

Effect of Sowing Date, Spacing and Fertilizer Levels on Crop Growth and Seed Yield of Hybrid Watermelon

S. B. Bellad, Umesh Hiremath

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Abstract An experiment was conducted to study the effect of sowing dates, spacing and fertilizer levels on crop growth and seed yield of hybrid watermelon (*Citrullus lanatus* Thunb) Arka Jyothi. The experiment was laid out in split plot design consisting of 24 treatment combinations involving four levels of sowing dates, two levels of spacing and three

levels of fertilizer doses as follows. Sowing dates (D)- D₁ : November sowing, D₂ : December sowing, D₃ : January sowing, D₄ : February sowing, Spacing levels (S)- S₁ : 2.5 m × 1.0 m, S₂ : 3.0 m × 1.0 m, Fertilizer levels (F)- F₁ : 100:90:100 kg NPK per ha (RDF), F₂ : 125:110:125 kg NPK per ha, F₃ : 150:135:150 kg NPK per ha in three replications. The results revealed that seeds sown during January month recorded significantly higher fruit weight (6.68 kg), filled seed (86.96%), seed weight per fruit (4.82 g) and seed yield per ha (73.04 kg) over 15th November sowing. Likewise, 3.00 m × 1.00 m spacing and fertilizer dose of 150:135:150 kg NPK per ha recorded significantly higher seed weight per fruit (4.89 g), seed yield per vine (22.69 g) as compared to 100:90:100 NPK kg per ha and 2.50 m × 1.00 m spacing respectively. The findings of the study indicated that for production of quality hybrid seeds of watermelon, parental seeds could be sown during January with NPK levels of 150:135:150 kg ha⁻¹ at 3.00 m × 1.00 m spacing.

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Introduction

Watermelon [*Citrullus lunatus* (Thunb)], an important annual fruit vegetable crop belongs to Cucurbitaceous family and is a native of tropical Africa. It is grown as a dessert fruit crop throughout India particularly in the hot and dry regions under

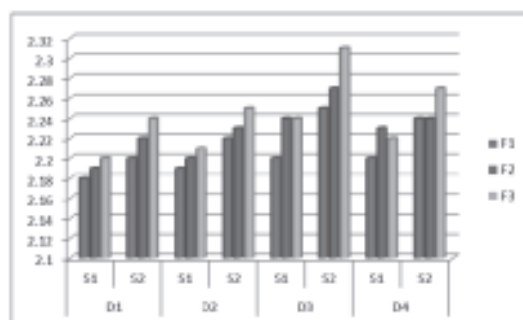


Fig. 1. Effect of sowing dates, spacing and fertilizer levels on vine length (m) at harvest in hybrid watermelon Arka Jyothi.

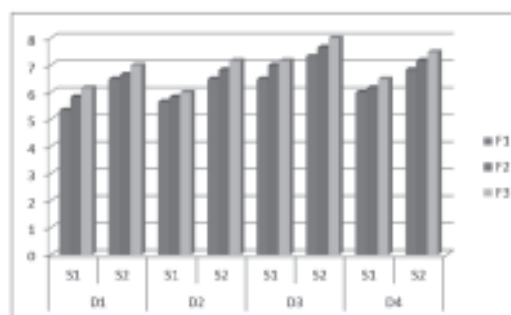


Fig. 2. Effect of sowing dates, spacing and fertilizer levels on number of lateral branches per vine at harvest in hybrid watermelon Arka Jyothi.

