EVALUATION OF WATERMELON [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] GENOTYPES FOR GROWTH, YIELD AND QUALITY

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by

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2021

DECLARATION

I, hereby declare that this thesis entitled "**EVALUATION OF WATERMELON [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] GENOTYPES FOR GROWTH, YIELD AND QUALITY**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "**EVALUATION OF WATERMELON [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] GENOTYPES FOR GROWTH, YIELD AND QUALITY**" is a record of research work done independently by Ms. Pavithra M.O. (2019-12-006) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

ANOVA	- Analysis of variance
CD (0.05)	- Critical difference at 5 % level
cm	- Centimetre
d.f.	- Degrees of freedom
DAS	- Days after sowing
et al.	- Co-workers/ Co-authors
Fig.	- Figure
g	- Gram
GA	- Genetic advance
GCV	- Genotypic coefficient of variation
GOI	- Government of India
h^2	- Heritability
ha	- Hectare
i.e.	- That is
KAU	- Kerala Agricultural University
Kg	- Kilogram
m	- Metre
No.	- Number
PCV	- Phenotypic coefficient of variation
RBD	- Randomized Block Design
RH	- Relative humidity
SEm	- Standard error of mean
TSS	- Total Soluble Solids
viz.,	- Namely

LIST OF SYMBOLS

@	- at the rate of
α	- Alpha
°C	- Degree Celsius
%	- Per cent

Introduction

1. INTRODUCTION

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is the most widely cultivated warm season crop of Cucurbitaceae family with chromosome number 2n=22. It is known by a variety of vernacular names like Tarbuj (Hindi), Thannimathan (Malayalam), Kalingarakaya (Tamil), Kallangadi (Kannada) *etc.,* in different parts of India. Globally, watermelon is consumed more than any other cucurbit (Goreta *et al*., 2005). It is grown in 6.2% of the world's vegetable cropland. China is the world's largest producer of watermelon, accounting for 52.3 million tonnes of total production. Turkey, Iran, Brazil, Uzbekistan, Algeria, the United States, Russia, Egypt and Mexico are also leading producers (FAOSTAT, 2019).

Watermelon is thought to have originated in Africa (Simmonds, 1979), but it is now widely dispersed over the tropics and the Mediterranean region. Wild watermelon (*Citrullus colocynthis*) is native of the African arid soils. Watermelon was domesticated at least 4000 years ago in Africa and is currently grown all over the world, particularly in areas with long, hot summers (Gichimu *et al*., 2009). *C. lanatus, C. ecirrhosus, C. colocynthis* and *C. rehmii* are the four species of the genus *Citrullus*, which are all cross compatible to some extent, with *C. colocynthis* being the putative ancestor of watermelon (Robinson and Walters, 1997).

In India, watermelon is cultivated in an area of 1.01 lakh hectares with a total production of 25.20 lakh tonnes (GOI, 2018). It is a prominent river bed crop in Uttar Pradesh, Rajasthan, Gujarat, Maharashtra and Andhra Pradesh. As a common summer season crop, it is grown from the lower Himalayan region to southern India. Uttar Pradesh, Rajasthan, Punjab, Haryana, Karnataka, Assam, West Bengal, Odisha and Tamil Nadu are the major watermelon producing states (Chadha, 2015).

The plant has a trailing habit with 3 to 5 m long vines and several branches. It is a monoecious species. The pistillate and staminate flowers are situated in distinct nodes of the same plant. Female flowers, like those of other cucurbits, appears after a large number of male flowers have opened. The shape of the fruit ranges from long cylindrical to spherical, with several intermediate shapes. Fruit is a modified form of berry called pepo and placenta is the edible portion. The exocarp is light to dark green coloured that can be plain, striped or marbled. Fruit flesh can be white, yellow, orange, pink or red with a variety of textures ranging from firm to fibrous. Watermelon seeds vary greatly in colour, shape and size making cultivar identification easier.

Watermelon is fat free, low in calories and regarded as an excellent diet food, as well as being high in energy, makes it an excellent energy booster (Altuntas, 2008). Nutritional value per 100 g of edible portion is 90 g moisture, 7.0 g carbohydrate, 7.0 mg phosphorous, 0.05 mg thiamine, 6.0 mg ascorbic acid, 1.0 g protein, 7.0 mg calcium, 599 1U vitamin A and 0.05 g riboflavin (Sahu *et al*., 2011). Cooling, purgative, antihelminthic, antipyretic and carminative properties are found in the fruit. It purifies blood, quenches thirst, cures biliousness and is effective against sore eyes, scabies and itching.

Watermelon is commonly grown for its juicy, sweet flesh and primarily utilised in desert areas. The rind can be used to make pickles and preserves. Pickling and candy making can be done with raw fruits. Unripe fruits are rarely cooked like other vegetables. Watermelon fruit can be used as a water substitute in semi arid areas. In western countries, the juice is fermented and condensed into sugar syrup, which is then used for making beverages. Its most significant benefit to human health is that it protects us from sunstroke by providing water in the most acceptable form, namely juice (More *et al.,* 2015). The seeds are roasted and consumed and the ‘Vedas' utilise them to make various tonics.

Watermelon is grown in an area of 100 ha in Kerala, with a production of 0.87 thousand MT (GOI, 2018). Despite the huge demand, watermelon cultivation has not become popular in Kerala. Kerala Agricultural University has released two seedless watermelon hybrids, Shonima and Swarna. Since the commercial cultivation of watermelon especially, mini and icebox types have great potential because of its small size, more emphasis need to be given in identifying varieties with small to medium sized fruits with good quality. The fruit has a wide range of variability and can be categorized by weight or size. Mini (1.5 to 4.0 kg), icebox (4.0 to 5.5 kg), small (5.0 to 8.0 kg), medium

(8.0 to 11.0 kg), large (11.0 to 14.0 kg) and gigantic (>14.0 kg) are the six weight categories (Gusmini and Wehner., 2007).

In any crop improvement programme, assessment of variability in the germplasm is a preliminary step which will help in the selection of genotypes with desirable characters that contribute to yield and quality. Yield, being a complex character, is influenced by different component characters and an understanding of the magnitude and direction of association between yield and its component traits will help in fixing the criteria for selection of better genotypes.

Hence, the present investigation was undertaken with the following objectives

- To evaluate watermelon genotypes for growth, yield and quality.
- To assess the genetic variability, heritability and genetic advance among the genotypes.
- To analyse the degree and direction of association between various traits and to estimate the direct and indirect effects of various components on yield.

Review of Literature

2. REVIEW OF LITERATURE

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] is a prominent cucurbitaceous crop widely grown for its delicious ripe fruits. In watermelon only few varieties have been developed in India, which are either introductions or selections from local types. Many hybrids have been introduced recently and are under cultivation. However, there are differences in cultivar performance depending on agroclimatic conditions. There is a need for an ideal variety with higher yield and quality characteristics which is suited to a wide range of agroclimatic conditions.

In any crop, plant breeding programme aims to improve existing types or evolve a new variety which must be superior to existing ones. The collection of genotypes from different geographical regions and evaluation of yield and quality characteristics may help to identify the potentialities of genotypes for direct introduction or as promising parents for subsequent crop improvement. In this chapter, an effort has been made to review the available literature on evaluation of watermelon and other cucurbitaceous vegetables for growth, yield and quality characters. The review is presented under the following sections:

2.1 GROWTH PARAMETERS

2.1.1 Vegetative and Flowering Characters

2.1.1.1 Vine length

Priya (2001) reported that in watermelon, vine length varied from 2.20 m to 4.92 m with a mean of 3.62 m. The highest vine length was observed in genotype CL 3 (4.92 m) and the lowest in CL 13 (2.20 m).

Mohanta and Mandal (2016) studied the performance of thirteen watermelon genotypes in red and laterite zone of West Bengal. They observed the highest vine length of 296.30 cm in KSP-1127 and the lowest vine length in TMWH-701 (188.50 cm). Mrema and Maerere (2018) reported that Sukari F_1 had the longest vine (345.80 cm) as compared to Zuri F_1 or Patanegra and other watermelon cultivars had intermediate vine lengths.

Evaluation of eleven hybrids and three open pollinated varieties of watermelon revealed the highest vine length in hybrid Shaktiman (283.70 cm) and the lowest in the variety Arka Muthu (184.30 cm) (Mohanta and Mandal, 2019).

Kumar *et al*. (2020) evaluated eight watermelon genotypes AS Kajal, Sangria, Saras Shaktiman-81, BSS 2000, Sugar Baby, Arka Manik and Arka Muthu for river bed cultivation and noted that Sangria (288.65 cm) recorded the longest vine. The shortest vine length was recorded in BSS 2000.

A study on genetic diversity of sixteen watermelon hybrids in Bangladesh by Mohosina *et al*. (2020) recorded longest vine (281.70 cm) in Dragon King and shortest in Red Sugar (161.70 cm).

2.1.1.2 Number of branches per vine

Gichimu *et al*. (2010) compared commercial cultivars of watermelon with local land races for yield and observed a significant variation among cultivars in number of branches. The highest number of branches was observed in GBK-04301 (11.00) followed by Yellow Crimson (9.39) and lowest in Crimson Sweet (5.00).

A study conducted by Choudhary *et al*. (2012) on morphological diversity of twenty six watermelon genotypes reported that the genotype VRW-17(7.67) had greater number of branches followed by Arka Manik (7.47).

Jadhav *et al.* (2014) studied the performance of four watermelon varieties for growth, yield and quality and revealed that Sugar Baby had the highest number of branches per plant (2.53) followed by the hybrid G.S-286 (2.37). An evaluation of thirteen watermelon genotypes was conducted by Mohanta and Mandal (2016) in West Bengal and found that the number of branches per plant ranged from 3.40 to 6.10.

Oraegbunam *et al*. (2016) studied the agronomic performance and adaptability of three watermelon varieties. They observed the higher number of branches in Charleston Gray as compared to Lagone and Koloss.

Mohosina *et al*. (2020) assessed the genetic diversity of sixteen watermelon hybrids and noticed that hybrid China Sugar (9.00) had highest number of branches per vine while the hybrid Red Sugar had the lowest (3.50).

2.1.1.3 Inter nodal length

A comparative study on vegetative characters of seven diploid and tetraploid watermelon lines was conducted by Jaskani *et al.* (2005). They observed a significant variation in internodal length in watermelon lines.

Sharma and Sengupta (2013) studied the genetic diversity in bottle gourd genotypes and reported the highest internodal length in Narendra Jyoti (15.26 cm) followed by Ketan (14.17 cm) and Narendra Shishir-1 (14.08 cm).

A Study on genetic diversity was conducted with sixteen hybrids of watermelon in Bangladesh by Mohosina *et al*. (2020) and observed that internodal length ranged from 8.90 cm to 12.00cm. The highest internodal length was recorded in the hybrid Dragon King and the lowest in Sweet Black.

2.1.1.4 Days to first male flower

Priya (2001) evaluated the watermelon genotypes for yield and quality traits. They noticed early male flowering in the genotype CL 9 (44.93 days) whereas, late flowering in CL 11 (56.67 days).

Alimari *et al*. (2017) reported a range of 52.50 to 66.00 days for first male flower production in the accessions of indigenous Palestinian watermelons.

Twenty three genotypes of watermelon were evaluated for genetic diversity and character association by Bhagyalekshmi (2019) and reported that the genotype WM-17 took shortest period of 22.70 days for opening of first male flower while WM-1 took the longest period of 35.35 days.

Anumala *et al.* (2020) reported that an average of 36.60 days was taken for opening of first male flower in their performance study of vegetable type watermelon varieties during off season.

A genetic diversity study of sixteen watermelon hybrids in Bangladesh revealed that the days required for first male flower anthesis was lowest in Big Badshah (54.00 days) and on the other hand, Tropical Dragon and Sonya took 58.00 days to first flowering (Mohosina *et al*., 2020).

2.1.1.5 Days to first female flower

Mohanta and Mandal (2016) reported that the genotype BS-504 was the earliest to produce first female flower in 58.50 days. The variety Lagone took lowest number of days to first flowering and 50 per cent flowering as compared to the variety Koloss and Charleston Gray (Oraegbunam *et al.,* 2016).

The genetic diversity of fourteen local Palestinian watermelon landraces revealed that the number of days for the first female flower to open was highest for the accession-20 (69.00 days) and lowest for the accession-12 (60.30 days) (Alimari *et al*., 2017)

Evaluation of twenty three genotypes of watermelon was done by Bhagyalekshmi (2019) revealed that the genotype WM-18 was earliest (31.05) to first female flower and WM-5 was late (54.35). Anumala *et al*. (2020) evaluated seven vegetable type watermelon during off season in red and laterite zone and recorded that an average of 49.90 days required for opening of first female flower.

Biswas *et al*. (2020) evaluated fourteen cooking type watermelon *i.e.,* ‘khero’ for growth and yield parameters and noticed that the days to first female opening ranged from 48.20 (VC-12-2) to 60.70 (VC-14-1) days.

Mohosina *et al.* (2020) studied the genetic diversity of watermelon hybrids and noted that Kanya was earliest (60.44) for first female flower anthesis and Anarkoli was late (67.00).

2.1.1.6 Node to first male flower

Evaluation of fifteen watermelon genotypes for yield and quality revealed that node at which first male flower appeared ranged from 11.73 to 23.40. The genotype CL-9 produced first male flower at lowest node. On the other hand, genotype CL-8 at highest node (Priya, 2001).

A study on watermelon performance in West Bengal conducted by Mohanta and Mandal (2016) revealed that the lowest node number at which first male flower appeared was 5.20 in KSP-1127 followed by Sugar Baby (5.80).

Anumala *et al.* (2020) reported that in watermelon genotypes, the lowest node at which the first male flower appeared was 7.20 in VC-12-2, while VC-12-3 bloomed at a higher node of 19.10. Evaluation of cooking type of watermelon revealed that, the node at which the first male flower appeared ranged from 7.80 to 14.30 (Biswas *et al*. 2020).

Sixteen hybrids of watermelon were evaluated for their genetic diversity in Bangladesh by Mohosina *et al.* (2020). The hybrid World Queen had the lowest node order per vine for male flower appearance (3.11) and Black Giant had the highest (4.83).

2.1.1.7 Node to first female flower

Mohanta and Mandal (2016) observed that the lowest node number at which first female flower appeared was 13.00 in KSP-1127 followed by Arka Manik (14.60).

Bhagyalekshmi (2019) investigated the genetic variability in watermelon genotypes and noticed that the first female flower appeared at the lowest node of 8.20 in genotype WM-2 and the highest node of 24.15 in genotype WM-5.

Anumala *et al*. (2020) reported that the node at which first female flower appeared was earliest in both VC-8-1 and VC-3-6 (23.50), while genotype VC-10-1(1) flowered at a higher node of 30.10.

Evaluation of cooking type of watermelon cultivars revealed that, the node at which the first female flower appeared ranged from 17.60 (VC-12-2) to 24.10 (VC-5-3) (Biswas *et al*., 2020).

Mohosina *et al.* (2020) reported that the hybrid China Sugar had the lowest node order per vine for female flower appearance (11.30) and Sugar Kis had the highest (18.00).

2.1.2 Fruit and Yield Characters

2.1.2.1 Fruit equatorial diameter

A study on watermelon performance indicated that the variety KSP1127 (66.30 cm) had the largest fruit equatorial diameter, whereas variety BSS-2000 (44.70 cm) had the smallest (Mohanta and Mandal, 2016).

Nisha (2017) conducted variability studies in watermelon and observed that the variety Sugar Baby had the highest fruit equatorial diameter of 23.50 cm and Arjun had the lowest (12.65 cm).

Singh *et al.* (2018) studied the morphological and biochemical characters in watermelon landraces and observed that the genotype EC-829853 had the highest fruit width (23.00 cm).

2.1.2.2 Fruit polar diameter

The cultivar KSP-1127 exhibited the highest polar diameter (69.20cm) and Black Magic had the lowest (49.00 cm) (Mohanta and Mandal, 2016). Nisha (2017) observed the highest fruit polar diameter in watermelon genotype Sumo (31.00 cm) and lowest in Arka Akash (15.00 cm).

Morphological and biochemical characterization of watermelon landraces done by Singh *et al*. (2018) revealed that EC-829870 had the longest fruit (28.88cm).

Kumar *et al.* (2020) evaluated watermelon varieties for river bed farming and found that the variety AS-Kajal had the highest fruit length (39.24 cm) and lowest in Arka Manik (29.34 cm).

2.1.2.3 Rind thickness

Jadhav *et al*. (2014) studied the performance of four watermelon genotypes under Tansa condition during rabi season and found that the hybrid Pyramid recorded the highest rind thickness of 0.72 cm and G.S-286 recorded the lowest (0.50 cm).

Hakimi and Madidi (2015) observed that Farao (1.77cm) recorded the highest rind thickness, while landrace Venizia had the lowest (1.47cm) in variability studies of Moroccan watermelon landraces.

Alimari *et al.* (2017) noticed the highest rind thickness in accession 17 (1.50 cm) and the lowest in accession 21 (0.70 cm) in their genetic diversity study on Palestinian watermelon. Bhagyalekshmi (2019) reported a range in rind thickness from 0.74 cm in WM-17 to 1.95 cm in WM-14.

