). Moreover, planting trees at higher density leads to higher light interception resulting in earlier cropping and higher yields with faster return on investment (Menzel and Lagadec, 2017, Mahmud et al., 2023). In India, release of high yielding, regular bearing mango hybrids viz., Mallika (Gaikwad et al., 2017, Mitra and Bhagwan, 2018, Kumar et al., 2019, Kavitha et al., 2022, Srivastava et al., 2024) and Amrapali (Das and Jana, 2013, Raj et al., 2017, Mitra and Bhagwan, 2018, Vidyashree et al., 2021, Kavitha et al., 2022) gradually paved the way for high density planting in mango. Furthermore, Dashehari (Gaikwad et al., 2017, Raj et al., 2017, Kumar et al., 2019) Kesar (Gaikwad et al., 2017, Kavitha et al., 2018, Kumar et al., 2019, Vidyashree et al., 2021, Kavitha et al., 2022) and Totapuri (Kavitha et al., 2018, Kumar et al., 2019, Vidyashree et al., 2021, Kavitha et al., 2022, Soman et al., 2024) cultivar also found promising for closer planting. The information on varietal evaluation is scanty and no systematic work has been done to evaluate the mango varieties under high density planting in North Gujarat. Thus, the present investigation was carried out to study the performance of different varieties of Mango in North Gujarat condition under different plant spacing.

## 2. MATERIALS AND METHODS

The experiment was laid out in Factorial Randomized Block Design with three replications at Horticulture Demonstration Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat). Geographically, Sardarkrushinagar falls in a subtropical climate and is situated at 24.32 °N (latitude) and 72.17 °E (longitude) and about 177 meters above mean sea level. The study was undertaken with an objective to find out the suitable varieties of Mango for commercial

cultivation in North Gujarat and to find out the most appropriate plant spacing for maximum production of Mango fruit. The different varieties (V) i.e. $V_1$ (Kesar), $V_2$ (Totapuri), $V_3$ (Dashehari), $V_4$ (Mallika) and $V_5$ (Amrapali) were evaluated as one factor whereas planting spacing (S) i.e. $S_1$ (4 m x 4 m), $S_2$ (5 m x 5 m), $S_3$ (6 m x 6 m) and $S_4$ (7 m x 7 m) were evaluated as another factor. There were total twenty treatment combinations and for each treatment one plant was considered for recording observation. The mango plants propagated through softwood grafting were planted in the monsoon of year 2008. The recommended dosage of fertilizer for Gujarat i.e. 750:160:750 g NPK per plant per year was given and standard package of practices were followed during the year of experimentation. The observations for adult tree were recorded during last week of December to first week of January every year. The different growth and yield parameters were recorded in terms of plant spread (E-W and N-S) (m), plant height (m), plant stem girth (cm), fruit yield plant$^{-1}$ (kg) and fruit yield hectare$^{-1}$(kg). Plant height was measured from base of the ground and stem girth was measured from base trunk of the plant. The growth parameters were recorded for 6$^{th}$ (2014), 10$^{th}$ (2018) and 15$^{th}$ (2023) year after planting and 15$^{th}$ year (2023) data is analysed for final interpretation. Whereas yield data were recorded for the year 2019 to 2023 (11$^{th}$ to 15$^{th}$ year after planting) and pooled data were analysed for interpretation. The data were statistically analysed as methods suggested by Panse and Sukhatme (1961).

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Spacing on Plant Growth Parameters

Analysis of data revealed that spacing showed significant effect on plant growth parameters (Tables 1 and 2). Data from Table 1 revealed that, plant spread (E-W) and plant spread (N-S) was found significant and maximum plant spread (E-W and N-S) (7.53 m and 7.55 m respectively) were recorded in $S_4$ (7m x 7m) spacing after 15$^{th}$ year of planting (2023). Similar trend was recorded after 6$^{th}$ (2014) and 10$^{th}$ (2018) year of planting. In high density planting natural tendency of the plant is to put forth reduced canopy growth as compare to normal planting spacing, due to several possible reasons viz., lesser available place in between the rows of plants, restrictions of light, increment in competition for water and soil nutrients and decreased plant stem girth. The above results were in agreement with earlier reports of Ibell et al., (2024), Gaikwad et al., (2017), Sousa et al., (2012), Nath et al., (2007), Dalvi et al., (2010), Policarpo et al., (2006) Ram et al., (1997). Likewise, data from Table 2 revealed that significantly maximum plant height (7.01 m) and plant stem girth (90.07 cm) were observed in $S_4$ (7m x 7m) spacing after 15$^{th}$ year of planting. However, $S_3$ (6 m x 6 m) and $S_2$ (5 m x 5 m) spacing were significantly at par with $S_4$ (7 m x 7 m) treatment in case of plant height whereas $S_3$ (6 m x 6 m) treatment was significantly at par with $S_4$ (7 m x 7 m) spacing in case of plant stem girth. The similar trend of reduced growth under high planting density in terms of plant stem girth was reported by Gaikwad et al., (2017), Nath et al., (2007), Dalvi et al., (2010). Plant height may decrease with increase in plant density as observed in Dashehari mango (Ram and Sirohi, 1991) and Kesar mango (Gaikwad et al., 2017) due to reduced trunk girth.