both irrigated river beds and rainfed conditions during *rabi* and summer seasons. Maharashtra, Karnataka, Tamil Nadu, Punjab, Rajasthan, Madhya Pradesh, Uttar Pradesh, Gujarat and Andhra Pradesh are the major watermelon growing states in the country. In southern India, watermelon is generally grown from November to February months as a rainfed crop during *rabi* season under the conserved soil moisture conditions. As a cool climate thriving crop, it grows well if sown under normal season i.e. in January month, wherein, it grows best morphophenologically and gives maximum fruit yield per unit area due to cool dry climate, moderately high humidity and sufficient sunny period. However, if sowing is delayed beyond February month, it usually encounters with wide fluctuation in relative humidity and rising day temperature, consequently reducing the crop yield drastically due to earliness in crop maturity. On the other hand, if watermelon is grown earlier i.e. in November and December months, it may grow well vegetatively but perform poorly due to improper reproductive characteristics due to existence of very high humidity and extreme low night temperature apart from untimely rains. These conditions not only hamper pollinator activity but also result in pollen washing causing poor yields in watermelon.

A field crop can give maximum yield and quality seeds if it is grown at optimum plant spacing (plant density per unit area) as it provides for maximum light interception and adequate plant interaction during

the entire cropping period. The plant spacing should be defined not only in terms of plant population per unit area but also special arrangements of these plants on the ground to realize the highest possible yield in watermelon. By standardizing the plant spacing in terms of plant population density per unit area, it is possible to achieve the best vegetative and reproductive growths to boost up average seed crop productivity. Normally, growth and development of crop plants and seeds are greatly influenced by factors like, genetic makeup and environmental factors where it is being grown apart from cultivation practices. Under normal cultivation, the deficiency or excess of major nutrients like nitrogen, phosphorus and potassium may pose serious problem in seed production of watermelon. Altering the soil nutrient status to suit the plant requirement is one of the ways to boost up the seed production in watermelon through maximum utilization of available nutrients from the soil by the plants. Any interception in supply and utilization of plant nutrients even for a brief period during the grand growth period is detrimental to the plants and it could pronounce negative effect on the ultimate yield and quality of seeds. The studies pertaining to optimization of different sowing dates, spacing and fertilizers for higher seed yield and quality are inadequate and inconclusive in hybrid watermelon. Hence, an experiment was conducted to standardize the sowing date, spacing and fertilizer for hybrid seed production of watermelon.

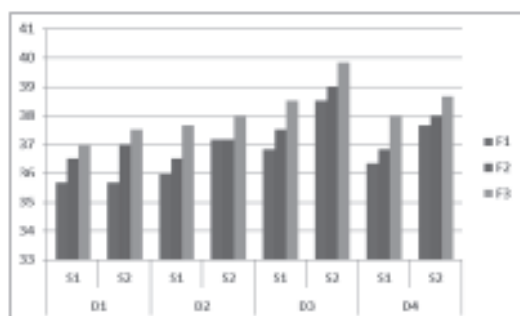


Fig. 3. Effect of sowing dates, spacing and fertilizer levels on days to first male flower initiation in hybrid watermelon Arka Jyothi.

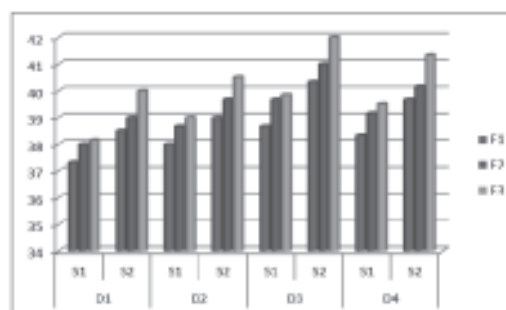


Fig. 4. Effect of sowing dates, spacing and fertilizer levels on days to first female flower initiation in hybrid watermelon Arka Jyothi.