Mohosina *et al.* (2020) studied the diversity of sixteen commercially cultivated watermelon hybrids in Bangladesh and noticed the thickest rind in Sweet Dragon and Red Sugar (2.00 cm), while cultivar Kanya recorded the thinnest rind (0.60 cm).

Rabou and Sayd (2021) observed that rind thickness was considerably higher in genotype 6-2-3-8 in two seasons (2.00 and 1.98 cm, respectively). In both seasons, thin rind was observed in Philippine 28-2 (0.40 and 0.34 cm).

2.1.2.4 Fruit weight

Gichimu *et al.* (2010) compared three commercial watermelon cultivars with native landrace in Kenya. They observed that Yellow Crimson had highest fruit weight (3.01 kg). More *et al.* (2015) reported a range in fruit weight of watermelon cultivars from 2.57 kg in Sugar Baby to 6.28 kg in GP-42.

Hakimi and Madidi (2015) observed the highest fruit weight of 8.30 kg in Farao and the lowest of 4.40 kg in landrace Rm2 in their diversity study in Moroccan watermelon landraces.

Anburani (2018) found that the average fruit weight ranged from 1.59 to 9.58 kg, with genotype CL 10 recording the highest average fruit weight and genotype CL 2 the lowest. Bhagyalekshmi (2019) investigated the genetic variability in watermelon genotypes and recorded highest fruit weight of 9.13 kg in WM-13 and lowest weight of 1.63 kg in WM-9.

Kumar *et al.* (2020) evaluated the watermelon cultivars for river bed cultivation under solar based boat operated gravitational drip irrigation. They observed the highest fruit weight in Sangria (3.47 kg) and the lowest in Arka Manik (2.42 Kg).

Rabou and Sayd (2021) studied genetic variability in watermelon over two summer seasons and found that the genotype 6-2-2-16 recorded the highest fruit weight in both seasons (8.20 and 8.10 kg, respectively) and the genotype 2-4-1-1 recorded the lowest (1.90 and 2.00 kg).

2.1.2.5 Days to first harvest

Anburani (2018) assessed thirty watermelon genotypes for their genetic diversity and noted that the number of days to fruit maturity showed wide range of variability (46.00 to 61.00 days).

Bhagyalekshmi (2019) found that the watermelon genotype WM-16 took the shortest duration to first fruit harvest (85.90 days) and the longest by WM-15 (112.10 days). Anumala *et al.* (2020) reported that the average number of days for the first fruit harvest in watermelon was 68.80 days. The shortest duration of 61.00 days was observed in VC-12-2, followed by 62.40 days in VC-12-3 and 62.40 days in VC-3-6 (62.40).

The number of days needed to harvest the first fruit of Khero, cooking type watermelon ranged from 61.70 to 73.30 days. The genotype VC-12-2 recorded the shortest time to first fruit harvest, followed by VC 25 and VC 22, while genotype VC-7-2 recorded the longest time to first fruit harvest (Biswas *et al.,* 2020).

2.1.2.6 Node to first fruit

Shivakumara (2019) evaluated twenty netted muskmelon genotypes under Kerala condition and found that the lowest node at which first fruit appeared was 5.30 in the genotype Novel and the highest node was 10.40 in Sugar Summer.

Evaluation of thirty one genotypes of bottle gourd revealed that the lowest node in which first fruit appeared was 13.70 in BG-3 and the highest node of 19.70 in IC342077 (Yogananda, 2020)

2.1.2.7 Fruits per plant

Gichimu *et al.* (2010) observed significant variation in fruit number among watermelon accessions. The highest number of fruits per plant was recorded in GBK-043014 (5.67) followed by Yellow Crimson (3.45). In a performance study of watermelon cultivars conducted by Jadhav *et al.* (2014), the genotypes Sugar Baby and Pyramid (2.17) produced the highest number of fruits per plant.

More *et al.* (2015) found that the performance of watermelon varieties was significantly different and the highest number of fruits per plant was produced by Sugar Baby (2.85 per plant) and GP- 42 produced the lowest number (1.50 per plant). The genotype WM-7(4.60) produced highest number of fruits per vine, while genotype WM-6 (1.70) produced the lowest (Bhagyalekshmi, 2019).

Anumala *et al.* (2020) observed the highest number of fruits per plant in watermelon genotype VC-12-2 (7.10) and lowest in VC-5-2 (4.70). Biswas *et al*. (2020) reported that the number of fruits per plant in watermelon ranged from 3.70 (VC-24) to 8.30 (VC-12-2).

Mohosina *et al.* (2020) assessed the commercially cultivating hybrids of watermelon in Bangladesh and recorded the highest number of fruits per plant in Sugar Kis (4.50) and the lowest in the hybrid Asian-2 (1.50).

2.1.2.8 Yield per plant

More *et al.* (2015) observed that the highest fruit yield per plant was recorded in Arka Manik (11.56 kg) and the lowest in cultivar GP- 3 (7.18 kg).

Anburani (2018) ranked the genotypes CL 4 (11.60 kg), CL 22 (10.62 kg) and CL 10 (9.85 kg) as top three based on the yield per plant in watermelon. The highest fruit yield per plot (172.13 kg) was noticed in WM-12 whereas, genotype WM-9 recorded the lowest (25.81 kg) (Bhagyalekshmi, 2019).

Mohosina *et al.* (2020) studied the diversity of sixteen watermelon hybrids in Bangladesh and found that the highest fruit yield of 29.60 kg per plant in World Queen and the lowest in Dragon King (5.50 kg).

2.1.2.9 Yield per plot

In watermelon variability study, Nisha (2017) reported that Sarsawati (81.65 kg) had the highest yield per plot and the lowest in Arka Akash (20.45 kg).

Shivakumara (2019) recorded the highest yield per plot in the genotype NS-915 (2.14 kg) and lowest in Rajasthan Local-1 (0.62 kg) in an evaluation study of netted muskmelon genotypes.

Evaluation of thirty one bottle gourd genotypes was conducted by Yogananda (2020) and noticed that Tvpm Local recorded highest yield per plot (197.90 kg) whereas, BG-3 recorded the lowest (17.30 kg).

2.1.2.10 Marketable yield per plot

Hassell *et al.* (2007) evaluated the triploid mini watermelon genotypes for yield and quality in diverse locations in the Southeastern United States and noticed that genotype Mielhart and Little Deuce Coupe recorded the highest percentage of marketable fruit at all locations.

Nisha (2017) conducted variability studies in watermelon ad noticed that Sarsawati recorded the highest (76.77kg) marketable yield per plot while Shonima recorded the lowest (14.19 kg) marketable yield per plot.

2.1.2.11 Crop duration (days)

Genetic variability studies in watermelon conducted by Nisha (2017) reported a range of 74.00 to 109.50 days for final harvest. Longest crop duration was observed in Shonima and the shortest in Prachi.

Evaluation of netted muskmelon genotypes was conducted by Shivakumara (2019) and noticed the longest crop duration of 106.00 days in genotype G-Kart and shortest duration in NS-915 (92.10 days).

Kunjam *et al*. (2019) evaluated the bottle gourd genotypes and noticed that duration of crop ranged from 120.60 to 143.00 days.

2.1.2.12 Seeds per fruit

Jadhav *et al.* (2014) assessed the performance of watermelon genotypes and revealed that Ayesha (666.03) recorded the highest number of seeds per fruit, whereas Sugar Baby (514.73) had the lowest. Alimari *et al*. (2017) observed that the number of seeds per fruit was highest in the accession 20 (289.50) and lowest in the accession 16 (76.70).

Rabou and Sayd (2021) assessed the genetic variability in watermelon and reported that the number of seeds per fruit of the inbred lines evaluated varied from 35.80 to 435.50. The lowest number of seeds per fruit was found in genotypes 2-3-4-11 and 6-2-3-16, while the highest number of seeds per fruit was found in genotypes 2-3-1-2 and 8- 2-1-6.

2.1.2.13 100 seed weight (g)

Performance study of four watermelon genotypes under Tansa conditions during rabi season revealed that the variety Sugar Baby (4.53g) had the highest weight of 100 seeds, while hybrid Ayesha (2.58g) had the lowest weight of 100 seeds (Jadhav *et al*., 2014).

Morphological and biochemical characterization in watermelon landraces conducted by Singh *et al.* (2018) recorded the highest hundred seed weight in EC-829841 (17.96 g) and lowest in IC-611630 (1.97 g).

Bhagyalekshmi (2019) reported the highest hundred seed weight of 11.45g in the genotype WM-6 and the lowest in genotype WM-22 (2.24 g).

Rabou and Sayd (2021) noted that the weight of 100 seeds of inbred lines varied between 3.00 g and 15.20 g in two summer seasons. The lowest 100 seed weight was found in the inbred lines 2-4-1-1 and 6-2-3-2 and the highest in 2-2-1-2 and Philippine 28-2.

2.1.3 Quality Characters

2.1.3.1 T.S. S (^{0}Brix)

Nagal *et al.* (2012) observed that total soluble content in watermelon cultivars ranged from 6.06 to 11.33 °Brix. PWM25-4, Kiran and Kareena recorded highest TSS than other cultivars.

More *et al.* (2015) found that watermelon genotypes differed significantly in total soluble solids content. Arka Manik (14.70 °Brix) recorded the highest TSS followed by Sugar Baby (13.15 °Brix) and lowest in GP- 42 (7.95 °Brix). High TSS content of 13.40 °Brix in Sugar Baby was also reported by Mohanta and Mandal (2016).

Nisha (2017) observed that the TSS content of the watermelon fruit was highest in Prachi (13.30°Brix) and lowest in NS-295 (9.30°Brix).

A study on physico chemical properties of watermelon revealed that the amounts of total soluble solid for red fleshed seeded, red fleshed seedless and yellow fleshed watermelons were 10.46, 9.24 and 9.91 ºBrix respectively (Sabeeta *et al*., 2017).

2.1.3.2 Lycopene

Perkins-Veazie *et al*. (2001) reported that lycopene content varied significantly among cultivars and stated that seedless watermelon tend to had higher amounts of lycopene than seeded cultivars.

Davis *et al.* (2004) assessed the amount of lycopene in watermelon flesh. Lycopene content was ranged from 1.00 (PI 482291) to 8.10 mg $100g^{-1}$ (PI 288232). Nagal *et al.* (2012) recorded highest levels of lycopene in Kiran and Kareena (7.75 and 8.00 mg $100g^{-1}$, respectively), followed by PWM 25-4 and Arun (7.30 and 6.40 mg $100g^{-1}$, respectively).

Choo and Sin (2012) examined the lycopene content of red and yellow fleshed watermelons. They found that the lycopene content of red fleshed watermelon was 2.60 mg kg^{-1}, which was greater than the lycopene content of yellow fleshed watermelon (0.37 mg kg^{-1}).

Choudhary *et al.* (2015) noticed that the lycopene content in the red fleshed watermelon genotypes ranged between 3.74 and 6.80 mg $100g^{-1}$. AHW/BR 16 (6.01 mg $100g^{-1}$) and Asahi Yamato (6.80 mg $100g^{-1}$) were considerably superior to all other genotypes.

Nisha (2017) evaluated twenty watermelon genotypes and found that Shonima recorded the highest lycopene content (7.95 mg $100g^{-1}$) and lowest in Swarna (0.53 mg

$100g^{-1}$). The highest lycopene levels were found in the red fleshed watermelon cultigen Dixielee, while the lowest lycopene levels were found in the yellow and orange fleshed cultigens Yellow Doll, Yellow Crimson and NC-517 (Wehner *et al.*, 2017).

Bhagyalekshmi (2019) reported that the lycopene content in watermelon genotypes ranged from 3.24 mg 100 g^{-1}(WM-17) to 5.59 mg $100g^{-1}$ (WM-21).

2.1.3.3 Ascorbic acid

The biochemical composition of watermelon fruits was assessed by Sahu *et al.* (2011) and they found that the ascorbic acid content was ranged from 8.56 to 12.53 mg g^{-1}. The hybrid Black Wonder (12.53 mg g^{-1}) had the highest concentration and lowest in Sugar Baby (8.56 mg g^{-1}).

Choo and Sin (2012) examined the antioxidant, lycopene and ascorbic acid contents of red and yellow fleshed watermelons and found that the ascorbic acid content of the red-fleshed watermelon was higher (8.60 mg $100g^{-1}$) than that of yellow-fleshed watermelon (5.20 mg $100g^{-1}$).

Nisha (2017) observed that ascorbic acid levels in watermelon fruits was ranged from 3.00 mg $100g^{-1}$ in Kiran to 5.85 mg $100g^{-1}$ in Anmol. Oberoi and Sogi (2017) analyzed the physicochemical parameters of watermelon juice and pulp and reported 4.96 mg $100g^{-1}$ ascorbic acid in watermelon juice and 4.09 mg 100 g^{-1} in pulp.

Morphological and biochemical characterization of watermelon landraces was done by Singh *et al.* (2018). The highest content of ascorbic acid was noticed in IC-611626 and the lowest in EC-829816 and EC-829818.

2.1.3.4 Reducing and non reducing sugars

Pardo *et al.* (1997) evaluated the quality parameters in watermelon and noticed the highest content of total sugars in triploids, AR-3404 and Apirena . The lowest in Antigua.

Sahu *et al*. (2011) analyzed the biochemical composition of watermelon varieties and concluded that Black Wonder had a high concentration of both reducing sugars (2.54 per cent) and non reducing sugars (1.66 per cent).

Soumya and Rao (2014) reported the cultivar Beauty had the highest reducing (28.67 mg g^{-1} FW) and non reducing (52.71 mg g^{-1} FW) sugars among four icebox cultivars investigated.

More *et al*. (2015) found that the cultivar Arka Manik recorded the highest reducing sugar (6.01 per cent) and the non-reducing sugar (4.21 per cent), whereas cultivar GP- 42 recorded the lowest reducing sugar (2.90 per cent) and non reducing sugar (2.86 per cent) contents.

Oberoi and Sogi (2017) analysed the physicochemical properties of watermelon juice and pulp and observed that watermelon juice contained 4.98 per cent total sugars, 3.58 per cent reducing sugars and 1.40 percent non reducing sugars, while pulp contained 4.80 percent total sugars, 3.69 percent reducing sugars and 1.11 percent non reducing sugars.

2.2 COEFFICIENT OF VARIATION

Priya *et al.* (2004) reported that phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters studied in watermelon. Higher estimates of PCV and GCV were recorded for 100 seed weight, fruit weight and yield per vine.

Rolania *et al*. (2004) noticed moderate values of phenotypic and genotypic coefficients of variation for vine length, number of primary branches per plant, internodal length, number of nodes per plant and fruit yield in watermelon.

Gusmini and Wehner (2007) crossed six watermelon cultivars in half diallel and conducted field trials in two North Carolina locations, Clinton and Kinston. It was observed that the phenotypic variance of large fruited parents was higher than that of small fruited ones. At Kinston, environmental variance was higher than genetic variance.

Ogbonna and Obi (2010) assessed the variability in egusi melon and reported that seed yield per plant had the highest genotypic coefficient of variation, while, 100 seed weight had the lowest. Estimates of phenotypic coefficient of variation were ranged from 3.60 to 52.00 per cent, whereas genotypic coefficient of variation ranged from 3.21 to 51.00 per cent.

Sundaram *et al.* (2011) assessed the genetic variability of 20 F_1 hybrids of watermelon and observed high estimates of genetic coefficient of variation and phenotypic coefficient of variation for 100 seed weight and yield per vine.

Choudhary *et al.* (2012) analyzed genetic variability in watermelon for 11 quantitative traits. Number of seeds per fruit recorded the highest range of variance, followed by fruit yield per plant, whereas, vine length showed the narrow range. The number of seeds per fruit and fruit yield per plant both exhibited a high magnitude of GCV.

Mahla and Choudhary (2013) assessed seed yield and related parameters in 57 watermelon genotypes. Fruit weight, rind weight, fruit diameter, number of seeds per fruit and test weight showed close association between GCV and PCV, which indicated that these traits were not significantly changed by the environment. However, there was considerable difference between GCV and PCV values for the number of fruits per plant, fruit yield per plant and seed yield per plant.

Hakimi and Madidi (2015) examined genotypic parameters and phenotypic variability in five Moroccan landraces and four commercial watermelon types. For all characters, the analysis of variance revealed extremely significant differences among genotypes. Fruit length exhibited the highest coefficient of variation, whereas fruit weight exhibited the lowest.

Anburani (2018) reported high estimates of GCV and PCV for single fruit weight and 100 seed weight in watermelon. The characters with the highest PCV and moderate

GCV were the number of fruits per plant, yield per plant, fruit diameter and flesh thickness.

In watermelon variability studies, high PCV and GCV values were found for node to first male flower, yield per plant and average fruit weight, whereas lower values were found for days to harvest after pollination, node to first fruit set, fruit diameter, flesh thickness and seed length (Jamatia *et al.*, 2019).

Mohosina *et al.* (2020) assessed the genetic diversity of sixteen watermelon hybrids and observed that fruit yield per plant had the highest genotypic and phenotypic coefficients, followed by single fruit weight.