### 3.2 Effect of Different Varieties on Growth Parameters

The varieties typically differ in its morphological characters due to varied varietal characters (Shah et al., 2013). Data from Tables 1 and 2 were in compliance with it. The plant spread (E-W), plant spread (N-S) and plant stem girth were found significant for different varieties after 15$^{th}$ year of planting (2023). However, plant height was found non-significant. The significantly maximum plant spread (E-W) (7.05 m), plant spread (N-S) (7.17 m) and plant stem girth (91.92 cm) were found in $V_3$ (Dashehari) variety which was at par with $V_4$ (Mallika), $V_5$ (Amrapali) and $V_1$ (Kesar) variety respectively parameter wise. While maximum plant height (7.54 m) was observed in $V_1$ (Kesar) variety after 15$^{th}$ year of planting (2023). These findings are in accordance with those reported by Gaikwad et al., (2017) and Ram and Sirohi, (1991). Dashehari is vigoruous cultivar (Victor et al., 2018, Balasubrahmanyam et al., 2000) which leads to higher plant spread and stem girth whereas Amrapali is a slow-growing cultivar (Oosthuyse et al., 2018). The increase in plant height appears to be due to shading in high density planting and in Kesar. Similar results were recorded by Gunjate et al., (2004), Balasubrahmanyam et al., (2000).

### 3.3 Interaction Effect of Spacing and Varieties on Growth Parameters

Despite of spacing and varieties individually had considerable effect on various growth

parameters of mango, the interaction effect was found non-significant for all the growth parameters (Tables 1 and 2). This shows that independence of both the factors which were affecting the growth individually.

### 3.4 Effect of Spacing on Fruit Yield Plant$^{-1}$

Fruit yield is an important parameter to evaluate merit of treatment. The concept of high density planting is based on accommodating more number of plants in unit area without considerable loss in the yield plant$^{-1}$. The change in the fruit yield plant$^{-1}$ affected by spacing is presented in Table 3. The results revealed that the $S_4$ (7 m x 7 m) spacing recorded significantly maximum fruit yield plant$^{-1}$for year 2019 (28.00 kg), 2021 (44.13 kg) and 2023 (37.07 kg). However, it was found non-significant for year 2020, 2022 and in pooled.

**Table 1. Effect of plant spacing and varieties on plant spread (E-W & N-S) (m) of mango**

| | Plant spread (E-W) (m) | | | Plant spread (N-S) (m) | | |
|---|---|---|---|---|---|---|
| **Spacing** | **6th Year (2014)** | **10th Year (2018)** | **15th Year (2023)** | **6th Year (2014)** | **10th Year (2018)** | **15th Year (2023)** |
| $S_1$ | 3.36 | 4.81 | 5.61 | 3.36 | 4.89 | 5.79 |
| $S_2$ | 3.98 | 4.89 | 5.90 | 3.99 | 4.96 | 6.21 |
| $S_3$ | 4.03 | 5.36 | 6.42 | 4.03 | 5.31 | 6.23 |
| $S_4$ | 4.22 | 6.45 | 7.53 | 4.34 | 6.45 | 7.55 |
| SEm± | 0.12 | 0.18 | 0.19 | 0.12 | 0.19 | 0.21 |
| CD (*p*=0.05) | 0.36 | 0.51 | 0.55 | 0.36 | 0.54 | 0.58 |
| Variety | | | | | | |
| $V_1$ | 3.51 | 5.34 | 6.15 | 3.62 | 5.25 | 6.08 |
| $V_2$ | 3.75 | 5.11 | 6.01 | 3.89 | 4.91 | 6.03 |
| $V_3$ | 4.12 | 6.03 | 7.05 | 4.08 | 5.95 | 7.17 |
| $V_4$ | 3.95 | 4.98 | 6.64 | 4.05 | 4.75 | 6.43 |
| $V_5$ | 4.16 | 5.44 | 5.98 | 4.00 | 5.59 | 6.52 |
| SEm± | 0.14 | 0.20 | 0.22 | 0.14 | 0.22 | 0.23 |
| CD (*p*=0.05) | 0.40 | 0.57 | 0.62 | NS | 0.60 | 0.65 |
| S x V | | | | | | |
| CD (*p*=0.05) | NS | NS | NS | NS | NS | NS |
| CV% | 12.34 | 12.77 | 11.77 | 12.21 | 13.81 | 12.20 |