Materials and Methods

The field and laboratory investigations were carried out to find out the effect of sowing dates on crop growth, seed yield and quality in hybrid watermelon at Agricultural Research Station, Kawadimatti, University of Agricultural Sciences, Raichur, Karnataka. The required seed materials of female parent IIHR-20 and male parent Crimson Red of hybrid watermelon Arka Jyothi were obtained from Division of Vegetable Crops, Indian Institute of Horticultural Research, Hesaragatta, Bengaluru. The experiment was laid out in split plot design consisting of 24 treatment combinations involving four levels of sowing dates, two levels of spacings and three levels of fertilizer doses as follows. Sowing dates (D)- D₁ : November sowing, D₂ : December sowing, D₃ : January sowing, D₄ : February sowing, Spacing levels (S)- S₁ : 2.5 m × 1.0 m, S₂ : 3.0 m × 1.0 m, Fertilizer levels (F)- F₁ : 100:90:100 kg NPK per ha (RDF), F₂ : 125:110:125 kg NPK per ha, F₃ : 150:135:150 kg NPK per ha in three replications. The emasculating work was carried out in the female parental block of hybrid watermelon experimental plot in the previous day evening hours. In the female IIHR-20 plants, emasculating was done manually by pinching off fully developed male buds from the vines and it was continued until last of male buds from the vines was removed. Further, only pistillate buds likely to open next day were bagged with butter paper bags for easy identification and were crossed manually with pollens of male parent in next day morning hour.

The both manual emasculating and dusting works were continued up to 15 days from the start of first anthesis day and subsequently all the floral buds emerging out beyond 15 days after crossing period were pinched off to ensure better growth and development of crossed fruits as well as hybrid seeds on the female parent.

Record of biometric observations

Vine length (cm)

The vine length was measured on metric scale from the ground level of the main stem to the tip of the two primaries of the five randomly tagged vines at 30, 60 DAS and at harvest. The average of five vines was computed and expressed in centimeter.

Number of lateral branches per vine

The number of lateral branches arising from the main stem were counted manually and recorded at final harvest. The average was computed and expressed as number of lateral branches per vine.

Days to first male flower initiation

Total number of days taken from the date of sowing

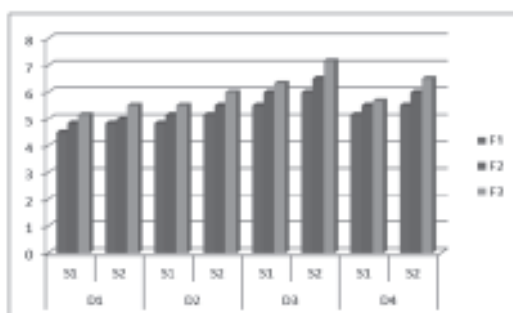


Fig. 5. Effect of sowing dates, spacing and fertilizer levels on number of fruits per vine in hybrid watermelon Arka Jyothi.

to the date of first initiation of male flower appearance was recorded on the five randomly tagged vines and average was computed.

Days to first female flower initiation

Total number of days taken from the date of sowing to the date of first initiation of female flower appearance was recorded in the five tagged vines and average was computed for each treatments replication wise.

Sex ratio (Female : Male)

Number of male and female flowers were counted on the five randomly tagged vines and their ratio calculated by using the formula as below.

$$\text{Sex ratio} = \frac{\text{Number of male flowers per vine}}{\text{Number of female flowers per vine}}$$

Number of fruits per vine

The number of fruits were counted manually on the five randomly tagged vines and it was expressed in number as total number of fruits produced per vine for each treatment and replications.

Fruit yield (kg) per vine

All the fully ripened fruits harvested treatment wise

from the five tagged vines and they were weighed using an electronic weighing balance and their average weight was expressed as fruit yield in kilograms per vine.

Total number of seeds per fruit

In each of the treatments, the five normal fruits from the tagged vines were chosen randomly and their seeds were extracted manually from the tagged fruits by slicing and squeezing method. The total number of matured and immature seeds extracted from each fruits was counted manually and their mean was expressed as total number of seeds per fruit.