Rabou and Sayd (2021) conducted a study on genetic variability, heritability and correlation in watermelon over two consecutive summer seasons and noticed high estimates of both GCV and PCV for the characters fruit weight, number of seeds per fruit, 100 seed weight and total yield per plant and low estimates of GCV and PCV for traits fruit length and shape index.

2.3 HERITABILITY AND GENETIC ADVANCE

Prasad *et al.* (2002) evaluated the genetic variance and divergence in 48 watermelon inbreds and found that yield per plot, number of nodes, days to female flowers appearance and number of fruits per plot recorded high heritability combined with high genetic advance.

Priya *et al.* (2004) noticed low heritability (19.80 per cent) for number of fruits per plant in watermelon. Weight of fruits and yield per vine recorded high heritability along with high genetic advance as a per centage of mean. Total soluble solids had a high heritability estimate (73.70 per cent) and moderate genetic advance as a per cent of the mean (19.66 per cent).

Rolania *et al.* (2004) studied variability in fifteen watermelon genotypes and noticed that days to first fruit harvest recorded the highest heritability estimates. Number of primary branches per plants, internodal length and number of nodes per plants showed moderate estimates of heritability and genetic advance.

In egusi watermelons, Ogbonna and Obi (2010) found strong heritability estimates for yield attributes. Heritability of seed yield per plant ranged from 83.00 to 98.00 per cent and genetic advance ranged between 25.90 and 48.40 per cent.

Kumar and Wehner (2011) studied the heritability of yield traits in two watermelon populations produced by crossing obsolete cultivars with high yielding modern cultivars and observed low narrow sense heritability estimates for fruit weight, marketable fruit weight, total fruit number and fruit size.

High heritability combined with genetic advance as a per centage of mean was observed in node to first fruit, yield and fruit weight in watermelon indicating that these traits are mostly controlled by additive genes (Sundaram *et al*., 2011).

Choudhary *et al*. (2012) studied the morphological diversity of watermelon genotypes and noticed that TSS recorded the highest heritability followed by rind thickness, days to first fruit harvest, number of primary branches per plant, fruit yield per plant, node at which first female flower and main vine length.

Mahla and Choudhary (2013) assessed seed yield and related parameters in 57 watermelon genotypes and observed high estimates of heritability and moderate to high genetic advance for all the characters studied.

Nisha *et al*. (2018) studied genetic variability, heritability and genetic advance in twenty watermelon genotypes. High heritability coupled with high genetic advance as per cent of mean were observed for fruit weight, yield per plant and 100 seed weight.

Vine length, number of primary branches per plant, number of male flowers, number of fruits per plant, fruit length, fruit diameter, single fruit weight, flesh thickness, yield per plant,100 seed weight, number of seeds per fruit and sex ratio exhibited high heritability coupled with high genetic advance (Anburani, 2018).

Jamatia *et al.* (2019) studied the heritability and genetic advance in watermelon genotypes and noticed that average fruit weight, yield per plant, Zn and Mn content showed moderate to high heritability with high genetic advance as a per cent of mean, while Mg and Na contents showed high heritability with moderate genetic advance as a per cent of mean, indicating wide variability for economically important characters.

Rabou and Sayd (2021) conducted a study on genetic diversity and heritability in watermelon during two consecutive summer seasons and found high heritability (89.36 to 99.94 per cent) for number of seeds per fruit, 100 seed weight, single fruit weight, fruit diameter, fruit length, flesh thickness and yield per plant.

2.4 CORRELATION STUDIES

Choudhary *et al.* (2012) studied the morphological diversity in watermelon and noticed that fruit yield per plant was positively correlated with node to first female flower (0.440), number of primary branches per plant (0.342), fruit weight (0.339) and number of fruits per plant (0.077).

Hakimi and Madidi (2015) recorded the highly significant and positive association between fruit weight, fruit length, fruit width and TSS in their diversity study of Moroccan watermelon landraces.

Alimari *et al.* (2017) reported that yield was positively correlated with days to male flowering, days to female flowering, node number and number of vines in the genetic diversity study of local Palestinian watermelon.

Nisha *et al*. (2018) observed a positive and significant correlation between yield per plant and fruit polar diameter, fruit weight, number of fruits per plant and seeds per fruit at both the phenotypic and genotypic levels.

Fruit yield per plant was found to be significantly and positively correlated with average fruit weight (0.951), fruit length (0.809), fruit circumference (0.575) and number of fruits per plant (0.537) in watermelon genotypes, while it had negative correlation with node to first female flower (-0.615) and days to first harvest (-0.604) (Anumala *et al.*, 2020).

Bhagyalekshmi *et al*. (2020) observed that fruit yield per vine had significant positive correlation with average fruit weight (0.729), number of fruits per vine (0.426), and flesh thickness (0.410). On the other hand, fruit yield per vine exhibited significant negative correlation with sex ratio.

Mohosina *et al*. (2020) assessed the genetic diversity of watermelon hybrids and revealed that the number of male flowers, fruit weight, fruit length, fruit diameter, leaf form and fruit yield were highly correlated traits among watermelon genotypes. The number of fruits had a negative correlation with rind thickness and a positive correlation with fruit yield.

Rabou and Sayd (2021) conducted a study on genetic diversity, heritability and correlation in watermelon over two successive summer seasons noticed that the fruit diameter showed a highly significant positive correlation with fruit length (0.66), fruit weight (0.23) and total yield per plant (0.44). In contrast, a negative correlation was found with the shape index (-0.26).

2.5 PATH ANALYSIS

Singh and Lal (2000) reported that fruit weight, vine length and flesh thickness exhibited positive and direct effects on yield in muskmelon. Rolania *et al.* (2003) studied the correlation and path analysis in watermelon and reported that days to first fruit harvest and node to first female flower exhibited a negative direct effect on yield.

In muskmelon, fruit weight exhibited a positive direct effect on fruit yield and it showed positive indirect effects through moisture percentage, fruit girth, total soluble sugars and flesh thickness (Tomar *et al*., 2008). Fruits per plant and moisture percentage exerted high positive direct effect and positive association with fruit yield per plant in muskmelon (Mehta *et al.*, 2009).

Choudhary *et al.* (2012) in their path analysis study observed that the highest direct effect on yield per plant was exerted by fruit weight (1.023) followed by number of fruits per plant (0.862) in watermelon.

Mahla and Choudhary (2013) in their path analysis study of seed purpose watermelon genotypes reported that seed yield per plant showed direct positive effect and significant positive correlation with number of fruits per plant, fruit yield per plant and 100 seed weight.

Srikanth *et al*. (2015) reported in pumpkin that fruit length (0.995) exhibited the highest positive direct effect on yield followed by primary branches (0.772), fruits per vine (0.474), fruit cavity (0.461), fruit diameter (0.421) and sex ratio (0.147) and the characters like days to first female flower (0.585), average fruit weight (0.554), seeds per fruit (0.310) and days to first harvest (0.194), fruit cavity (0.069) and fruit diameter (0.031) showed positive indirect effect on yield.

In ridge gourd, node to first female flower, vine length, fruit length and fruit girth exerted negative direct effect on fruit yield (Varalakshmi *et al*., 2015). Pal *et al*. (2017) observed that harvest duration and marketable fruits per plant exhibited direct positive effect on yield and days to first harvest had direct negative effect in cucumber.

Nisha *et al.* (2018) studied the path coefficient analysis in watermelon and revealed that number of fruit weight (0.858) and fruits per plant (0.832) had positive direct effect on yield per plant and characters like vine length, fruit equatorial diameter, seeds per fruit and weight of 100 seeds exerted negative direct effect on yield. Fruit yield per plant showed the highest positive direct effect (0.880) with number of branches per plant in bitter gourd (Talukder *et al*., 2018).

In bitter gourd, node to of first male flower (1.468), average fruit weight (1.210) and number of fruits per plant (0.967) showed positive direct effect on fruit yield per plant in bitter gourd (Tyagi *et al*., 2018). Days to first female flower (-0.161), fruit length (-0.164) and fruit girth (-0.105) exhibited a negative direct effect on yield in pumpkin (Anusa *et al.,* 2020).

Bhagyalekshmi *et al*. (2020) reported that days to fist male flower, days to first female flower, days to first fruit harvest, average fruit weight, number of fruits per vine, flesh thickness, number of seeds per fruit and hundred seed weight showed the positive direct effect on fruit yield per plant. Whereas, negative direct effect was noticed in traits like vine length, number of branches, node to first female flower, fruit diameter, rind thickness, total soluble solids and lycopene content.

In watermelon, number of fruits per plant (0.890) showed a high direct effect on yield and it has negative indirect effects on other traits like fruit weight (-0.200), fruit length (-0.220) and fruit diameter (-0.440) (Correa *et al*., 2020).

Materials and Methods

3.MATERIALS AND METHODS

The present investigation entitled 'Evaluation of watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] genotypes for growth, yield and quality' was conducted at the Department of Vegetable Science, College of Agriculture, Vellayani, during 2020-2021. The study aimed to evaluate watermelon genotypes for growth, yield and quality and identify superior genotypes suitable for South Kerala condition.

3.1 EXPERIMENTAL SITE

The experiment was conducted at experimental plot located at 8.25^0 North latitude and 76.59^0 East longitude, at an altitude of 20 m above mean sea level.

3.1.1 Soil

The predominant soil type at the experimental site is red loam of Vellayani series, texturally classified as sandy clay loam.

3.1.2 Climate and weather condition

Warm, humid tropical climate prevails throughout the region. The summer receives good rainfall, while the winter have very little. The data on weather parameters like minimum and maximum temperatures, sunshine hours, number of rainy days and relative humidity during the crop season recorded at the meteorological observatory are presented in Fig.1 and Appendix I.

3.2 MATERIALS

Thirty watermelon genotypes including 17 hybrids and 13 varieties were collected from public and private sectors for this study. Saraswati, the best performing hybrid and Sugar Baby the best performing variety from the previous research work conducted at Department of Vegetable Science was used as standard check for hybrids and varieties respectively. The list of watermelon hybrids and varieties are given in Table 1. and Plate 1.

3.3 METHODS

3.3.1 Design and Layout

Thirty genotypes of watermelon were evaluated for yield and quality during Dec. 2020 to April 2021. The crop was raised as per to the package of practices recommendations (KAU, 2016) for watermelon (Plate 2).

The experiment was laid out as follows:

Design	: RBD
Treatments	: 30
Replication	: 2
Spacing	: 3m x 2 m
Plants per plot	: 10
Plot size	: 60 m^2

3.4 OBSERVATIONS

3.4.1 Vegetative and Flowering Characters

Five plants were chosen at random from each plot and tagged for recording the biometric observations.

3.4.1.1 Vine length (m)

The length of the vine was measured from cotyledonary node to the tip of the main vine after the final harvest and expressed in meter (m).

3.4.1.2 Number of branches per vine

The number of primary branches from the main vine was recorded at final harvest and the average was presented as number of branches per vine.

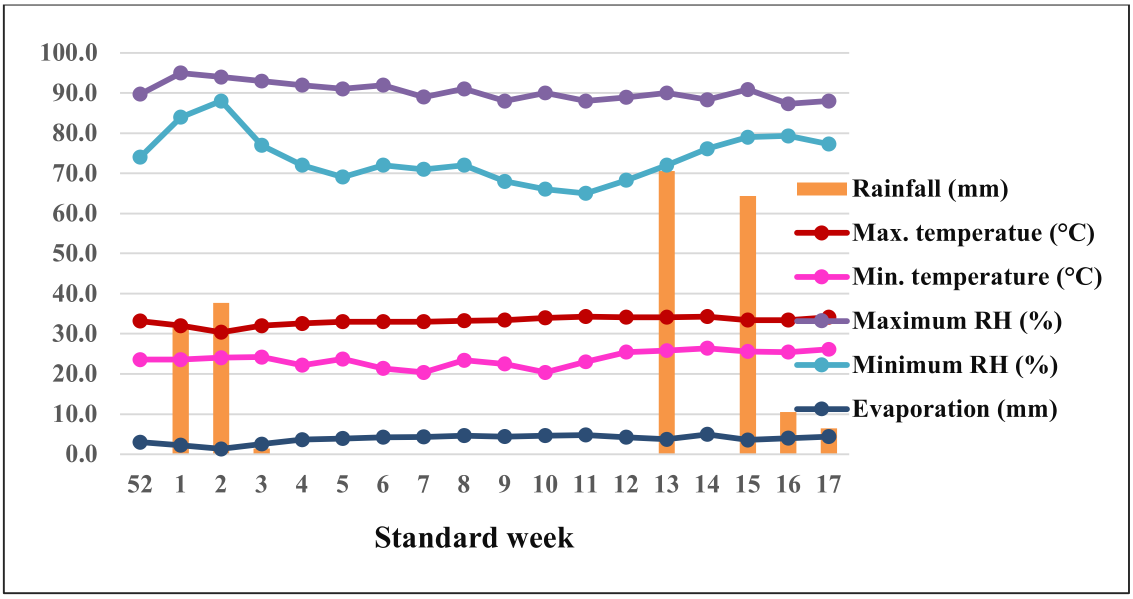


Fig. 1. Weather parameters during the cropping period (December 2020 – April 2021)

Table 1. Details of watermelon genotypes used for evaluation

Treatment No.	Accessions / Genotypes	Variety/ hybrid	Source of collection
T1	Jannat	Hybrid	Known-You Seed Pvt. Ltd. Pune
T2	Mannat	Hybrid	Known-You Seed Pvt. Ltd. Pune
T3	Shabari	Hybrid	Laher seeds, Ahmedabad
T4	Prachi	Hybrid	Known-You Seed Pvt. Ltd. Pune
T5	Yellow Angel	Hybrid	Laher seeds, Ahmedabad
T6	WHS -20011	Hybrid	Urja seeds, New Delhi
T7	Yellow Queen	Hybrid	Laher seeds, Ahmedabad
T8	Jolo gold	Hybrid	Laher seeds, Ahmedabad
T9	Aarohi	Hybrid	Known-You Seed Pvt. Ltd. Pune
T10	Vankat	Hybrid	Laher seeds, Ahmedabad
T11	Yellow Lion	Hybrid	Laher seeds, Ahmedabad
T12	Shonima	Hybrid	Kerala Agriculture University, Thrissur
T13	Devyani	Hybrid	Known-You Seed Pvt. Ltd., Pune
T14	Swarna	Hybrid	Kerala Agriculture University, Thrissur
T15	Anmol	Hybrid	Known-You Seed Pvt. Ltd., Pune
T16	Simran	Hybrid	Known-You Seed Pvt. Ltd., Pune
T17	Saraswati (Check)	Hybrid	Known-You Seed Pvt. Ltd. Pune
T18	Arka Manik	Variety	IIHR, Bangalore
T19	Arka Muthu	Variety	IIHR, Bangalore
T20	Arka Shyama	Variety	IIHR, Bangalore
T21	Best of All	Variety	American seeds, Bangalore
T22	Crimson Sweet	Variety	IIHR, Bangalore
T23	Asahi Yamato	Variety	IIHR, Bangalore
T24	Durgapura Meetha	Variety	IIHR, Bangalore
T25	Durgapura Lal	Variety	IIHR, Bangalore
T26	Durgapura Kesar	Variety	IIHR, Bangalore
T27	AHW 65	Variety	IIHR, Bangalore
T28	AHW 19	Variety	IIHR, Bangalore
T29	Thar Manak	Variety	IIHR, Bangalore
T30	Sugar Baby (Check)	Variety	Kerala Agriculture University, Thrissur

Jannat

Prachi

Yellow Angel

Plate 1. Fruits of watermelon genotypes

Mannat

Shabari

Yellow Queen

Plate 1. Continued

WHS-20011

Jolo Gold

Arohi

Plate 1. Continued

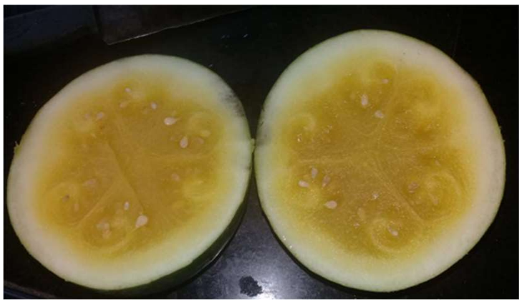
Vankat

Yellow Lion

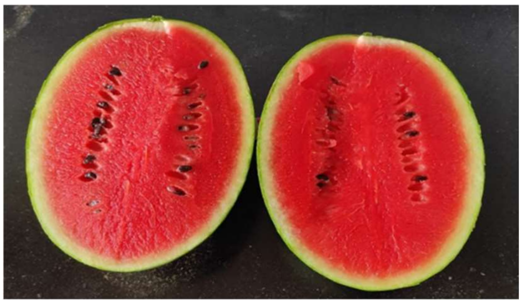
Shonima

Plate 1. Continued

Devyani



Swarna



Saraswati

Plate 1. Continued

Anmol

Arka Shyama

Sugar Baby

Plate 1. Continued

Arka Muthu

Best of All

Arka Manik

Asahi Yamato

Plate 1. Continued

Plate 2. General view of experimental field

3.4.1.3 Inter nodal length (cm)

The internodal length of the main stem was measured as distance between two nodes.

3.4.1.4 Days to first male flower

The number of days were counted from the date of sowing to the opening of the first male flower on the vine.