**Table 2. Effect of plant spacing and varieties on plant height (m) and plant stem girth (cm) of mango**

| | Plant height (m) | | | Plant stem girth (cm) | | |
|---|---|---|---|---|---|---|
| **Spacing** | **6th Year (2014)** | **10th Year (2018)** | **15th Year (2023)** | **6thYear (2014)** | **10thYear (2018)** | **15thYear (2023)** |
| $S_1$ | 4.22 | 4.81 | 6.11 | 45.23 | 64.67 | 74.13 |
| $S_2$ | 4.64 | 5.11 | 6.67 | 51.47 | 66.33 | 79.40 |
| $S_3$ | 4.57 | 5.30 | 6.79 | 52.60 | 73.00 | 85.00 |
| $S_4$ | 4.32 | 5.31 | 7.01 | 54.57 | 73.27 | 90.07 |
| SEm± | 0.13 | 0.11 | 0.14 | 1.61 | 3.32 | 1.95 |
| CD @ 5% | NS | 0.32 | 0.41 | 4.64 | NS | 5.58 |
| Variety | | | | | | |
| $V_1$ | 5.13 | 5.88 | 7.54 | 55.46 | 78.33 | 89.00 |
| $V_2$ | 4.16 | 4.73 | 6.12 | 47.04 | 63.33 | 75.25 |
| $V_3$ | 4.44 | 5.41 | 6.83 | 53.83 | 72.42 | 91.92 |
| $V_4$ | 4.02 | 4.49 | 6.37 | 46.79 | 60.83 | 77.75 |
| $V_5$ | 4.43 | 5.15 | 6.38 | 51.71 | 71.67 | 76.83 |
| SEm± | 0.14 | 0.12 | 0.16 | 1.81 | 3.71 | 2.18 |
| CD (*p*=0.05) | 0.41 | 0.36 | 0.46 | 5.19 | 10.60 | 6.24 |
| S x V | | | | | | |
| CD (*p*=0.05) | NS | NS | NS | NS | NS | NS |
| CV% | 11.01 | 8.44 | 8.40 | 12.27 | 18.53 | 9.20 |

Most of the commercial Indian mango varieties exhibit alternate cycles of heavy yield in 'on-year' followed by reduced or no fruiting in the 'off-year'. Though essentially a cultivar-specific trait, alternate bearing is also modulated by environmental factors and cultural practices (Chaudhari and Singh, 2019). Although, in pooled, the maximum fruit yield plant$^{-1}$ (25.16 kg) was observed under $S_4$ (7 m x 7 m) spacing and minimum (16.47 kg) was observed under $S_1$ (4 m x 4 m) spacing. The smaller the area available to plants, the higher the tendency to decrease the number of lower shoots, and the yield of fruit per plant (Gaikwad et al., 2017). Moreover, higher plant spacing provide adequate inter space between plant while provide adequate light penetration inside the canopy resulting in better reproductive growth.

### 3.5 Effect of Varieties on Fruit Yield Plant$^{-1}$

The varieties had remarkable influence on yield. From Table 3, it was noted that fruit yield plant$^{-1}$ was found significant for all the year but found non- significant for pooled. The highest fruit yield plant$^{-1}$ was recorded in $V_2$ (33.58 kg), $V_1$ (22.75 kg), $V_3$ (40.08 kg), $V_4$ (16.67 kg), and $V_3$ (37.42) in year 2019, 2020, 2021, 2022 and 2023 respectively. However, in pooled data maximum fruit yield plant$^{-1}$ (24.83 kg) was in $V_1$ (Kesar) variety whereas minimum fruit yield plant$^{-1}$ (18.55 kg) was in $V_5$ (Amrapali) variety. The above results were in agreement with those reported by Gaikwad et al., (2017), Joglekar et al., (2013), Gunjate et al., (2009), Gunjate et al., (2004). Balasubrahmanyam et al., (2000) observed that in terms of yield kesar variety maintained its edge over the other commercial varieties in dry region of Maharashtra due to varietal characters i.e. higher fruit weight. It is evident that diverse mango varieties have morphological variations viz., fruit weight (Shah et al., 2013) in addition to that individual cultivar does not grow equally well under different sets of climatic conditions prevailing in various parts of the country. (Chakraborti et al., 2022).