Percentage of filled seeds

Based on the number of matured and immature seeds obtained from the each fruits, the percentage of filled seeds was calculated treatment wise and replication wise by using the following formula.

$$\text{Filled seeds (\%)} = \frac{\text{Number of filled seeds obtained per fruit}}{\text{Number of filled + unfilled seeds obtained per fruit}} \times 100$$

Seed weight (g) per fruit

The total number of seeds extracted from each fruit were weighed on an electronic precision balance and their average weight was expressed as seed weight in grams per fruit.

Seed yield (kg) per hectare:

Based on the seed yield obtained from vines of the net plot area, the seed yield per hectare was calculated and expressed in kilograms of seed yield per hectare.

Statistical analysis

The analysis of variance and interpretation of data were done as per the standard procedures. Levels of

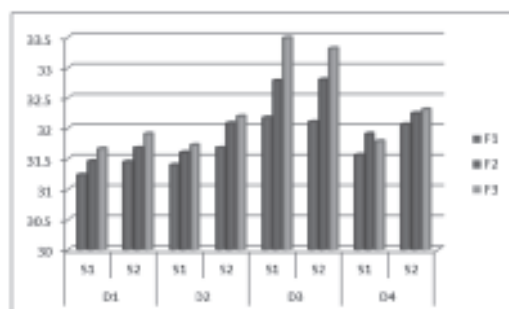


Fig. 6. Effect of sowing dates, spacing and fertilizer levels on fresh fruit yield per vine (kg) at harvest in hybrid watermelon Arka Jyothi.

significance used in 'F' test was $p=0.05$. Critical difference (CD) values were calculated only wherever the 'F' test was found significant.

Results and Discussion

Plant growth and quality of seed production are generally influenced by the interplay between genetic makeup and environment backed by judicious application of seed crop management practices. A dessert vegetable fruit crop like watermelon can give the highest possible yield of quality seeds, if the adopted superior genotype is grown at optimum sowing time at suitable spacing under adequate fertilizer dose. Generally, watermelon enjoys cool winter season (January and February) for its luxuriant growth and best yielding ability. It is obvious that if the watermelon crop is grown in November and December months, it may grow well vegetatively, but it performs differently with inconsistent reproductive parameters giving rise to poor seed yield and quality seeds due to fluctuating cloudy weather, extreme low night temperature and high humidity often coupled with unseasonal rains during the November and December months. In contrast to this, if it is grown very late that is in the February month, then also it may exhibit poor growth performance resulting in lower seed yield and poor quality seeds due to prevalence of fluctuating weather conditions like rising day temperature, receding moisture and dry climate causing field weath-

ering. Nevertheless, it is also observed that providing optimum plant spacing plays a decisive role in getting maximum yield as well as quality seeds as it provides optimum growth conditions for the growing vines with respect to nutrients, light, aeration, space and water. Any variation in plant spacing may affect its yielding ability due to variable competition amongst the growing vines. Likewise, watermelon plants also need adequate and balanced major plant nutrients like nitrogen, phosphorus and potash for their grand vegetative and reproductive growth to give maximum yield and quality seeds. Under normal cultivation, availability of either deficit or excess plant nutrients may affect not only the yield but also cause serious problems during seed production. Therefore, providing optimum plant nutrition according to the watermelon crop requirement is one of the best ways to boost up the seed crop productivity.

The results of this experiment revealed significant and consistent variations of growth parameters at 30, 60 DAS and at harvest stages due to four dates of sowing starting from November second week to February second week sowing irrespective of spacing and fertilizer levels. The growth parameters like vine length and number of lateral branches per vine harvest were more in both the years irrespective of sowing dates, spacing and fertilizer levels. The pooled data of two year experiments revealed that vine length increased linearly from 0.96 m at 30 DAS to 2.25 m at harvest in all the four sowing dates over spacing and fertilizer levels (Fig. 1). However, at harvest the vine at length and number of lateral branches per vine were significantly more (2.25 m and 7.27) in the January sowing followed by the February sowing but they were less (2.20 m and 6.25) in the November sowing (Fig. 2). It can be stated that the vines sown in January month recorded more vine length and lateral branches per vine due to prevalence of congenial dry weather, bright sunshine cool humidity, moderately high light temperature prevailed during grand vegetative growth period at Agricultural Research Station, Kawadimatti which under Zone-II of the Agro climatic Region of the Karnataka State. Whereas, those vines sown in November month recorded less vine length and lateral branches which may be due to fluctuating cool weather, very low light temperature, high humid climate and shorter sunshine hours often