3.4.1.5 Days to first female flower

The number of days were counted and recorded from the date of sowing to the opening of first female flower.

3.4.1.6 Node to first male flower

The node number at which the first male flower appeared was determined by counting its position from the first true leaf on the vine.

3.4.1.7 Node to first female flower

The node number at which the first female flower appeared was determined by counting its position from the first true leaf on the vine

3.4.2 Fruit and Yield Characters

3.4.2.1 Fruit equatorial diameter (cm)

Fruits were cut horizontally and the diameter of the fruit at the broadest point was measured.

3.4.2.2 Fruit polar diameter (cm)

Fruits were cut longitudinally and the diameter from the fruit stalk to the tip was measured.

3.4.2.3 Rind thickness (cm)

Fruit was divided into two halves and rind thickness was measured by scale.

3.4.2.4 Fruit weight (kg)

The average weight of five fruits randomly selected from each accession in each replication was calculated.

3.4.2.5 Days to first harvest

The number of days from the date of sowing to the harvest of first fruit was recorded.

3.4.2.6 Node to first fruit

The node number at which the first fruit appeared was determined by counting its position from the first true leaf on the vine

3.4.2.7 Fruits per plant

The total number of fruits harvested from five labelled plants of each treatment was counted and the average number of fruits per plant was calculated.

3.4.2.8Yield per plant (kg)

Fruit yield per plant was calculated by summing the weight of all harvested fruits from each plant and expressed in kilogram.

3.4.2.9Yield per plot (kg)

The weight of fruits from each plot per harvest was recorded and expressed in kilogram (kg).

3.4.2.10 Marketable yield per plot (kg)

The weight of marketable fruits from each plot was recorded at each harvest and the total was expressed in kilogram.

3.4.2.11 Crop duration

Crop duration was measured by counting the days from date of sowing to final harvest from the observational plants and the average was worked out.

3.4.2.12 Seeds per fruit

The average number of seeds found in each fruit was counted and recorded.

3.4.2.13 100 seed weight (g)

Dry weight of randomly selected 100 seeds was recorded using an electronic weighing balance.

3.4.3 Quality Characters

3.4.3.1 TSS (°Brix)

The juice was extracted from the fruit flesh using a pestle and mortar, and the total soluble solid content was measured using an Erma Hand Refractometer (0-32).

3.4.3.2 Lycopene (mg 100 g^{-1})

The lycopene content of the fruits was estimated using the method proposed by Sadasivam and Manickam (2008).

3.4.3.3 Ascorbic acid (mg 100 g^{-1})

The amount of ascorbic acid in the fruit was determined using the 2, 6-dichlorophenol indophenol dye method (Sadasivam and Manickam, 1992).

3.4.3.4 Reducing sugar

25 mL of clarified juice was placed in a 250 mL volumetric flask, 100mL distilled water was added to the mixture. The solution was neutralized with 1 N NaOH using a pH indicator, then titrated against Fehling's solution to determine the reducing sugar content in percentage.

$$\% \text{ of reducing sugars} = \frac{0.05 \times \text{Dilution} \times 250}{\text{Titrate value} \times \text{Weight of the sample}}$$

3.4.3.5 Non reducing sugar

Non-reducing sugars were calculated by subtracting reducing sugars from total sugars (% of total sugars - % of reducing sugars).

3.4.4 Incidence of Pests and Diseases

Pest and disease incidence in watermelon genotypes was monitored in the field. The major disease observed was fusarium wilt and the most common pest was pumpkin caterpillar.

3.4.4.1 Fusarium wilt (*Fusarium oxysporum f.sp. niveum*)

Wilting symptoms appear first on single laterals and manifested as flaccidity of the leaves. Long, narrow brown streak may form on one side of the stem near the soil level and extend upward. The diseased plant may produce a large number of fruits, which eventually shrivel before reaching full size.

Data on the severity of fusarium wilt was recorded following 1-4 rating scale (Tziros *et al.*, 2007) where,

1- Apparently healthy plant
2- Slight chlorosis of lower leaves, slight wilt of plant
3- Necrosis, falling of lower leaves yellow areas on upper leaves
4- Dead plant

Based on the scores assigned to each plant, severity (Percentage disease index) was worked out using the formula described by Mc Kinney (1923).

$$\text{Percentage Disease Index} = \frac{\text{Sum of individual ratings}}{\text{Total number of plants observed}} \times \frac{100}{\text{Maximum grade}}$$

3.4.4.2 Pumpkin caterpillar (Diaphania indica)

The young caterpillars lacerate and feed on the chlorophyll in the leaves. They feed within the folds and webs the leaves. The caterpillars also scrape the green matter from the rind of developing fruits, forming a feeding scar.

The pest could be effectively managed by spraying Flubendiamide 39.35 SC (Fame) @ 0.1ml l^{-1}

3.5 SENSORY ANALYSIS

Watermelon slices from various genotypes were evaluated for sensory aspects such as appearance, colour, flavour, taste, texture and overall acceptability by ten members. According to Hedonic rating, each attribute was assigned a score ranging from 1 to 9 (Ranganna, 1986) (Appendix II). The score was statistically analysed using the Kruskal-Wallis test (Chi square value) and ranked (Shamrez *et al*., 2013)

3.6 STATISTICAL ANALYSIS

The data recorded were processed using the following statistical procedures.

3.6.1 Analysis of Variance

The observations recorded were subjected to ANOVA (Panse and Sukhatme, 1985) for comparison among various treatments and to estimate variance components.

ANOVA for each character

Sources of variation	Degrees of freedom	Mean sum of squares	F ratio
Replication	r-1	MSR	MSR/MSE
Treatment	t-1	MST	MST/MSE
Error	(r-1) (t-1)	MSE	
Total	rt-1		

Where, r = number of replications

t = number of treatments

MSR = mean sum of replication

MST = mean sum of treatments

MSE= mean sum error

Critical difference (CD)= $t\alpha \sqrt{\frac{2\ MSE}{r}}$

Where, tα = Student's 't' table value at error degrees of freedom at α level of significance.

3.6.2 Estimation of Genetic Parameters

3.6.2.1 Genetic component of variance

The phenotypic and genotypic variances were calculated by utilizing the respective mean square values (Johnson *et al*., 1955).

i. Genotypic variance (V_G)

$$V_G = \frac{MST-MSE}{r}$$

ii. Environmental variance (V_E)

V_E = MSE

iii. Phenotypic variance (V_P)

$V_P = V_G + V_E$

3.6.2.2 Coefficient of variation

The genotypic and phenotypic coefficients of variation are calculated as per Burton (1952).

i. Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{Vp}}{\bar{X}} \times 100$$

ii. Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sqrt{V_G}}{\bar{X}} \times 100$$

$\bar{X}$ = General mean of characters

Categorization of the range of variation was followed as proposed by Sivasubramanian and Menon (1973).

Low	: Less than 10 per cent
Moderate	: 10 to 20 per cent
High	: More than 20 per cent

3.6.2.3 Heritability

Heritability in the broad sense refers to the proportion of genotypic variance to the total observed variance in the total population. Heritability in broad sense was estimated for various characters and expressed in percentage (Allard, 1960).

$$\text{Heritability } (h^2) = \frac{V_G}{V_P} \times 100$$

As suggested by Johnson *et al.* (1955) heritability in broad sense estimates were categorized as,

Low	: Less than 30 per cent
Moderate	: 30 to 60 per cent
High	: More than 60 per cent

3.6.2.4 Genetic Advance

Genetic advance refers to the expected genetic gain or improvement in the next generation by selecting superior individuals under certain amount of selection pressure. It depends upon standardized selection differential, heritability and phenotypic standard deviation (Allard, 1960). The genetic advance was calculated in per cent by the formulae suggested by Johnson *et al.* (1955).

Genetic advance (GA) = k x $h^2 \sqrt{V_P}$

$$\text{GA as percentage of mean} = \frac{GA}{\bar{X}} \times 100$$

Where, k = standardized selection differential (2.06 at 5 % selection intensity)

h^2 = heritability

The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al*. (1955).

Low	: Less than 10 per cent
Moderate	: 10 to 20 per cent
High	: More than 20 per cent

4.6.2.5 Correlation Analysis

Phenotypic and genotypic correlation coefficients were calculated using the respective variance and covariance of the characters which showed significant variation in ANOVA**.**

$$\text{Phenotypic correlation coefficient,}\left(r_{PX,Y}\right) = \frac{Cov_P(X,Y)}{\sqrt{V_P(X)},V_P(Y)}$$

$$\text{Genotypic correlation coefficient,}\left(r_{GX,Y}\right) = \frac{Cov_G(X,Y)}{\sqrt{V_G(X)},V_G(Y)}$$

Where, CovP (X, Y) = phenotypic variance between two traits X and Y

Cov G (X, Y) = genotypic covariance between two traits X and Y

VP (X) and VP (Y) = phenotypic variance (PV) for X and Y respectively

VG(X)and VG (Y) = genotypic variance (GV) for X and Y respectively

3.6.2.6 Path Coefficient Analysis

To study the cause and effect relationship of yield and its component characters, direct and indirect effects were analysed using path coefficient analysis as suggested by Dewey and Lu (1959).

Results

4. RESULTS

The present investigation was conducted at the Department of Vegetable science, College of Agriculture, Vellayani from December 2020 to April 2021 to evaluate the performance of watermelon varieties and hybrids for growth, yield and quality characteristics. The experimental data were analyzed statistically and the results are presented below.

4.1 ANALYSIS OF VARIANCE

The analysis of variance revealed that the mean sum of squares due to genotypes were highly significant for all the characters studied. The mean sum of squares for twenty five characters of thirty genotypes comprising of 17 hybrids and 13 varieties are presented in Table 2 and Table 3 respectively.

4.2 MEAN PERFORMANCE OF WATERMELON GENOTYPES

The mean performance of thirty watermelon genotypes for twenty five characters is given below.

4.2.1 Vegetative and Flowering Characters

The mean performance of 17 watermelon hybrids and 13 varieties including checks for vegetative and flowering characters like vine length, number of branches per vine, internodal length, days to first male flower, days to first female flower, node to first male flower and node to first female flower are presented in Table 4 and Table 5 respectively.

4.2.1.1 Vine length

Significant difference was observed among the hybrids for vine length. The mean vine length ranged from 2.84 m to 5.99 m. Among the hybrids and check, Swarna produced the longest vine of 5.99 m length while Jannat produced the shortest vine of 2.84 m.

Vine length varied significantly among varieties. The vine length ranged from 1.40 m to 5.18 m, with a mean of 3.76 m. Among the varieties and check, AHW 19 had the longest vine length (5.18 m), whereas Arka Muthu had the shortest vine length (1.40 m).

4.2.1.2 Number of branches per vine

In hybrids, the number of branches per vine varied from 5.50 to 16.84, with a mean of 9.82. The highest number of branches was produced by Prachi, while the lowest was observed in Simran.

Among the varieties and check, the highest number of branches was observed in Best of All (7.50). The varieties Durgapura Lal (7.34), Crimson Sweet (7.17) and the check Sugar Baby (6.84) were on par with it. Minimum number of branches was noticed in Arka Muthu (2.84).

4.2.1.3 Internodal length

The average internodal length in hybrids was 8.43 cm, ranging from 5.25 cm to 12.95 cm. The hybrid Jannat had the longest internodal length of 12.95 cm while Yellow Angel exhibited the shortest internodal length (5.25 cm).

The internodal length of varieties varied from 3.30 cm to 9.77 cm with a mean of 6.98 cm. The highest internodal length was recorded in the check Sugar Baby (9.77 cm) followed by Crimson Sweet (9.63cm). The lowest internodal length was observed in Arka Muthu (3.30 cm).

4.2.1.4 Days to first male flower

Lowest value is preferred. Among the hybrids and check, Jannat was the earliest to produce first male flower (31.40 days) which was on par with Mannat (33.40 days), WHS-20011 (33.40 days) and Saraswati (33.50 days). Shonima was late with 40.20 days for flowering which was on par with Devyani (39.50), Anmol (39.30) and Simran (37.80)

Days required to first male flower production in varieties ranged from 29.90 to 51.50 days with a mean 40.10 days. Arka Shyama (29.90 days) was the earliest and was on par with Thar Manak (31.50 days). Duragapura Meetha was late and took 51.50 days for flowering.

Table 2. Analysis of variance for characters in watermelon hybrids (Mean squares are given)

Source of variation	Replication	Genotypes	Error
Vine length	0.073	1.316**	0.030
Number of branches per vine	0.011	19.251**	0.361
Internodal length	0.430	6.87**	0.172
Days to first male flower	1.699	11.581**	1.686
Days to first female flower	0.989	8.528**	1.587
Node to first male flower	0.042	2.57**	0.050
Node to first female flower	0.090	15.111**	0.087
Fruit equatorial diameter	0.029	4.645**	0.284
Fruit polar diameter	0.130	22.636**	0.267
Rind thickness	0.004	0.439**	0.017
Fruit weight	0.003	0.501**	0.003
Days to first harvest	4.235	170.313**	2.798
Node to first fruit	0.340	16.977**	0.205
Fruits per plant	0.014	1.381**	0.043
Yield per plant	0.141	11.971**	0.250
Yield per plot	0.622	514.908**	1.342
Marketable yield per plot	0.403	552.847**	1.137
Crop duration	29.078	183.779*	54.515
Seeds per fruit	13.333	4960.062**	35.262
100 seed weight	0.006	0.917**	0.035
TSS	0.003	5.102**	0.174
Lycopene	0.015	13.859**	0.024
Ascorbic acid	0.015	2.379**	0.030
Reducing sugar	0.011	0.159**	0.012
Non reducing sugar	0.010	0.075**	0.008

**Significant at $P \leq 0.01$

Table 3. Analysis of variance for characters in watermelon varieties (Mean squares are given)

Source of variation	Replication	Genotypes	Error
Vine length	0.014	1.633**	0.012
Number of branches per vine	0.015	3.1**	0.099
Internodal length	0.005	6.379**	0.044
Days to first male flower	1.122	55.632**	0.695
Days to first female flower	0.025	75.272**	1.015
Node to first male flower	0.098	8.241**	0.078
Node to first female flower	0.222	43.558**	0.465
Fruit equatorial diameter	0.615	13.071**	0.233
Fruit polar diameter	0.154	29.407**	0.383
Rind thickness	0.031	0.144**	0.017
Fruit weight	0.004	1.307**	0.005
Days to first harvest	98.550	304.551**	49.139
Node to first fruit	3.846	41.879**	0.116
Fruits per plant	0.075	0.507**	0.035
Yield per plant	0.299	8.171**	0.247
Yield per plot	0.846	696.456**	4.332
Marketable yield per plot	12.670	634.663**	5.608
Crop duration	0.346	211.788**	6.763
Seeds per fruit	81.385	20505.949**	35.885
100 seed weight	0.125	23.171**	0.227
TSS	0.025	5.618**	0.145
Lycopene	0.006	2.675**	0.036
Ascorbic acid	0.024	0.846**	0.020
Reducing sugar	0.030	0.171**	0.016
Non reducing sugar	0.011	0.098**	0.015

**Significant at $P \leq 0.01$

Table 4. Mean performance of watermelon hybrids for vegetative and flowering characters

Treatments		Vine length (m)	Number of branches per vine	Internodal length (cm)	Days to first male flower	Days to first female flower	Node to first male flower	Node to first female flower
T1	Jannat	2.84	9.67	12.95	31.40	37.70	3.70	9.03
T2	Mannat	3.10	10.67	7.10	33.40	40.10	4.50	10.10
T3	Shabari	3.15	12.00	8.85	36.20	41.60	4.00	12.80
T4	Prachi	3.90	16.84	9.11	34.50	38.80	3.60	8.10
T5	Yellow Angel	3.51	8.17	5.25	35.30	40.90	3.60	8.00
T6	WHS-20011	3.40	14.00	9.90	33.40	39.40	3.50	10.90
T7	Yellow Queen	2.87	7.34	8.12	35.30	40.80	4.10	9.10
T8	Jolo gold	2.94	7.67	8.14	36.20	41.50	4.40	12.40
T9	Aarohi	2.88	10.50	6.27	34.40	37.80	5.30	8.90
T10	Vankat	3.39	6.34	6.87	36.60	39.50	3.80	10.80
T11	Yellow Lion	4.33	11.33	11.38	34.60	38.20	3.20	8.80
T12	Shonima	4.51	8.84	8.74	40.20	43.90	6.00	16.00
T13	Devyani	4.27	14.50	8.80	39.50	43.80	6.00	11.60
T14	Swarna	5.99	7.84	8.74	36.60	43.00	7.50	16.70
T15	Anmol	3.60	7.34	6.82	39.30	42.00	4.20	15.80
T16	Simran	3.77	5.50	7.52	37.80	42.60	4.60	11.90
T17	Saraswati (Check)	3.05	8.50	8.75	33.50	38.30	3.80	10.60
Mean		3.62	9.82	8.43	35.78	40.58	4.46	11.27
SEm (±)		0.12	0.42	0.29	0.92	0.89	0.16	0.21
CD (0.05)		0.37	1.27	0.88	2.75	2.67	0.47	0.63

Table 5. Mean performance of watermelon varieties for vegetative and flowering characters

Treatments		Vine length (m)	Number of branches per vine	Internodal length (cm)	Days to first male flower	Days to first female flower	Node to first male flower	Node to first female flower
T18	Arka Manik	3.34	6.00	8.09	36.90	46.00	6.60	15.30
T19	Arka Muthu	1.40	2.84	3.30	35.60	43.70	3.30	14.10
T20	Arka Shyama	3.51	5.67	6.59	29.90	35.80	7.00	16.60
T21	Best of All	4.39	7.50	8.55	40.10	49.20	8.30	15.90
T22	Crimson Sweet	4.28	7.17	9.63	41.60	50.60	7.90	28.20
T23	Asahi Yamato	3.61	5.50	7.27	38.40	49.10	5.10	10.40
T24	Durgapura Meetha	4.14	6.84	5.83	51.50	60.60	10.30	18.40
T25	Durgapura Lal	4.31	7.34	6.90	41.30	53.70	9.60	20.80
T26	Durgapura Kesar	3.57	5.85	5.62	38.10	50.30	8.70	18.70
T27	AHW 65	4.27	5.17	5.49	39.70	47.40	7.90	15.90
T28	AHW 19	5.18	5.84	7.39	36.30	45.50	7.10	20.70
T29	Thar Manak	3.04	5.17	6.32	31.50	40.20	4.40	10.60
T30	Sugar Baby (Check)	3.84	6.84	9.77	36.20	44.70	5.80	19.40
Mean		3.76	5.98	6.98	38.24	47.45	7.08	17.31
SEm (±)		0.08	0.22	0.15	0.59	0.71	0.20	0.48
CD (0.05)		0.24	0.69	0.46	1.82	2.19	0.61	1.49

4.2.1.5 Days to first female flower

The hybrids and check differed significantly for days to first female flowering with an average of 40.58 days. Jannat took the lowest number of days to first female flowering (37.70 days) which was on par with Aarohi (37.80 days), Yellow Lion (38.20 days), Saraswati (38.30 days), Prachi (38.80 days), WHS-20011 (39.40 days), Vankat (39.50 days) and Mannat (40.10 days). Shonima (43.90 days) took highest number of days to first female flowering.