### 3.6 Interaction Effect of Spacing and Varieties on Fruit Yield Plant$^{-1}$

The interaction effect of spacing and varieties on fruit yield plant$^{-1}$ was found significant for year 2019, 2023 and pooled (Table 3). The interaction effect is presented in Table 4. In year 2019, $V_2S_2$ (Totapuri variety at 5 m x 5 m spacing) recorded highest fruit yield plant$^{-1}$(41.67 kg) which was followed by $V_2S_3$ (36.67 kg), $V_2S_4$ (36.67 kg), $V_1S_4$ (36.67 kg) and $V_3S_4$ (31.67 kg) while in year 2023, $V_3S_4$ (Dashehari variety at 7 m x 7 m spacing) recorded highest fruit yield plant$^{-1}$(49.33 kg) which was at par with $V_1S_4$ (41.67 kg). However, in pooled (Table 4) maximum fruit yield plant$^{-1}$ (32.73 kg) was observed in $V_1S_4$ (Kesar variety at 7 m x 7 m spacing) which was followed by $V_3S_4$ (28.60 kg). These results follow the combine effect of planting density and varieties as observed by Gunjate et al., (2009). While evaluating different mango varieties under high density planting, Vidyashree et al., (2021) observed higher fruit set, fruit weight and yield in kesar mango.

### 3.7 Effect of Spacing on Fruit Yield Hectare$^{-1}$ (kg)

With regard to fruit yield hectare$^{-1}$(kg), $S_1$ (4 m x 4 m) spacing found significant for all the year as well as in pooled (Table 3) noting 10083.33 kg, 7125.00 kg, 14375.00 kg, 7208.33 kg, 12666.67 kg and 10291.67 kg yield in year 2019, 2020, 2021, 2022, 2023 and in pooled respectively. Conversely, minimum fruit yield hectare$^{-1}$(5132.64 kg) was in $S_4$ (7 m x 7 m) spacing. Higher planting density accommodates more number of trees per unit area. Hence, closure spacing gave higher fruit yield hectare$^{-1}$. Similar results were observed by Kumar (2019), Srivastava et al., (2024), Soman et al., (2024). Though, it is noteworthy that it generally lower yield per plant.

### 3.8 Effect of Varieties on Fruit Yield Hectare$^{-1}$ (kg)

From Table 3 it was found that, fruit yield hectare$^{-1}$(kg) was found significant for year 2019, 2020, 2022 and 2023 recording 11605.83 kg ($V_2$), 8293.75 kg ($V_2$), 13432.42 kg ($V_1$), 5878.92 kg ($V_4$) and 12630.08 kg ($V_3$) yield respectively whereas it was found non-significant for year 2021 and in pooled. Though, in pooled the maximum fruit yield hectare$^{-1}$(kg) (8696.65 kg) was observed in $V_1$ (Kesar) variety and minimum (6723.82 kg) in $V_4$ (Mallika) variety. It depicts the adaptability of kesar as high yielding variety in particular area. Similar results were recorded by Gaikwad et al., (2017), Joglekar et al., (2013), Gunjate et al., (2009), Gunjate et al., (2004); Singh et al., 2023; Kushwah, et al., 2024, Balasubrahmanyam et al., (2000).

**Table 3. Effect of spacing and varieties on fruit yield plant$^{-1}$ (kg) and fruit yield hectare$^{-1}$ (kg) of mango**