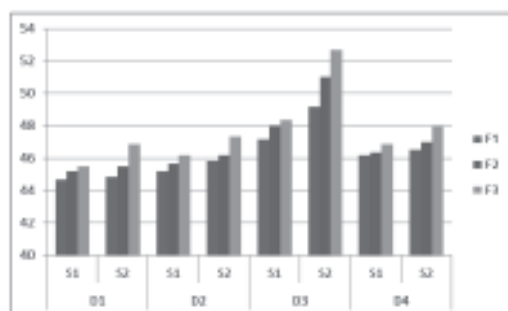


Fig. 7. Effect of sowing dates, spacing and fertilizer levels on number of seeds per fruit in hybrid watermelon Arka Jyothi.

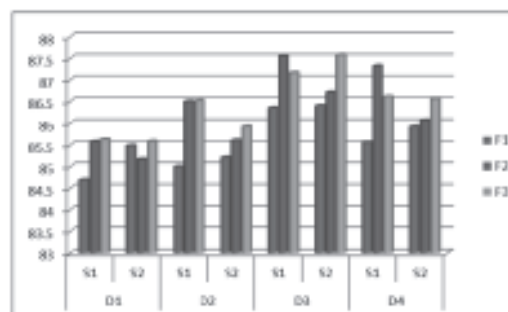


Fig. 8. Effect of sowing dates, spacing and fertilizer levels on percentage of filled seeds in hybrid watermelon Arka Jyothi.

coupled with unseasonal rains compared to those sown during January month. The similar results on growth parameters due to different sowing dates were also confirmed by the other scientists in various crops [1–6].

In a dessert fruit crop like watermelon, seed yield is the final outcome between interaction of genotype and environments which reflected in the vine length, lateral branches, fruits per vine, fruit weight, seeds per fruit, seed weight per fruit and other related yield components. In the present study, an attempt is made to investigate the influence of four sowing dates from November to February months on various fruiting and seed yield components of hybrid watermelon Arka Jyothi. The results of these two year experiments and their pooled analysis revealed significant differences in fruiting and seed yield components due to effect of different sowing dates irrespective of spacing and fertilizer levels. In the pooled analysis, it is observed that January sowing (D_3) recorded significantly the highest number of fruits per vine (6.25), fresh fruit yield per vine (32.78 kg), number of seeds per fruit (49.38), seed weight per fruit (4.82 g), percentage of filled seeds (86.96%), seed yield per hectare (73.04 kg) and it was followed by February sowing (D_4) (Figs. 5, 6, 7, 8, 9). On the other hand, all these yield components were significantly the lowest (4.97, 31.56 kg, 45.41, 4.39 g, 85.36% and 70.81 kg/ha) in November sowing (D_1) irrespective of spacings and fertilizer doses. Further, it can be stated that the crop sown during January month (D_3) exhibited better growth parameters like vine length and lateral branches as

seen in this study due to the prevalence of congenial cool weather condition and it might have enhanced the carbohydrate metabolism, accumulation and physiological processes during grand vegetative growth period process. Further, congenial weather might also have hastened pollen viability of male buds as well as stigma receptivity of female buds. Obviously, the male pollens dusted on the female buds resulted in higher fruit and seed setting and hence it resulted in more number of fruits per vine, fruit weight, seeds per fruit filled seeds percentage, seed recovery compared to November sowing as evident from the findings of this study. On the other hand, November sowing recorded the lowest seed yield per vine and hectare due to poor growth and reproductive performances in view of fluctuating cool humid climate and very low night temperature backed by unseasonal rains during November month. Obviously, it might have affected the viability of pollens as well as stigma receptivity causing poor seed setting, seed yield per vine and hectare unlike those sown in January and February sowings. These results are in agreement with findings of other workers [1–6].