Among the varieties and checks, Arka Shyama was the earliest with 35.80 days for first female flower opening, whereas Duragapura Meetha took longest period of 60.60 days. Seven varieties flowered earlier than the general mean of 47.45 days.

4.2.1.6 Node to first male flower

The node to first male flower production was found significantly different among hybrids and check and it varied from 3.20 to 7.50. The lowest node number was recorded in Yellow Lion (3.20) and the hybrids WHS-20011 (3.50), Prachi (3.60) and Yellow Angel (3.60) were on par with it. The highest node number was recorded in Swarna (7.50).

Arka Muthu produced the first male flower in the lowest node of 3.30 followed by Thar Manak (4.40). The highest node number of 10.30 was recorded in Durgapura Meetha.

4.2.1.7 Node to first female flower

The hybrids and check differed significantly for node to first female flowering with a mean of 11.27. Yellow Angel produced the first female flower at the lowest node (8.00) whereas Swarna recorded the highest node of 16.70.

The node at which first female flower appeared varied from 10.40 to 28.20 in varieties. The lowest node of 10.40 was recorded in Asahi Yamato and was on par with Thar Manak (10.60). The highest node number was observed in Crimson Sweet (28.20). Among the thirteen varieties, seven produced female flowers in nodes lower than the average of 17.31.

4.2.2 Fruit and Yield Characters

Table 6 and Table 7 presents the mean values for fruit and yield characters like fruit equatorial diameter, fruit polar diameter, rind thickness, fruit weight, days to first harvest, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, crop duration, seeds per fruit and 100 seed weight of hybrids and varieties respectively.

4.2.2.1 Fruit equatorial diameter

Hybrids and varieties of watermelon showed significant difference for the trait, fruit equatorial diameter. Among the hybrids and check, the highest fruit equatorial diameter was observed in Devyani (17.60 cm) which was statistically on par with Shabari (17.50 cm), Jannat (16.85 cm), Anmol (16.75), Yellow Queen (16.75 cm) and Swarna (16.55 cm). Yellow Lion recorded the lowest fruit equatorial diameter of 12.85 cm.

Durgapura Lal exhibited the highest fruit equatorial diameter of 24.05 cm among varieties. Lowest diameter was expressed by Arka Muthu (15.90 cm) which was on par with Asahi Yamato (16.00 cm), Best of All (16.30 cm) and Durgapura Kesar (16.35 cm).

4.2.2.2 Fruit polar diameter

The fruit polar diameter exhibited a range of 15.70 cm to 28.75 cm. WHS-20011 (28.75 cm) recorded the highest fruit polar diameter while, Shonima (15.70 cm) recorded the lowest.

Fruit polar diameter in varieties ranged from 16.50 cm in Arka Muthu to 27.80 cm in AHW 65 with a mean of 21.90 cm.

4.2.2.3 Rind thickness

The hybrids and varieties differed significantly for rind thickness. The thickest rind was observed in WHS-20011 (2.15 cm) while Prachi exhibited lowest rind thickness of 0.35 cm. Six hybrids including the check Saraswati, had lesser rind thickness than the mean 1.31 cm.

Table 6. Mean performance of watermelon hybrids for fruit and yield characters

Treatments		Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Rind thickness (cm)	Fruit weight (kg)	Days to first harvest	Node to first fruit	Fruits per plant
T1	Jannat	16.85	21.65	1.10	2.57	65.00	12.10	2.40
T2	Mannat	16.00	21.15	1.40	3.34	82.50	12.10	1.40
T3	Shabari	17.50	22.80	1.60	2.95	77.50	12.90	4.20
T4	Prachi	14.50	16.95	0.35	1.70	62.00	10.60	3.30
T5	Yellow Angel	13.85	24.00	1.70	2.14	82.00	10.60	1.90
T6	WHS-20011	13.20	28.75	2.15	2.88	86.50	11.50	1.60
T7	Yellow Queen	16.75	17.40	1.40	2.25	84.00	10.70	2.55
T8	Jolo gold	14.50	21.55	1.65	2.62	89.50	11.80	1.40
T9	Aarohi	13.20	24.70	1.40	3.17	72.00	13.30	1.50
T10	Vankat	15.05	23.10	1.60	2.64	77.50	10.40	2.40
T11	Yellow Lion	12.85	18.25	1.15	1.48	67.50	11.40	1.30
T12	Shonima	15.10	15.70	1.55	1.94	87.50	19.00	1.70
T13	Devyani	17.60	21.40	0.70	2.80	88.50	12.00	3.30
T14	Swarna	16.55	17.25	1.35	2.58	93.50	20.40	1.90
T15	Anmol	16.75	18.65	0.80	2.93	77.50	15.70	2.10
T16	Simran	15.05	20.55	1.75	2.53	81.00	13.50	2.80
T17	Saraswati (Check)	15.20	18.50	0.63	2.70	69.00	10.70	3.10
Mean		15.32	20.73	1.31	2.54	79.00	12.86	2.29
SEm (±)		0.38	0.37	0.09	0.04	1.18	0.32	0.15
CD (0.05)		1.13	1.10	0.28	0.13	3.55	0.96	0.44

Table 6. continued

Treatments		Yield per plant (kg)	Yield per plot (kg)	Marketable yield per plot (kg)	Crop duration	Seeds per fruit	100 seed weight (g)
T1	Jannat	6.17	51.45	42.47	88.00	238.50	4.85
T2	Mannat	4.65	42.13	35.46	103.50	290.50	5.05
T3	Shabari	11.84	82.90	79.95	107.50	180.00	3.55
T4	Prachi	5.43	40.28	29.23	87.00	292.50	3.90
T5	Yellow Angel	3.94	31.06	25.72	114.00	250.50	3.45
T6	WHS-20011	4.00	36.83	32.50	105.50	301.50	4.30
T7	Yellow Queen	5.27	44.37	37.67	97.00	236.50	4.65
T8	Jolo gold	3.67	30.05	22.19	111.00	232.50	3.40
T9	Aarohi	4.83	36.61	28.72	95.00	180.50	4.60
T10	Vankat	6.39	51.40	42.20	101.50	269.50	3.70
T11	Yellow Lion	2.00	17.09	12.67	95.00	315.00	2.85
T12	Shonima	3.28	26.22	19.47	109.50	0.00	3.70
T13	Devyani	9.85	70.17	66.00	115.50	180.00	4.70
T14	Swarna	4.90	37.36	28.35	120.50	0.00	3.83
T15	Anmol	6.29	48.20	40.87	101.00	162.50	4.90
T16	Simran	7.08	54.16	42.78	96.50	211.00	3.47
T17	Saraswati (Check)	8.05	55.12	49.72	95.00	200.00	3.20
Mean		5.74	44.43	37.41	102.53	236.07	4.01
SEm (±)		0.35	0.82	0.75	5.22	4.20	0.13
CD (0.05)		1.06	2.46	2.26	15.65	12.74	0.39

Table 7. Mean performance of watermelon varieties for fruit and yield characters

Treatments		Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Rind thickness (cm)	Fruit weight (kg)	Days to first harvest	Node to first fruit	Fruits per plant
T18	Arka Manik	18.30	20.15	1.95	3.62	76.50	20.80	1.50
T19	Arka Muthu	15.90	16.50	1.45	2.58	63.50	17.40	2.00
T20	Arka Shyama	17.85	23.10	1.30	3.25	59.00	17.40	3.00
T21	Best of All	16.30	17.35	1.35	2.70	76.00	18.50	2.10
T22	Crimson Sweet	17.15	21.10	1.40	2.73	84.50	29.00	1.20
T23	Asahi Yamato	16.00	18.10	1.20	4.31	73.50	11.30	2.10
T24	Durgapura Meetha	23.05	24.45	1.65	4.76	107.50	20.60	1.30
T25	Durgapura Lal	24.05	26.30	1.55	4.17	85.00	25.90	2.10
T26	Durgapura Kesar	16.35	17.15	1.20	2.64	71.00	23.30	1.90
T27	AHW 65	19.00	27.80	1.65	3.34	77.00	20.70	1.50
T28	AHW 19	17.55	25.70	1.45	2.60	80.50	19.00	1.30
T29	Thar Manak	18.10	24.95	1.50	3.74	62.50	14.80	1.80
T30	Sugar Baby (Check)	19.50	22.05	2.10	4.67	74.50	21.90	1.30
Mean		18.39	21.90	1.52	3.47	76.23	20.05	1.78
SEm (±)		0.34	0.44	0.09	0.05	4.96	0.24	0.13
CD (0.05)		1.05	1.35	0.28	0.15	15.27	0.74	0.41

Table 7. continued

Treatments		Yield per plant (kg)	Yield per plot (kg)	Marketable yield per plot (kg)	Crop duration	Seeds per fruit	100 seed weight (g)
T18	Arka Manik	6.86	51.29	45.88	101.00	296.00	4.77
T19	Arka Muthu	5.15	41.64	35.20	89.00	269.50	3.54
T20	Arka Shyama	9.82	98.18	86.84	96.50	219.50	3.82
T21	Best of All	5.65	41.92	32.54	95.50	239.00	6.44
T22	Crimson Sweet	3.28	27.35	15.11	110.00	231.00	12.50
T23	Asahi Yamato	9.05	69.41	52.17	101.00	295.00	2.25
T24	Durgapura Meetha	6.19	47.00	35.09	109.50	487.50	4.65
T25	Durgapura Lal	8.76	60.54	39.68	122.00	464.50	6.15
T26	Durgapura Kesar	5.01	35.46	28.86	105.50	431.50	3.40
T27	AHW 65	5.38	40.58	23.91	95.50	388.00	10.05
T28	AHW 19	3.38	29.82	20.74	107.50	357.50	9.03
T29	Thar Manak	7.11	52.18	35.36	81.50	260.50	12.11
T30	Sugar Baby (Check)	6.06	50.46	38.79	98.00	491.50	4.93
Mean		6.28	49.68	37.70	100.96	340.85	6.43
SEm (±)		0.35	1.47	1.67	1.84	4.24	0.34
CD (0.05)		1.08	4.53	5.16	5.67	13.05	1.04

Among the varieties, the check Sugar Baby recorded the highest rind thickness of 2.10 cm which was on par with Arka Manik (1.95 cm). Asahi Yamato and Durgapura Kesar exhibited the lowest rind thickness of 1.20 cm.

4.2.2.4 Fruit weight (kg)

Significant difference was noticed among hybrids and check for the trait fruit weight with a range of 1.48 kg to 3.34 kg. In varieties, it ranged from 2.58 kg to 4.76 kg.

Hybrid Mannat exhibited the highest fruit weight of 3.34 kg. Lowest weight of 1.48 kg was observed in Yellow Lion. Six hybrids recorded lesser fruit weight than the general mean of 2.54 kg.

Among the varieties, the highest fruit weight was observed in Duragapura Meetha (4.76 kg) which was on par with the check Sugar Baby (4.67 kg). Lowest weight of 2.58 kg was recorded in Arka Muthu and was on par with AHW 19 (2.60 kg), Durgapura Kesar (2.64 kg), Best of All (2.70 kg) and Crimson Sweet (2.73 kg).

4.2.2.5 Days to first harvest

Lowest value is preferred. Among the hybrids and check, Prachi was the earliest to harvest (62.00 days) followed by Jannat (65.00 days). Swarna exhibited highest number of 93.50 days for first harvest. Seven hybrids were earlier to first harvest than the mean of 79.00 days.

Days to first harvest ranged from 59.00 days to 107.50 days in varieties. Arka Shyama (59.00 days) was earliest for first harvest which was on par with Thar Manak (62.50 days) and Arka Muthu (63.50 days). Duragapura Meetha (107.50 days) took highest number of days for first harvest.

4.2.2.6 Node to first fruit

There was a significant difference among the hybrids and varieties for node to first fruit. It ranged from 10.40 to 20.40 with an overall treatment mean of 12.86 in hybrids.

The lowest mean value for node to first fruit was recorded by Vankat (10.40) which was on par with Prachi (10.60), Yellow Angel (10.60), Yellow Queen (10.70) and Saraswati (10.70). The highest node order to first fruit was registered in Swarna (20.40).

Among varieties and check, node to first fruit ranged from 11.30 (Asahi Yamato) to 29.00 (Crimson Sweet) with a general mean of 20.05.

4.2.2.7 Fruits per plant

The number of fruits per plant ranged from 1.30 to 4.20 with a mean of 2.29 in hybrids. Shabari recorded the highest number followed by Prachi (3.30). The lowest number was observed in Yellow Lion. Eight hybrids had higher number of fruits per plant than the general mean of 2.29.

In varieties, the average number of fruits per plant was 1.78, with a range of 1.20 to 3.00. The highest number of 3.00 fruits per plant was recorded in Arka Shyama, while lowest in Crimson Sweet (1.20).

4.2.2.8 Yield per plant

The hybrids and varieties differed significantly for yield per plant. Shabari recorded the highest yield of 11.80 kg per plant followed by Devyani (9.85 kg) and the check, Saraswati (8.05 kg). Lowest yield per plant was observed in Yellow Lion (2.00 kg).

The variety Arka Shyama produced the highest yield per plant (9.82 kg) which was on par with Asahi Yamato (9.05 kg) and Durgapura Lal (8.76 kg). The lowest yield was registered in Crimson Sweet (3.28 kg) and was on par with AHW 19 (3.38 kg).

4.2.2.9 Yield per plot

The average yield per plot of hybrids ranged from 17.09 kg to 82.90 kg with a mean of 44.43 kg. The highest yield per plot of was observed in Shabari (82.90 kg) and lowest in Yellow Lion.

Among the varieties and check, Arka Shyama (98.18 kg) produced the highest yield per plant and Crimson Sweet (27.35 kg) recorded the lowest.

4.2.2.10 Marketable yield per plot

Among the hybrids and check, the highest marketable yield per plot of 79.95 kg was recorded by Shabari and the lowest by Yellow Lion (12.67 kg). The mean marketable yield per plot was 37.41 kg with nine hybrids having more yields per plot than the mean.

The marketable yield per plot of varieties ranged from 15.11 kg to 86.84 kg with a mean of 37.70 kg. The highest marketable yield per plot was recorded by Arka Shyama and the lowest by Crimson Sweet.

4.2.2.11 Crop duration

Duration of the crop differed significantly among the hybrids and it ranged from 87.00 days to 120.50 days with a mean of 102.53 days. The highest crop duration was observed in Swarna, while Prachi recorded the lowest.

Among the varieties crop duration ranged from 81.50 days in Thar Manak to 122.00 days in Durgapura Lal. The average crop duration was 100.96 days.

4.2.2.12 Seeds per fruit

The number seeds per fruit showed a significance difference among the hybrids and varieties. The number of seeds per fruit in hybrids varied from 00.00 to 315.00 with a mean of 236.07. The highest number of seeds were found in Yellow Lion (315.00), while Shonima and Swarna were seedless.

In varieties, the lowest number of seeds was observed in Arka Shyama (219.50). Sugar baby recorded the highest number of seeds (491.50) followed by Durgapura Meetha (487.50).