| | Fruit yield plant$^{-1}$ (kg) | | | | | | Fruit yield hectare$^{-1}$ (kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spacing** | **2019** | **2020** | **2021** | **2022** | **2023** | **Pooled** | **2019** | **2020** | **2021** | **2022** | **2023** | **Pooled** |
| $S_1$ | 16.13 | 11.40 | 23.00 | 11.53 | 20.27 | 16.47 | 10083.33 | 7125.00 | 14375.00 | 7208.33 | 12666.67 | 10291.67 |
| $S_2$ | 24.33 | 9.20 | 30.27 | 7.87 | 26.87 | 19.71 | 9733.33 | 3680.00 | 12106.67 | 3146.67 | 10746.67 | 7882.67 |
| $S_3$ | 24.53 | 8.73 | 38.07 | 12.60 | 34.73 | 23.73 | 6820.27 | 2761.47 | 10582.53 | 3502.80 | 9655.87 | 6664.59 |
| $S_4$ | 28.00 | 7.53 | 44.13 | 9.07 | 37.07 | 25.16 | 5712.00 | 1536.80 | 9003.20 | 1849.60 | 7561.60 | 5132.64 |
| SEm± | 1.81 | 1.48 | 2.46 | 2.19 | 1.22 | 2.22 | 1991.95 | 2114.53 | 2644.02 | 2404.89 | 1279.12 | 931.94 |
| CD (*p*=0.05) | 5.17 | NS | 7.06 | NS | 3.48 | NS | 695.91 | 738.73 | 923.72 | 840.18 | 446.88 | 334.00 |
| Variety | | | | | | | | | | | | |
| $V_1$ | 26.25 | 22.75 | 33.42 | 11.83 | 29.92 | 24.83 | 8870.42 | 8293.75 | 11613.17 | 4685.00 | 10020.92 | 8696.65 |
| $V_2$ | 33.58 | 13.42 | 31.25 | 8.00 | 25.00 | 22.25 | 11605.83 | 5957.67 | 10447.58 | 2943.42 | 8429.50 | 7876.80 |
| $V_3$ | 19.67 | 3.25 | 40.08 | 4.67 | 37.42 | 21.02 | 6489.58 | 1836.58 | 13432.42 | 1753.50 | 12630.08 | 7228.45 |
| $V_4$ | 16.33 | 2.92 | 36.33 | 16.67 | 26.67 | 19.68 | 5437.83 | 909.58 | 12175.83 | 5878.92 | 9214.42 | 6723.82 |
| $V_5$ | 20.42 | 3.75 | 28.25 | 10.67 | 29.67 | 18.55 | 8032.50 | 1881.50 | 9915.25 | 4373.42 | 10493.58 | 6939.25 |
| SEm± | 2.02 | 1.66 | 2.76 | 2.44 | 1.36 | 2.79 | 778.05 | 825.93 | 1032.75 | 939.35 | 499.62 | 991.82 |
| CD (*p*=0.05) | 5.78 | 4.74 | 7.90 | 6.99 | 3.89 | NS | 2227.07 | 2364.11 | NS | 2688.75 | 1430.10 | NS |
| S x V | | | | | | | | | | | | |
| CD (*p*=0.05) | 11.55 | NS | NS | NS | 7.77 | 5.26 | 4454.14 | NS | NS | NS | NS | 2083.87 |
| | Y x S | Y x V | Y x S x V | | | | Y x S | Y x V | Y x S x V | | | |
| S.Em± | 1.89 | 2.11 | 4.22 | | | | 746.84 | 834.99 | 1669.99 | | | |
| CD (*p*=0.05) | 5.26 | 5.88 | NS | | | | NS | 2329.837 | NS | | | |
| CV% | 30.06 | 62.19 | 28.22 | 82.42 | 15.82 | 34.35 | 33.33 | 75.77 | 31.06 | 82.87 | 17.04 | 38.60 |

**Table 4. Interaction effect of spacing and varieties on yield plant$^{-1}$ (kg) of mango**

| | 2019 | | | | | | 2023 | | | | | | Pooled | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **$V_4$** | **$V_5$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **$V_4$** | **$V_5$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **$V_4$** | **$V_5$** | **Mean** |
| $S_1$ | 18.33 | 19.33 | 10.33 | 9.33 | 23.33 | 16.13 | 18.33 | 15.33 | 23.67 | 19.67 | 24.33 | 20.27 | 19.00 | 16.80 | 14.67 | 13.13 | 18.73 | 16.47 |
| $S_2$ | 21.67 | 41.67 | 23.33 | 15.00 | 20.00 | 24.33 | 29.00 | 20.67 | 35.67 | 23.33 | 26.67 | 26.87 | 24.60 | 22.27 | 18.33 | 17.87 | 15.47 | 19.71 |
| $S_3$ | 20.33 | 36.67 | 13.33 | 21.00 | 23.33 | 24.53 | 30.67 | 38.00 | 41.00 | 30.33 | 33.67 | 34.73 | 23.00 | 25.87 | 22.46 | 24.33 | 22.99 | 23.73 |
| $S_4$ | 36.67 | 36.67 | 31.67 | 20.00 | 15.00 | 28.00 | 41.67 | 26.00 | 49.33 | 33.33 | 35.00 | 37.07 | 32.73 | 24.07 | 28.60 | 23.40 | 17.00 | 25.16 |
| Mean | 26.25 | 33.58 | 19.67 | 16.33 | 20.42 | | 29.92 | 25.00 | 37.42 | 26.67 | 29.67 | | 24.83 | 22.25 | 21.02 | 19.68 | 18.55 | |
| Factor | S.Em± | CD (*p*=0.05) | CV % | | | | S.Em± | CD (*p*=0.05) | CV % | | | | S.Em± | CD (*p*=0.05) | CV % | | | |
| Spacing | 1.80 | 5.17 | 30.06 | | | | 1.22 | 3.48 | 15.82 | | | | 2.22 | NS | 34.35 | | | |
| Variety | 2.02 | 5.78 | | | | | 1.36 | 3.89 | | | | | 2.78 | NS | | | | |
| S x V | 4.04 | 11.55 | | | | | 2.72 | 7.78 | | | | | 1.89 | 5.26 | | | | |