Effect of sowing dates on flowering parameters

Significant variations in flowering parameters such as days to male and female flower initiation and sex ratio were observed due to different dates of sowing

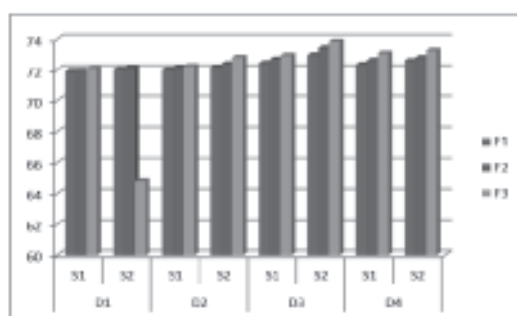


Fig. 9. Effect of sowing dates, spacing and fertilizer levels on seed yield per hectare (kg) in hybrid watermelon Arka Jyothi.

over spacing and fertilizer doses. The longest period (38.36 and 40.25 days) for initiation of male and female flowers in the November sowing (D_1) followed by February sowing (D_4) and December sowing (D_2). Whereas, it was the shortest period (36.55 and 38.50 days) on the other hand sex ratio was significantly maximum (6.08) and minimum (5.99) with January sowing (D_3) (Figs. 3, 4 and 10). The vines sown during January and February months took longer period for initiation of male and female flowers and recorded higher sex ratio which may be related to their increased vegetative growth parameters like higher vine length and lateral branch, number per vine noticed at 30, 60 DAS and at harvest in view of congenial weather conditions prevailed during these months compared to November sowing. Further, it might have also favored in the increased morphogenic and photosynthetic activities causing delay in flowering behavior and lower sex ratio during January and February months. On the contrary, the vines sown during November months performed poorly with respect to flowering behavior parameters compared to January and February sowing. This earliness in male and female flower initiations and higher sex ratio in November sowing may be attributed to the poor vegetative growth parameters causing earliness in flowering behavior and more sex ratio due to the fluctuation weather conditions prevailed during November months unlike January and February month. Further, the less sex ratio noticed in January month unlike November sowing may be due to less production of male flowers by the

female parent during flowering period. These findings on flowering behavior were also in conformity with other scientists in various crops [5—7].

Effect of spacing on growth parameters

Significantly higher (1.08 m, 1.60, 2.24 and 7.09) vine length at 30, 60 DAS and at harvest and number of lateral branches per vine at harvest were observed in the wider spacing of 3.00×1.00 m (S_2) compared to narrow spacing of 2.50×1.00 m (S_1) (0.93, 1.57, 2.21 m and 6.18) over sowing dates and fertilizer levels. The increase in vine length and lateral branches number under wider spacing was mainly attributed to better growth and development of vines in view of their less competition for nutrients, space, water aeration and light unlike those at narrow spacing which experienced stiffer competition due to less space availability between the vines. These results are in line with findings of other scientists [8—12].

Effect of spacing on flowering parameters

It is observed that the vines sown at wider spacing of 3.00×1.00 m (S_2) took consistently more number of days for initiation of male and female flowers (37.84 and 40.09) than those at narrow spacing of 2.50×1.00 m (S_1) (36.94 and 38.69). On the other hand, the effect of two spacing was found to be non-significant for the sex ratio which was numerically less (5.99) in February sowing (D_3) followed by the January sowing (D_4) (6.01) compared to November sowing (6.03). It is observed from these results that the vines sown in January and February months have shown earliness in initiation of male and female flowers in wider spacing due to increased space availability for plant nutrients, water aeration and light and obviously it resulted in more sex ratio in the wider spacing compared to narrow spacing. These results are further supported by the increased number of vine length and lateral branch number per vine in the wider spacing as seen in the present study. On the other hand, the vines sown in narrow spacing have shown adequate delay in initiation of male and female flowers and it resulted in less sex ratio due to stiff competition for nutrients, water light and space between grow-

ing plants unlike those at wider spacings. Present findings are in agreement with outcome of similar investigations [7].