4.1.2.13 100 seed weight

Mannat exhibited the highest 100 seed weight of 5.05 g which was on par with

Anmol (4.90 g), Jannat (4.85 g) and Devyani (4.70 g). The lowest weight of 2.85 g was observed in Yellow Lion.

Among the varieties, Crimson Sweet recorded the highest 100 seed weight (12.50 g) which was on par with Thar Manak (12.11 g). Lowest weight was recorded in Asahi Yamato (2.25 g).

4.2.3 Quality Characters

Mean values for quality characters like total soluble solids (TSS), lycopene, ascorbic acid, reducing sugars and non reducing sugars of hybrids and varieties are presented in Table 8 and Table 9 respectively.

4.2.3.1 TSS

Total soluble solids (TSS) content varied among different hybrids and varieties. The highest TSS content was observed in the check Saraswati (12.25 ^{0}B) which was on par with Shabari (11.50 ^{0}B) and the lowest in WHS-20011 (6.75 ^{0}B).

In varieties, the TSS content ranged from 7.35 ^{0}B in Durgapur Kesar to 12.65 ^{0}B in Arka Shyama. Six varieties exhibited higher TSS values than the average of 9.64 ^{0}B.

4.2.3.2 Lycopene

Significant difference was noticed among hybrids for lycopene content. The range varied from 0.54 mg 100 g^{-1} to 7.61 mg 100 g^{-1} with a mean of 3.50 mg 100 g^{-1}. The highest lycopene content was observed in Mannat and lowest in Jolo Gold.

Lycopene content in varieties varied from 2.77 mg 100 g^{-1} in Durgapura Kesar to 6.40 mg 100 g^{-1} in Arka Shyama.

4.2.3.3 Ascorbic acid

Among the hybrids and check, Prachi recorded the highest ascorbic acid content of 6.35 mg 100 g^{-1} and the lowest by Yellow Lion (2.76 mg 100 g^{-1}).

Table 8. Mean performance of watermelon hybrids for quality characters

Treatments		TSS (°Brix)	Lycopene (mg 100 g^{-1})	Ascorbic acid (mg 100 g^{-1})	Reducing sugar (%)	Non reducing sugar (%)
T1	Jannat	9.25	5.76	5.84	3.05	3.75
T2	Mannat	9.75	7.61	3.05	2.96	3.36
T3	Shabari	11.50	6.39	5.29	3.23	3.68
T4	Prachi	11.25	6.18	6.35	3.12	3.41
T5	Yellow Angel	8.25	0.70	3.44	2.40	3.32
T6	WHS-20011	6.75	3.53	4.23	2.38	3.38
T7	Yellow Queen	9.25	0.67	3.49	2.81	3.31
T8	Jolo gold	9.60	0.54	4.40	2.80	3.30
T9	Aarohi	6.85	0.71	4.18	2.87	3.72
T10	Vankat	8.50	5.37	3.53	2.55	3.45
T11	Yellow Lion	7.25	4.29	2.76	2.48	3.30
T12	Shonima	8.25	4.45	3.66	2.96	3.17
T13	Devyani	8.75	0.80	4.51	2.32	3.39
T14	Swarna	7.25	0.75	3.27	2.64	3.24
T15	Anmol	8.15	0.89	5.56	2.80	3.74
T16	Simran	9.00	3.70	3.19	3.09	3.72
T17	Saraswati (Check)	12.25	7.27	5.42	2.96	3.48
Mean		8.93	3.50	4.24	2.79	3.45
SEm (±)		0.29	0.11	0.12	0.08	0.06
CD (0.05)		0.88	0.33	0.37	0.24	0.18

Table 9. Mean performance of watermelon varieties for quality characters

Treatments		TSS(°Brix)	Lycopene (mg 100 g^{-1})	Ascorbic acid (mg 100 g^{-1})	Reducing sugar (%)	Non reducing sugar (%)
T18	Arka Manik	11.25	5.28	3.23	3.23	3.85
T19	Arka Muthu	10.15	6.34	4.19	2.67	3.59
T20	Arka Shyama	12.65	6.40	5.10	3.09	3.30
T21	Best of All	8.50	4.29	4.35	2.35	3.32
T22	Crimson Sweet	8.25	3.49	3.04	2.57	3.10
T23	Asahi Yamato	11.75	3.47	4.63	2.82	3.13
T24	Durgapura Meetha	8.70	3.69	3.18	2.43	3.14
T25	Durgapura Lal	11.50	5.00	3.49	2.34	3.12
T26	Durgapura Kesar	7.35	2.77	3.10	2.99	3.12
T27	AHW 65	8.00	3.88	3.25	2.96	3.12
T28	AHW 19	8.45	3.47	3.49	2.59	3.32
T29	Thar Manak	9.00	5.48	3.59	2.80	3.28
T30	Sugar Baby (Check)	9.75	4.43	3.80	3.02	3.38
Mean		9.64	4.46	3.72	2.76	3.29
SEm (±)		0.27	0.13	0.10	0.09	0.09
CD (0.05)		0.83	0.41	0.31	0.27	0.27

In varieties, the ascorbic acid content was highest in Arka Shyama (5.10 mg 100 g^{-1}) and Crimson Sweet recorded the lowest ascorbic acid content of 3.04 mg 100 g^{-1}. The check variety Sugar Baby (3.80 mg 100 g^{-1}) recorded higher ascorbic content than the general mean of 3.72 mg 100 g^{-1}.

4.2.3.4 Reducing sugar

The reducing sugar content of hybrids ranged from 2.32 per cent to 3.23 per cent with a mean of 2.79 per cent. The highest content was observed in Shabari and the lowest in Devyani.

Among the varieties, Arka Manik had the highest reducing sugar content of 3.23 per cent which was on par with Arka Shyama (3.09 per cent), Sugar Baby (3.02 per cent), Durgapura Kesar (2.99 per cent) and AHW 65 (2.96 per cent). The lowest content was noticed in Durgapura Lal (2.34 per cent).

4.2.3.5 Non reducing sugar

The highest content of non reducing sugar in hybrids was observed in Jannat (3.75 per cent) which was on par with Anmol (3.74 per cent), Aarohi (3.72 per cent) and Shabari (3.68 per cent). The lowest value was recorded in Shonima (3.17 per cent).

Among the varieties and check, the highest non reducing sugar content was recorded by Arka Manik (3.85 per cent) followed by Arka Muthu (3.59 per cent) which were on par and the lowest by Crimson Sweet (3.10 per cent).

4.3 EVALUATION OF SENSORY PARAMETERS OF WATERMELON GENOTYPES

Sensory parameters *viz.*, appearance, colour, flavour, taste, texture and overall acceptability were statistically analysed using Kruskal - Wallis test and was observed that both the hybrids and varieties showed significant difference in organoleptic qualities and acceptability (Table10 and Table 11). Among watermelon hybrids and check, Shabari recorded the highest mean score for appearance, colour, flavour, taste, texture and overall acceptability. The check Saraswati and Jannat ranked second and third in appearance and colour. But for parameters flavour, taste and texture, the check Saraswati and Prachi ranked second and third. Regarding overall acceptability, the highest mean score was recorded by Shabari (9.20) followed by the check Saraswati (9.10) and Prachi (8.50).

Among the varieties and check, Arka Shyama recorded the highest mean score for all the sensory parameters. The varieties Arka Muthu and Best of All ranked second and third for appearance and colour. But for the parameters flavour, taste and texture, the check Sugar Baby and Arka Muthu ranked second and third. Regarding overall acceptability, the highest mean score was recorded by Arka Shyama (9.00) followed by the check Sugar Baby (8.70) and Arka Muthu (8.30).

4.4 PEST AND DISEASE INCIDENCE

Throughout the cropping season, the crop was monitored for the incidence of pests and diseases (Plate 3 and 4 respectively). Incidence of pumpkin caterpiller [*Diaphania indica* (Saunders)] was detected during the initial stage of crop development, and Flubendiamide 39.35 SC (Fame) @ 0.1ml l^{-1} was sprayed to control the pest.

Among the hybrids and the varieties, incidence of Fusarium wilt (*Fusarium oxysporum* f. sp. *niveum*) was detected. Percentage Disease Index (PDI) was calculated and presented in Table 12 and 13 respectively. Among the hybrids evaluated, nine showed incidence of Fusarium wilt and the PDI ranged from 12.50 per cent (Mannat) to 55.00 per cent (Yellow Queen).

Among the varieties evaluated, 8 showed incidence of the disease, while 5 were free from Fusarium wilt. The range of PDI was between 12.50 per cent (Arka Muthu) and 37.50 per cent (Best of All).

4.5 GENETIC VARIABILITY PARAMETERS

The genetic parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance of seventeen hybrids and thirteen varieties were studied. The population means, range, GCV, PCV,

Table10. Evaluation of sensory parameters of watermelon hybrids

Genotypes		Sensory parameters					
		Appearance		Colour		Flavour	
		Mean score	Rank	Mean score	Rank	Mean score	Rank
T1	Jannat	8.7	3	8.6	3	8.2	4
T2	Mannat	8.0	5	7.8	5	7.9	5
T3	Shabari	9.2	1	9.1	1	9.0	1
T4	Prachi	8.4	4	8.3	4	8.4	3
T5	Yellow Angel	7.3	6	7.6	6	7.4	6
T6	WHS-20011	4.0	17	4.0	15	4.1	17
T7	Yellow Queen	5.2	12	5.2	11	5.5	12
T8	Jolo Gold	4.8	13	5.4	10	5.2	13
T9	Aarohi	4.4	16	4.5	13	5.0	14
T10	Vankat	6.2	10	5.7	9	5.8	11
T11	Yellow Lion	4.1	15	4.0	15	4.4	16
T12	Shonima	5.7	11	5.1	12	5.9	10
T13	Devyani	7.1	8	6.5	8	7.2	8
T14	Swarna	4.2	14	4.3	14	4.8	15
T15	Anmol	7.0	9	7.1	7	6.9	9
T16	Simran	7.7	6	7.2	6	7.3	7
T17	Saraswati (Check)	8.9	2	9.0	2	8.8	2
Chi square (KW test)		156.00**		149.59**		155.54**	

** Significant at 1 per cent level

Table.10 continued

Genotypes		Sensory parameters					
		Taste		Texture		Overall acceptability	
		Mean score	Rank	Mean score	Rank	Mean score	Rank
T1	Jannat	8.2	4	8.2	4	8.2	4
T2	Mannat	7.8	5	8.1	5	7.7	5
T3	Shabari	9.6	1	9.2	1	9.2	1
T4	Prachi	8.7	3	8.4	3	8.5	3
T5	Yellow Angel	6.6	9	8	6	7.4	6
T6	WHS-20011	4.0	17	4.0	17	4.0	16
T7	Yellow Queen	5.2	12	5.2	12	5.2	11
T8	Jolo Gold	4.8	13	5.0	13	4.9	12
T9	Aarohi	4.3	14	4.7	14	4.7	13
T10	Vankat	6.2	10	5.5	11	5.8	9
T11	Yellow Lion	4.1	16	4.1	16	4.1	15
T12	Shonima	5.7	11	5.8	10	5.7	10
T13	Devyani	7.5	6	7.4	9	6.8	8
T14	Swarna	4.2	15	4.2	15	4.3	14
T15	Anmol	7.2	8	7.3	8	7.2	7
T16	Simran	7.3	7	6.3	7	7.5	6
T17	Saraswati (Check)	9.3	2	9.1	2	9.1	2
Chi square (KW test)		143.03**		148.17**		159.17**	

** Significant at 1 per cent level

Table 11. Evaluation of sensory parameters of watermelon varieties

Genotypes		Sensory parameters					
		Appearance		Colour		Flavour	
		Mean score	Rank	Mean score	Rank	Mean score	Rank
T18	Arka Manik	7.8	5	7.5	5	7.7	5
T19	Arka Muthu	8.6	2	8.7	2	8.2	3
T20	Arka Shyama	8.9	1	9.1	1	8.4	1
T21	Best of All	8.4	3	8.2	3	6.6	7
T22	Crimson Sweet	5.5	10	5.4	10	5.2	10
T23	Asahi Yamato	7.3	6	7.3	6	7.2	6
T24	Durgapura Meetha	5.9	9	4.6	13	4.9	12
T25	Durgapura Lal	6.9	7	6.3	7	8.0	4
T26	Durgapura Kesar	5.3	11	5.7	9	5.8	8
T27	AHW 65	6.6	8	6.2	8	5.5	9
T28	AHW 19	5.0	12	4.9	12	5.0	11
T29	Thar Manak	4.8	13	5.0	13	4.7	13
T30	Sugar Baby (Check)	8.1	4	7.7	4	8.3	2
Chi square (KW test)		112.87**		89.00**		112.53**	

** Significant at 1 per cent level

Table.11 continued

Genotypes		Sensory parameters					
		Taste		Texture		Overall acceptability	
		Mean score	Rank	Mean score	Rank	Mean score	Rank
T18	Arka Manik	7.5	5	7.8	4	7.7	5
T19	Arka Muthu	8.3	3	8.0	3	8.3	3
T20	Arka Shyama	9.1	1	8.8	1	9.0	1
T21	Best of All	8.0	4	7.4	5	7.8	4
T22	Crimson Sweet	5.4	10	5.0	11	5.4	9
T23	Asahi Yamato	7.1	6	7.0	6	7.3	6
T24	Durgapura Meetha	5.0	12	5.1	10	5.0	10
T25	Durgapura Lal	6.8	8	6.6	8	6.9	7
T26	Durgapura Kesar	5.9	9	5.5	9	5.7	9
T27	AHW 65	7.0	7	6.9	7	6.8	8
T28	AHW 19	5.2	11	4.8	12	4.8	11
T29	Thar Manak	4.7	13	4.4	13	4.6	12
T30	Sugar Baby (Check)	8.7	2	8.6	2	8.7	2
Chi square (KW test)		109.83**		113.19**		111.13**	

** Significant at 1 per cent level

Pumpkin caterpillar and its feeding symptom

Red pumpkin beetle

Plate 3. Incidence of pests

Fusarium wilt

Plate 4. Incidence of disease

Table 12. Intensity of fusarium wilt among watermelon hybrids

Treatments		Percentage Disease Index
T1	Jannat	0.00
T2	Mannat	12.50
T3	Shabari	0.00
T4	Prachi	0.00
T5	Yellow Angel	17.50
T6	WHS-20011	35.00
T7	Yellow Queen	55.00
T8	Jolo Gold	0.00
T9	Sarswati	0.00
T10	Aarohi	0.00
T11	Vankat	22.50
T12	Yellow Lion	42.50
T13	Shonima	32.5
T14	Devayani	15.00
T15	Swarna	12.50
T16	Anmol	22.50
T17	Simran	0.00

Table 13. Intensity of fusarium wilt among watermelon varieties

Treatments		Percentage Disease Index
T18	Arka Manik	0.00
T19	Arka Muthu	12.50
T20	Arka Shyama	0.00
T21	Best of All	37.50
T22	Crimson Sweet	32.50
T23	Asahi Yamato	20.00
T24	Durgapura Meetha	22.50
T25	Durgapura Lal	0.00
T26	Durgapura Kesar	32.50
T27	AHW 65	25.00
T28	AHW 19	17.50
T29	Thar Manak	0.00
T30	Sugar Baby	0.00

heritability and genetic advance of hybrids and varieties are presented in Table 14, Fig. 2 and Table 15, Fig. 3 respectively.

4.5.1 Vegetative and Flowering Characters

4.5.1.1 Hybrids

Vine Length exhibited high PCV (22.69) and GCV (22.18) with high estimates of heritability (95.48 per cent) and genetic advance (44.64). High PCV and GCV values (31.88 and 31.29 respectively) coupled with high heritability (96.32 per cent) and high genetic advance (63.25) were recorded for number of branches per vine.

Internodal length exhibited high PCV and GCV (22.26 and 21.72 respectively) with high heritability (95.12 per cent) and genetic advance (43.63).

A low PCV of 7.20 and GCV of 6.22 were recorded for days to first male flower. A high heritability of 74.58 percent and moderate genetic advance of 11.06 percent were noticed.

The PCV and GCV estimates were low (5.54 and 4.59 respectively) for days to first female flower. The estimate of heritability (68.62 per cent) was high with low genetic advance (7.83).

High PCV and GCV values (25.67 and 25.18 respectively) coupled with high heritability (96.19 per cent) and high genetic advance (50.87) was evident for node to first male flower.

Node to first female flower exhibited high PCV (24.47) and GCV (24.33) values with high heritability (98.86 per cent) as well as genetic advance (49.83).

4.5.1.2 Varieties

High PCV and GCV values (24.14 and 23.96 respectively) coupled with high heritability (98.52 per cent) and high genetic advance (48.99) were noted for vine length.

Number of branches per vine exhibited high PCV (21.17) and GCV (20.50) with high estimates of heritability (93.78 per cent) and genetic advance (40.89).

High PCV and GCV (25.68 and 25.50 respectively) along with high heritability (98.62 per cent) and genetic advance (52.17) were recorded for internodal length.

Moderate estimate of PCV (13.88) and GCV (13.71) were observed for days to first male flower. This trait also exhibited high heritability (97.53 per cent) and high genetic advance (27.88).