**Table 5. Interaction effect of spacing and varieties on fruit yield hectare$^{-1}$ (kg) of mango**

| | 2019 | | | | | | Pooled | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **$V_4$** | **$V_5$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **$V_4$** | **$V_5$** | **Mean** |
| $S_1$ | 11458.33 | 12083.33 | 6458.33 | 5833.33 | 14583.33 | 10083.33 | 11875.00 | 10500.00 | 9166.73 | 8208.33 | 11708.33 | 10291.67 |
| $S_2$ | 8666.67 | 16666.67 | 9333.33 | 6000.00 | 8000.00 | 9733.33 | 9840.00 | 8906.66 | 7333.33 | 7146.67 | 6186.66 | 7882.67 |
| $S_3$ | 7876.67 | 10193.33 | 3706.67 | 5838.00 | 6486.67 | 6820.27 | 6394.00 | 7190.93 | 6579.33 | 6766.66 | 6394.00 | 6664.59 |
| $S_4$ | 7480.00 | 7480.00 | 6460.00 | 4080.00 | 3060.00 | 5712.00 | 6677.60 | 4909.60 | 5834.40 | 4773.60 | 3468.00 | 5132.64 |
| Mean | 8870.42 | 11605.83 | 6489.58 | 5437.83 | 8032.50 | | 8696.65 | 7876.80 | 7228.45 | 6723.82 | 6939.25 | |
| Factor | S.Em± | CD (*p*=0.05) | CV % | | | | S.Em± | CD (*p*=0.05) | CV % | | | |
| Spacing | 695.91 | 1991.95 | 33.33 | | | | 334.00 | 931.94 | 38.60 | | | |
| Variety | 778.05 | 2227.07 | | | | | 991.82 | NS | | | | |
| S x V | 1556.10 | 4454.14 | | | | | 746.84 | 2083.87 | | | | |

### 3.9 Interaction Effect of Spacing and Varieties on Fruit Yield Hectare$^{-1}$ (kg)

The interaction Table 3 data showed that significant difference observed for fruit yield hectare$^{-1}$(kg) in year 2019 and in pooled, while non-significant in rest of the years. The interaction effect is presented in Table 4. In year 2019, $V_5S_1$ (Amrapali variety at 4 m x 4 m spacing) recorded highest fruit yield hectare$^{-1}$(14583.33 kg) which was followed by $V_2S_1$ (12083.33 kg), $V_1S_1$ (11458.33 kg) and $V_2S_3$ (10193.33 kg) while in pooled, $V_1S_1$ (Kesar variety at 4 m x 4 m spacing) recorded highest fruit yield hectare$^{-1}$ (11875.00 kg) which was followed by $V_5S_1$ (11708.33 kg), $V_2S_1$ (10500.00 kg) and $V_1S_2$ (9840.00 kg). The data support the suitability of kesar variety under high density planting while recording maximum yield as it accommodate more plants while maintaining higher fruit yield plant$^{-1}$. These results were in accordance with Kumar et al., (2019), Gaikwad et al., (2017) and Joglekar et al., (2013).

## 4. CONCLUSION

From the above findings, it was clear that among the different varieties and planting spacing evaluated, the variety Kesar is best suited to plant at 4 m x 4 m spacing in high density planting for commercial cultivation of Mango in North Gujarat while sustaining optimal growth in terms of plant stem girth, plant height along with maximum fruit yield plant$^{-1}$ and fruit yield hectare$^{-1}$ after 15 year of planting.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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