Effect of spacing on fruiting and seed yield components

Wider spacing of 3.00×1.00 m (S_1) recorded significantly and consistently higher number of fruits per vine (5.80), fresh fruit yield per vine (32.15 kg), number of seeds per fruit (47.56), percentage of filled seeds (86.11%), seed yield per hectare (72.36 kg) compared to narrow spacing 2.50×1.00 m (S_2). About 15% of increase in seed yield per vine and hectare was seen in the wider spacing over narrow spacing which may be attributed to increase in number of fruits per vine, number of seeds per fruit and seed weight per vine. Further, it was also related to increased availability of nutrients light, water and aeration in the wider spacings resulting in more number of lateral branches as well as seed yield components as compared to narrow spacing which recorded less seed yield (21.97 g) per vine and per hectare (72.23) due to stiff competition and less space availability between vines. These results are in conformity with the findings of other scientists [8, 12].

Effect of fertilizer levels on growth parameters

Fertilizer dose of 150:135:150 kg per ha (F_1) recorded significantly the highest vine length (2.24 m) and number of lateral branches at harvest (6.93) and it was followed by 125:110:125 kg NPK per ha (F_2). Whereas, all these growth parameters were lowest (2.21 m and 6.33) in 100:90:100 kg NPK per ha (F_3). The significant increase in vine length and lateral branch number per vine at harvest noticed in F_3 level was attributed to increased availability of nutrients under higher fertilizer level and it might have stimulated in faster vegetative growth due to increased cell division and elongation compared to those with lower fertilizer level (F_1). Similarly, the vines grown with F_2 level also exhibited next better growth parameters like vine length and lateral branches compared to F_1 fertilizer level. However, the significant reduction in vine length and lateral branches noticed in F_1 level may be due to inadequate supply and availability of balanced plant

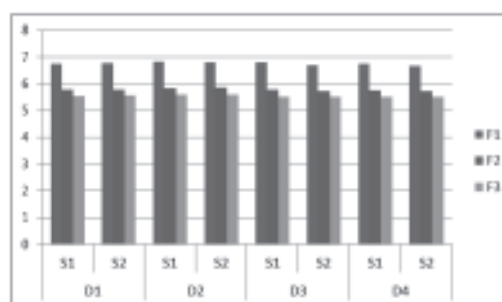


Fig. 10. Effect of sowing dates, spacing and fertilizer levels on female to male sex ratio in hybrid watermelon Arka Jyothi. Sowing dates (D) : D_1 : November sowing; D_2 : December sowing; D_3 : January sowing. Spacing levels (S) : S_1 : 2.5×1.0 m; S_2 : 3.0×1.0 m. Fertilizer level (F) : F_1 : 100:90:100 kg NPK per ha (RDF); F_2 : 125:110:125 kg NPK per ha; F_3 : 150:135:150 kg NPK per ha.

nutrients during crop growth period and obviously it has hindered the vegetative growth under F_1 fertilizer level compared to F_3 fertilizer level. Similar results were reported by many scientists [5, 8, 13, 14].