Days to first female flower exhibited a moderate PCV (13.02) and GCV (12.84) with high estimates of heritability (97.34 per cent) and high genetic advance (26.10).

High PCV (28.82) and GCV (28.55) coupled with high heritability of 98.11 per cent and high genetic advance (58.25) was recorded for node to first male flower.

Node to first female flower exhibited a high PCV (27.11) and GCV (26.82) with high heritability of 97.89 per cent and high genetic advance (54.66).

4.5.2 Fruit and Yield Characters

4.5.2.1 Hybrids

Moderate PCV and low GCV were recorded (10.25 and 9.64 respectively) with high heritability (88.46 per cent) and moderate genetic advance (18.67) for fruit equatorial diameter.

PCV and GCV were moderate for fruit polar diameter (16.33 and 16.14 respectively) with high heritability (97.67 per cent) and high genetic advance (32.85).

Rind thickness exhibited high PCV (36.44) and GCV (35.05) along with high heritability (92.53 per cent) and genetic advance (69.46).

Moderate PCV of 19.78 and GCV of 19.65 were recorded for fruit weight with high estimates of heritability (98.62 per cent) and genetic advance (40.19).

Table 14. Estimates of genetic parameters for various characters in watermelon hybrids

Characters	Range	Mean	PCV	GCV	Heritability (%)	Genetic Advance	GA as per cent of mean
Vine length	2.84-5.99	3.62	22.69	22.18	95.48	1.61	44.64
Number of branches per vine	5.50-16.84	9.82	31.88	31.29	96.32	6.21	63.25
Internodal length	5.25-12.95	8.43	22.26	21.72	95.12	3.68	43.63
Days to first male flower	31.40-40.20	35.78	7.20	6.22	74.58	3.96	11.06
Days to first female flower	37.70-43.90	40.58	5.54	4.59	68.62	3.18	7.83
Node to first male flower	3.20-7.50	4.46	25.67	25.18	96.19	2.27	50.87
Node to first female flower	8.00-16.70	11.27	24.47	24.33	98.86	5.61	49.83
Fruit equatorial diameter	12.85-17.60	15.32	10.25	9.64	88.46	2.86	18.67
Fruit polar diameter	15.70-28.75	20.73	16.33	16.14	97.67	6.81	32.85
Rind thickness	0.35-2.15	1.31	36.44	35.05	92.53	0.91	69.46
Fruit weight	1.48-3.34	2.54	19.78	19.65	98.62	1.02	40.19
Days to first harvest	62.00-93.50	79.00	11.78	11.59	96.77	18.55	23.48
Node to first fruit	10.40-20.40	12.86	22.78	22.51	97.61	5.89	45.82
Fruits per plant	1.30-4.20	2.29	36.93	35.79	93.94	1.63	71.46
Yield per plant	2.00-11.84	5.74	43.05	42.15	95.90	4.88	85.04
Yield per plot	17.09-82.90	44.43	36.16	36.06	99.48	32.92	74.10
Marketable yield per plot	12.67-79.95	37.41	44.49	44.4	99.59	34.14	91.28
Crop duration	87 -120.50	102.53	10.65	7.84	54.25	12.20	11.90
Seeds per fruit	0.0-315	236.07	21.17	21.02	98.59	101.50	43.00
100 Seed weight	2.85-5.05	4.01	17.22	16.58	92.73	1.32	32.90
TSS	6.75-12.25	8.93	18.18	17.57	93.41	3.13	34.99
Lycopene	0.54-7.61	3.50	75.21	75.08	99.66	5.41	92.50
Ascorbic acid	2.76-6.35	4.24	25.87	25.54	97.47	2.20	51.95
Reducing sugar	2.32-3.23	2.79	10.50	9.70	85.45	0.52	18.46
Non reducing sugar	3.17-3.75	3.45	5.88	5.31	81.59	0.34	9.88

Table 15. Estimates of genetic parameters for various characters in watermelon varieties

Characters	Range	Mean	PCV	GCV	Heritability (%)	Genetic Advance	GA as per cent of mean
Vine length	1.40-5.18	3.76	24.14	23.96	98.52	1.84	48.99
Number of branches per vine	2.84-7.50	5.98	21.17	20.50	93.78	2.44	40.89
Internodal length	3.30-9.77	6.98	25.68	25.50	98.62	3.64	52.17
Days to first male flower	29.90-51.50	38.24	13.88	13.71	97.53	10.66	27.88
Days to first female flower	35.80-60.60	47.45	13.02	12.84	97.34	12.38	26.10
Node to first male flower	3.30-10.30	7.08	28.82	28.55	98.11	4.12	58.25
Node to first female flower	10.40-28.20	17.31	27.11	26.82	97.89	9.46	54.66
Fruit equatorial diameter	15.90-24.05	18.39	14.02	13.78	96.50	5.13	27.88
Fruit polar diameter	16.50-27.80	21.90	17.62	17.40	97.43	7.75	35.37
Rind thickness	1.20-2.10	1.52	18.66	16.57	78.87	0.46	30.32
Fruit weight	2.58-4.76	3.47	23.35	23.27	99.28	1.66	47.76
Days to first harvest	59-107.50	76.23	17.45	14.82	72.22	19.78	25.95
Node to first fruit	11.30-29	20.05	22.86	22.80	99.45	9.39	46.83
Fruits per plant	1.20-3.00	1.78	29.31	27.33	86.96	0.93	52.51
Yield per plant	3.28-9.82	6.28	32.65	31.68	94.13	3.98	63.32
Yield per plot	27.35-98.18	49.68	37.68	37.45	98.76	38.09	76.67
Marketable yield per plot	15.11-86.84	37.70	47.46	47.04	98.25	36.21	96.05
Crop duration	81.50-122	100.96	10.35	10.03	93.81	20.20	20.01
Seeds per fruit	219.50-491.50	340.85	29.73	29.69	99.65	208.04	61.04
100 Seed weight	2.25-12.50	6.43	53.18	52.66	98.06	6.91	97.19
TSS	7.35-12.65	9.64	17.61	17.16	94.98	3.32	34.46
Lycopene	2.77-6.40	4.46	26.11	25.77	97.37	2.34	52.38
Ascorbic acid	3.04-5.10	3.72	17.67	17.26	95.43	1.29	34.73
Reducing sugar	2.34-3.23	2.76	11.10	10.13	83.26	0.53	19.04
Non reducing sugar	3.10-3.85	3.29	7.24	6.17	72.76	0.36	10.85

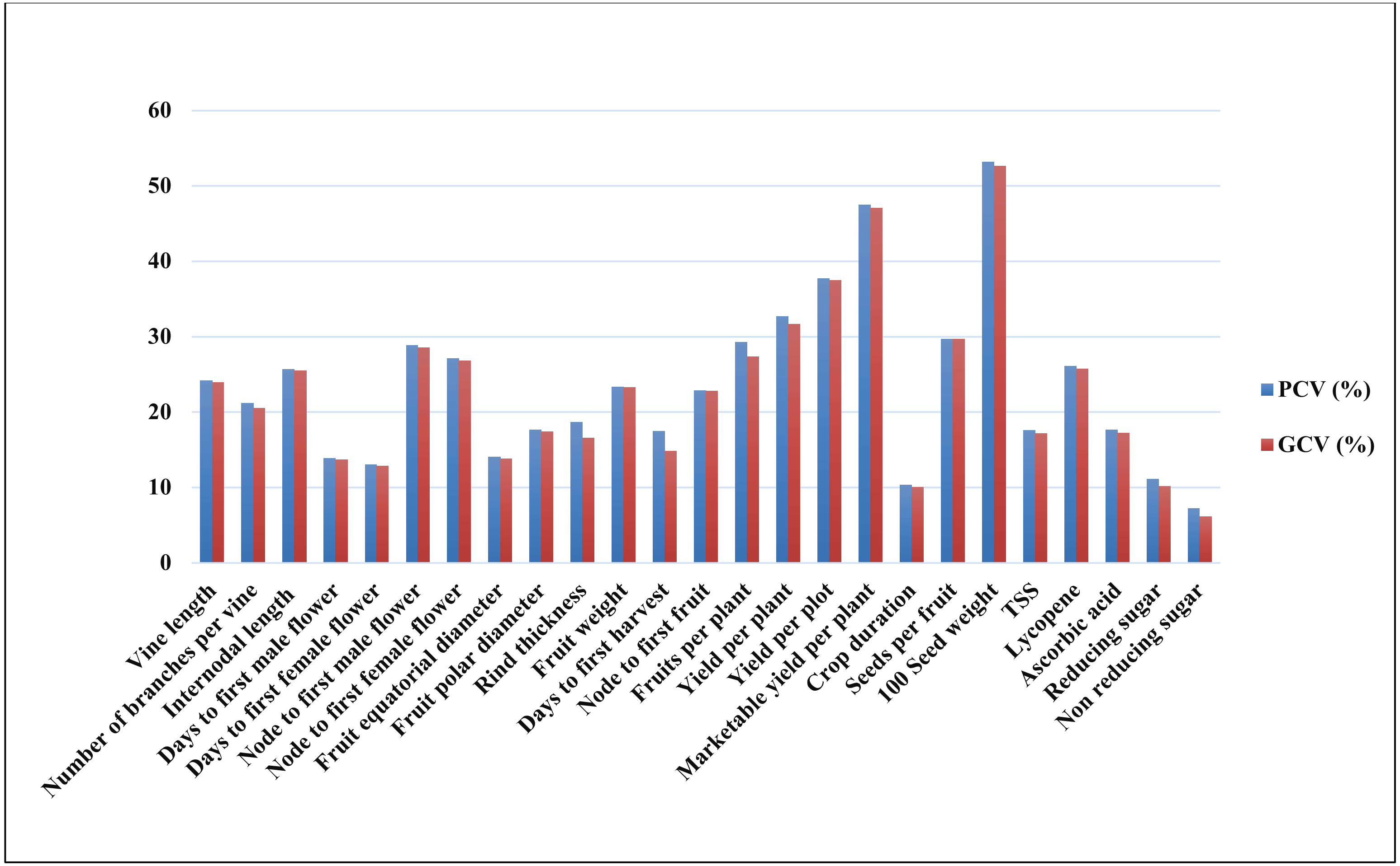


Fig. 2. Phenotypic and genotypic coefficients of variation for twenty five characters in watermelon hybrids

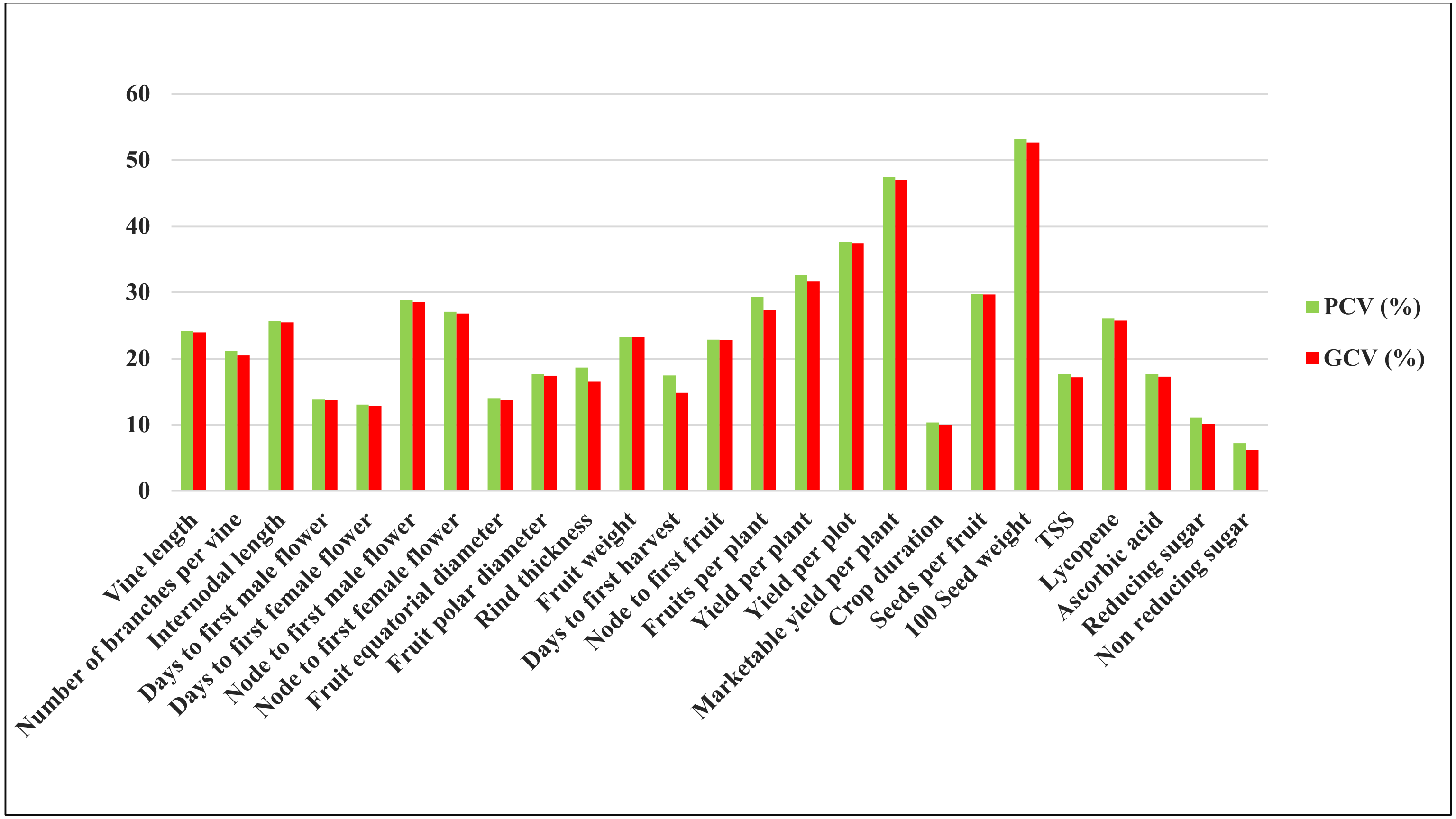


Fig. 3. Phenotypic and genotypic coefficients of variation for twenty five characters in watermelon varieties

Days to first harvest exhibited moderate PCV and GCV (11.78 and 11.59 respectively) along with high heritability (96.77 per cent) and high genetic advance (23.48).

High PCV and GCV values (22.78 and 22.51 respectively) coupled with high heritability (97.61 per cent) and high genetic advance (45.82) were noted for node to first fruit.

High estimate of PCV (36.93) and GCV (35.79) were recorded for fruits per plant. This trait also exhibited high heritability (93.94 per cent) and high genetic advance (71.46).

Yield per plant exhibited high PCV (43.05) and GCV (42.15) values with high heritability (95.90 per cent) and high genetic advance (85.04).

High estimate of PCV (36.16) and GCV (36.06) were recorded for the trait yield per plot. This trait also exhibited high heritability (99.48 per cent) and high genetic advance (74.10).

The estimates of PCV (44.49) and GCV (44.40) were high for marketable yield per plot along with high estimates of heritability (99.59 per cent) and genetic advance (91.28).

A moderate PCV (10.65) and low GCV (7.84) were noticed along with medium heritability (54.25 per cent) and moderate genetic advance (11.90) for crop duration.

Seeds per fruit exhibited a high PCV (21.17) and GCV (21.02) coupled with high heritability (98.59) and genetic advance (43.00).

A moderate PCV (17.22) and GCV (16.58) were recorded along with high heritability (92.73) and high genetic advance (32.90) for 100 seed weight.

4.5.2.2 Varieties

Fruit equatorial diameter exhibited moderate PCV (14.02) and GCV (13.78) with high estimates of heritability (96.50 per cent) and genetic advance (27.88).

Moderate PCV and GCV (17.62 and 17.40 respectively) coupled with higher heritability (97.43per cent) and genetic advance (35.37) was expressed for fruit polar diameter.

The estimates of PCV (18.66) and GCV (16.57) were moderate for rind thickness. High heritability (78.87 per cent) and genetic advance (30.32) were also recorded.

High PCV (23.35) and GCV (23.27) were observed with high heritability (99.28 per cent) and high genetic advance as per cent of mean (47.76) for fruit weight.

A moderate PCV (17.45) and GCV (14.82) was recorded along with high heritability (72.22per cent) and high genetic advance (25.95) for days to first harvest.

Node to first fruit exhibited high PCV (22.86) and GCV (22.80) values with high heritability (99.45 per cent) as well as high genetic advance estimates (46.83).

The estimates of PCV (29.31) and GCV (27.33) were high for number of fruits per plant. High heritability (89.96 per cent) and genetic advance (52.51) were also recorded.

Yield per plant recorded high PCV and GCV values (32.65 and 31.68 respectively) coupled with high heritability (94.13 per cent) and high genetic advance (63.32).

High PCV and GCV (37.68 and 37.45 respectively) with high heritability (98.76 per cent) and genetic advance (76.67) were noted for yield per plot.

Marketable yield per plot showed high values for PCV (47.46) and GCV (47.04) along with high heritability (98.25 per cent) and genetic advance (96.05) estimates.

A moderate PCV (10.35) and GCV (10.03) were recorded along with high heritability (93.81 per cent) and high genetic advance (20.01) for crop duration.