Effect of fertilizer levels on flowering parameters

The vines grown with 150:135:150 kg NPK per ha (F_3) dose exhibited the delayed initiation of male (38.14) and female flower (40.04) followed by 125:110:125 kg NPK per ha (F_2) dose as compared to 100:90:100 kg NPK per ha (F_1) fertilizer level which revealed the earliness in flower initiation. On the other hand, reciprocal trend was observed for sex ratio which was higher in F_1 than F_3 level irrespective of the sowing dates and spacings. The delayed flowering and less sex ratio noticed under high fertilizer level (F_3) may be attributed to the increased vegetative growth parameters like vine length and lateral branches due to adequate availability of balanced plant nutrients. This has favored the increased photosynthetic activity and postponed the initiation of male and female flowers. On the contrary, the vines grown with 100:90:100 kg NPK per ha fertilizer level (F_1) exhibited earliness in flower initiation and higher sex ratio which may be related to the inadequate plant nutrient availability as well as in efficient photosynthate activities compared

to those with higher fertilizer level. The results are in conformity with the findings of scientists in radish, chickpea and fenugreek [5, 8].

Effect of fertilizer levels on fruiting and seed yield components

The number of fruit per vine (5.97), fresh fruit yield per vine (32.30 kg), number of seeds per fruit (4.70), percentage of filled seeds (86.45%), seed yield per hectare (72.67 kg) were significantly the highest in 150:135:150 kg NPK per ha (F_3) fertilizer level followed by 125:110:125 kg NPK per ha (F_2), as against 100:90:100 kg NPK per ha (F_1). Among the three fertilizer levels, F_3 recorded significantly higher seed yield per hectare which may be due to increase in number of fruits per vine, seed number per fruit, fruit weight, seed recovery and filled seeds percentage. Whereas, the F_1 fertilizer level recorded the lower seed yield per vine and per hectare due to unsatisfactory fruiting and yield components as seen from the results of the study. The significant increase in seed yield per hectare with higher seed yield components noticed in F_3 fertilizer level may be ascribed to the enhanced photosynthetic from source to sink resulting in more number of heavier and bolder seeds per fruit compared to those at lower fertilizer level. These results are in agreement with the findings of other scientists in various crops [5, 9, 13, 14].

Interaction effect of sowing date, spacing and fertilizer levels

The three way interaction effect between ($D \times S \times F$) did not differ significantly for all the growth, flower, fruiting, seed yield parameters. The analysis of the pooled data revealed that the vines sown during January month at 3.00×1.00 m spacing with dose of 150:135:150 kg NPK per ha ($D_3S_2F_3$) interaction effect recorded comparatively more vine length (2.31 m), number of lateral branches (7.16), number of fruits per vine (7.16), number of seeds per fruit (52.66), seed yield per vine (23.80 g) and per hectare (73.85 kg), as against those sown in November month at 2.50×1.0 m with F_1 level (DSF). The higher seed yield and better quality parameter were noticed in the interaction

of $D_3S_2F_2$, $D_4S_2F_3$, $S_3S_2F_1$ due to their better vegetative and reproductive parameters. Whereas, sex ratio was comparatively less (5.51) and more (6.83) in the interaction of $D_3S_2F_3$ and $D_1S_1F_1$ interactions respectively which have also shown reciprocal values for male and female flower initiation. These results are in collaborative with findings of other scientists [5, 6].

Seeds sown on 15th January recorded significantly higher fruit weight (6.68 kg), filled seed (86.96%), seed weight per fruit (4.82 g) and seed yield per ha (73.04 kg) over 15th November sowing. Likewise, $3.00 \text{ m} \times 1.00 \text{ m}$ spacing and fertilizer dose of 150:135:150 kg NPK per ha recorded significantly higher seed weight per fruit (4.89 g), seed yield per vine (22.69 g) as compared to 100:90:100 NPK kg per ha and $2.50 \text{ m} \times 1.00 \text{ m}$ spacing respectively. The findings of the study indicated that for production of quality hybrid seeds of watermelon, parental seeds could be sown during January with NPK levels of 150:135:150 kg ha⁻¹ at $3.00 \text{ m} \times 1.00 \text{ m}$ spacing.

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