For seeds per fruit, high PCV of 29.73 and GCV of 29.69 were recorded. The estimate of heritability (99.65 per cent) was high with high genetic advance (61.04).

The PCV and GCV estimates were high (53.18 and 52.66 respectively) for 100 seed weight. A high heritability of 98.06 percent and a high genetic advance of 97.19 was observed.

4.5.3 Quality characters

4.5.3.1 Hybrids

Moderate PCV and GCV values (18.18 and 17.57) coupled with high heritability (93.41 per cent) and moderate genetic advance (34.99) were recorded for TSS of the fruit.

Lycopene content of the fruit showed high values for PCV (75.21) and GCV (75.08) along with high heritability (99.66 per cent) and genetic advance (92.50).

High PCV and GCV (25.87 and 25.54 respectively) along with high heritability (97.47 per cent) and genetic advance (51.95) were expressed for ascorbic acid content of the fruit.

Moderate PCV (10.50) and low GCV (9.70) coupled with high heritability (85.45 per cent) and moderate genetic advance (18.46) were evident for reducing sugar.

Low PCV (5.88) and GCV (5.31) values along with high heritability (81.59 per cent) and low genetic advance (9.88) were recorded for non reducing sugars.

4.5.3.2 Varieties

Moderate PCV and GCV values (17.61 and 17.16 respectively) with high heritability (94.98 per cent) and high genetic advance (34.46) were noted for TSS.

Lycopene content of the fruits exhibited high PCV (26.11) and GCV (25.77) values with high heritability (97.37 per cent) as well as high genetic advance estimates (52.38).

Moderate estimate of PCV (17.67) and GCV (17.26) were noted for Ascorbic acid content. This trait also exhibited high heritability (95.43 per cent) and high genetic advance (34.73).

Reducing sugar exhibited moderate PCV (11.10) and GCV (10.13) values with high heritability (83.26 per cent) and moderate genetic advance estimates (19.04).

Low PCV and GCV values (7.24 and 6.17 respectively) with high heritability (72.76 per cent) and moderate genetic advance (10.85) were recorded for non reducing sugar.

4.6 CORRELATION ANALYSIS

Genotypic and phenotypic correlation coefficients between yield and yield compo nents and interrelationship among the traits of hybrids were computed and are presented in Table 16 and Table 18 respectively. Genotypic and phenotypic correlation coefficients between yield and yield components of varieties are presented in Table 17 and Table 19.

4.6.1 Genotypic Correlation

4.6.1.1 Hybrids

Fruit yield per plant had significant positive association at genotypic level with fruits per plant (0.891), fruit equatorial diameter (0.707) and fruit weight (0.445). Vine length (-0.160), days to first harvest (-0.074) and seeds per fruit (-0.112) had negative but non significant correlation with yield.

Vine length had a significant positive genotypic correlation with days to first female flower (0.577), node to first female flower (0.564) and days to first harvest (0.376). While, fruit polar diameter (-0.455), fruit weight (-0.372) and seeds per fruit (-0.598) showed negative significant relationship with yield.

The days to first female flower exhibited significant positive genotypic correlation with days to first harvest (0.859), node to first female flower (0.803), vine length (0.577) and fruit equatorial diameter (0.536) while, it had a significant negative correlation with seeds per fruit (-0.713).

The node at which first female flower appeared was positively correlated with days to first female flower (0.803), days to first harvest (0.589), vine length (0.564) and fruit equatorial diameter (0.425). While, it exhibited negative significant genotypic correlation with seeds per fruit (-0.808).

Table 16. Genotypic correlation coefficients between yield and yield components of hybrids

Characters	Vine length	Days to first female flower	Node to first female flower	Fruit equatorial diameter	Fruit polar diameter	Fruit weight	Days to first harvest	Fruits per plant	Seeds per fruit	Weight of 100 seeds	Yield per plant
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1.000	0.577**	0.564**	0.078	-0.455**	-0.372*	0.376*	-0.093	-0.598**	-0.245	-0.160
X2		1.000	0.803**	0.536**	-0.305	0.055	0.859**	0.145	-0.713**	0.031	0.239
X3			1.000	0.425*	-0.328	0.197	0.589**	-0.022	-0.808**	-0.005	0.134
X4				1.000	-0.311	0.350*	0.221	0.589**	-0.385*	0.466**	0.707**
X5					1.000	0.524**	0.101	-0.122	0.438**	0.163	0.100
X6						1.000	0.278	0.042	-0.055	0.564**	0.445**
X7							1.000	-0.261	-0.475**	0.096	-0.074
X8								1.000	-0.033	-0.058	0.891**
X9									1.000	0.012	-0.112
X10										1.000	0.128
X11											1.000

*Significant at 5 per cent level   ** Significant at 1 per cent level

Table 17. Genotypic correlation coefficients between yield and yield components of varieties

Characters	Vine length	Days to first female flower	Node to first female flower	Fruit equatorial diameter	Fruit polar diameter	Fruit weight	Days to first harvest	Fruits per plant	Seeds per fruit	Weight of 100 seeds	Yield per plant
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1.000	0.380	0.515**	0.330	0.508**	0.085	0.551**	-0.348	0.300	0.353	-0.214
X2		1.000	0.354	0.518**	0.038	0.321	0.903**	-0.496*	0.573**	-0.083	-0.237
X3			1.000	0.268	0.195	-0.211	0.469*	-0.420*	0.219	0.348	-0.530**
X4				1.000	0.669**	0.668**	0.659**	-0.196	0.687**	0.035	0.286
X5					1.000	0.339	0.318	-0.244	0.357	0.537**	0.083
X6						1.000	0.408*	-0.131	0.554**	-0.248	0.554**
X7							1.000	-0.635**	0.563**	0.079	-0.279
X8								1.000	-0.422*	-0.471*	0.723**
X9									1.000	-0.223	-0.049
X10										1.000	-0.488*
X11											1.000

*Significant at 5 per cent level   ** Significant at 1 per cent level

Fruit equatorial diameter manifested a significant positive relationship with yield per plant (0.707), fruits per plant (0.589), days to first female flower (0.536), 100 seeds weight (0.466), node to first female flower (0.425) and fruit weight (0.350) at genotypic level. But a negative significant relationship with seeds per fruit (-0.385).

Polar diameter of fruit showed a significant positive correlation with fruit weight (0.524) and seeds per fruit (0.438). While, it showed negative significant relation with vine length (-0.455).

Fruit weight exhibited significant positive correlation with weight of 100 seeds (0.564), fruit polar diameter (0.524), yield per plant (0.445) and fruit equatorial diameter (0.350). While, it had negative significant correlation with vine length (-0.372).

Number of days to first harvest showed a significant positive correlation with days to first female flower (0.859), node to first female flower (0.589) and vine length (0.376). But it had a significant negative relation with seeds per fruit (-0.475).

The number fruits per plant manifested a significant positive correlation with yield per plant (0.891) and fruit equatorial diameter (0.589) at genotypic level.

Number of seeds per fruit showed a significant positive correlation for fruit polar diameter (0.438). but it had negative significant correlation with vine length (-0.598), days to first female flower (-0.713), node to first female flower (-0.808), fruit equatorial diameter (-0.385) and days to first harvest (-0.475).

Weight of 100 seeds exhibited significant positive correlation with fruit weight (0.564) and fruit equatorial diameter (0.466). But a non significant negative correlation was associated with vine length (-0.245), node to first female flower (-0.005), fruits per plant (-0.058).

4.6.1.2 Varieties

Yield per plant exhibited significant positive correlation with fruits per plant (0.723) and fruit weight (0.554) While, it had negative significant correlation with node to first female flower (-0.530) and weight of hundred seeds (-0.488).

At genotypic level, vine length had highly significant positive correlation with days to first harvest (0.551), node to first female flower (0.515) and fruit polar diameter (0.508). while, it had negative non significant relationship with fruits per plant (-0.348) and yield per plant (-0.214).

Number of days to first female flower showed a positive significant correlation with days to first harvest (0.903), seeds per fruit (0.573) and fruit equatorial diameter (0.518) at genotypic level. While, it had significant negative correlation with fruits per plant (-0.496).

Node to first female flower had significant positive correlation with vine length (0.515), days to first harvest (0.469). While it had significant negative correlation with fruits per plant (-0.420) and yield per plant (-0.530).

Fruit equatorial diameter had significant correlation with days to seeds per fruit (0.687), fruit polar diameter (0.669), fruit weight (0.668), days to first harvest (0.659) and first female flower (0.518) While, it had non significant negative correlation with fruits per plant (0.196).

Fruit polar diameter had significant positive correlation with fruit equatorial diameter (0.669), weight of 100 seeds (0.537) and vine length (0.508) at genotypic level. But, fruits per plant (-0.244) had negative non significant correlation with fruit polar diameter.

Fruit weight had significant positive correlation with fruit equatorial diameter (0.668), seeds per fruit (0.554), yield per plant (0.554) and days to first harvest (0.408) at genotypic level.

Number of days to first harvest showed a significant positive correlation with days to first female flower (0.903), fruit equatorial diameter (0.659), seeds per fruit (0.563), vine length (0.551), node to first harvest (0.469) and fruit weight (0.408). Fruits per plant

(-0.635) had significant negative relationship with days to first harvest at genotypic level.

Fruits per plant was significantly correlated with yield per plant (0.723). While, it had significant negative correlation with days to first female flower (-0.496), node to first female flower (-0.420), days to first harvest (-0.422) and weight of 100 seeds (-0.471) at genotypic level.

Number seeds per fruit was significantly and positively correlated with fruit equatorial diameter (0.687), days to first female flower (0.573), days to first harvest (0.563) and fruit weight (0.554). While, it had negative significant interaction with fruits per plant (-0.422).

Weight of 100 seeds showed a significant positive correlation with fruit polar diameter (0.537). While, it had significant negative interaction with fruits per plant (-0.471) and yield per plant (-0.488) at genotypic level.

4.6.2 Phenotypic Correlation

4.6.2.1 Hybrids

Yield per plant had significant positive association at phenotypic level with fruits per plant (0.883), fruit equatorial diameter (0.665) and fruit weight (0.429) and while vine length (-0.163), days to first harvest (-0.055) and seeds per fruit (-0.101) had a negative relationship with yield plant.

Vine length had a significant positive phenotypic correlation with node to first female flower (0.547), days to first female flower (0.475) and days to first harvest (0.354). While, it had negative significant correlation with fruit polar diameter (-0.432), fruit weight (-0.354) and seeds per fruits (-0.585).

Days to first female flower had significant positive phenotypic correlation with days to first harvest (0.718), node to first female flower (0.675), vine length (0.475) and fruit equatorial diameter (0.430). While, it had significant negative association with seeds per fruit (-0.594).

Node to first female flower was positively correlated with days to first female flower (0.675), days to first harvest (0.576) vine length (0.547), weight of hundred seeds (0.425) and fruit equatorial diameter (0.391). While, it had negative significant relationship with seeds per fruit (-0.804).

Fruit equatorial diameter had significant positive phenotypic correlation with yield per plant (0.665), fruits per plant (0.555), days to first female flower (0.430) and node to first female flower (0.391) While, it had significant negative correlation with seeds per fruit (-0.362).

Fruit polar diameter exhibited a significant correlation with fruit weight (0.521) and seeds per fruit (0.431). While, it had significant negative interaction with vine length (-0.432).

At phenotypic level, fruit weight had highly significant positive correlation with weight of 100 seeds (0.541), fruit polar diameter (0.521) and yield per plant (0.429). Vine length had significant negative relationship with fruit weight (-0.354).

Number of days to first harvest manifested a significant positive phenotypic correlation with days to first female flower (0.718), node to first female flower (0.576) and vine length (0.354). While, seeds per fruit (-0.465) had negative significant correlation with number of days to first harvest.

Fruits per plant exhibited significant positive correlation with yield per plant (0.883) and fruit equatorial diameter (0.555) at phenotypic level. But a non significant negative correlation was associated with vine length (-0.083), node to first female flower (-0.028), fruit polar diameter (-0.122), days to first harvest (-0.232) and weight of 100 seeds (-0.073).

Number of seeds per fruit showed a significant positive correlation with fruit polar diameter (0.431) and significant negative correlation observed with vine length (-0.585), days to first female flower (-0.594), node to first female flower (-0.804), fruit equatorial diameter (-0.362) and days to first harvest (-0.465).

Table 18. Phenotypic correlation coefficients between yield and yield components of hybrids

Character	Vine length	Days to first female flower	Node to first female flower	Fruit equatorial diameter	Fruit polar diameter	Fruit weight	Days to first harvest	Fruits per plant	Seeds per fruit	Weight of 100 seeds	Yield per plant
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1.000	0.475**	0.547**	0.063	-0.432*	-0.354*	0.354*	-0.083	-0.585**	-0.252	-0.163
X2		1.000	0.675**	0.430*	-0.264	0.031	0.718**	0.140	-0.594**	-0.020	0.200
X3			1.000	0.391*	-0.318	0.198	0.576**	-0.028	-0.804**	-0.010	0.124
X4				1.000	-0.303	0.328	0.220	0.555**	-0.362*	0.425*	0.665**
X5					1.000	0.521**	0.089	-0.122	0.431*	0.154	0.090
X6						1.000	0.266	0.027	-0.056	0.541**	0.429*
X7							1.000	-0.232	-0.465**	0.070	-0.055
X8								1.000	0.020	-0.073	0.883**
X9									1.000	0.011	-0.101
X10										1.000	0.113
X11											1.000

*Significant at 5 per cent level ** Significant at 1 per cent level

Table 19. Phenotypic correlation coefficients between yield and yield components of varieties

Character	Vine length	Days to first female flower	Node to first female flower	Fruit equatorial diameter	Fruit polar diameter	Fruit weight	Days to first harvest	Fruits per plant	Seeds per fruit	Weight of 100 seeds	Yield per plant
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1.000	0.371	0.496**	0.330	0.503**	0.083	0.537**	-0.299	0.296	0.355	-0.193
X2		1.000	0.346	0.500**	0.028	0.313	0.895**	-0.436*	0.565**	-0.078	-0.206
X3			1.000	0.250	0.177	-0.205	0.461*	-0.404*	0.215	0.332	-0.510**
X4				1.000	0.670**	0.657**	0.624**	-0.177	0.672**	0.046	0.259
X5					1.000	0.330	0.296	0.217	0.351	0.528**	0.067
X6						1.000	0.398*	-0.140	0.553**	-0.241	0.531**
X7							1.000	-0.554**	0.554**	0.077	-0.239
X8								1.000	-0.396*	-0.430*	0.717**
X9									1.000	-0.220	-0.049
X10										1.000	-0.462*
X11											1.000

*Significant at 5 per cent level   ** Significant at 1 per cent level

Weight of 100 seeds had a significant positive correlation with fruit weight (0.541) and fruit equatorial diameter (0.425). While, it had non significant negative correlation with vine length (-0.252), days to first female flower (-0.020), node to first female flower (-0.010) and fruits per plant (-0.073) at phenotypic level.

4.6.2.2 Varieties

Yield per plant had significant positive correlation at phenotypic level with fruits per plant (0.717) and fruit weight (0.531). While, it had significant negative relationship with node to first female flower (-0.510) and weight of hundred seeds (-0.462).

Vine length had significant positive phenotypic correlation with days to first harvest (0.537) node to first female flower (0.496) and fruit polar diameter (0.503) and it had negative non significant correlation with fruits per plant (-0.299) and yield per plant (-0.193)

Days to first female flower exhibited significant positive phenotypic correlation with days to first harvest (0.895) and seeds per fruit (0.565) and fruit equatorial diameter (0.500). While, it had significant negative phenotypic correlation with fruits per plant (-0.436).

Node to first female flower had significant positive interaction with vine length (0.496) and days to first harvest (0.461) and it had negative significant relationship with fruits per plant (-0.404) and yield per plant (-0.510).

Fruit equatorial diameter of harvest exhibited positive and significant correlation with seeds per fruit (0.672), fruit polar diameter (0.670), fruit weight (0.657), days to first harvest (0.624) and days to first female flower (0.500).

Fruit polar diameter showed a significant positive phenotypic correlation with fruit equatorial diameter (0.670), weight of hundred seeds (0.528) and vine length (0.503).

At phenotypic level, fruit weight had significant positive correlation with fruit equatorial diameter (0.657), seeds per fruit (0.553), yield per plant (0.531) and days to first harvest (0.398) and it had non significant negative interaction with node to first female flower (-0.205), fruits per plant (-0.140) and weight of hundred seeds (-0.241).

Number of days to first harvest exhibited significant positive correlation with days to first female flower (0.895), yield per plant (0.717), fruit equatorial diameter (0.624), seeds per fruit (0.554), vine length (0.537), node to first female flower (0.461) and fruit weight (0.398).

Fruits per plant exhibited significant positive correlation with yield per plant (0.717). While, it had significant negative correlation with days to first female flower (-0.436), node to first female flower (-0.404), days to first harvest (-0.554), seeds per fruit (-0.396) and weight of 100 seeds (-0.430) at phenotypic level.

Number of seeds per fruit had significant positive phenotypic correlation with fruit equatorial diameter (0.672), days to first female flower (0.565), days to first harvest (0.554) and fruit weight (0.553) and it had negative significant correlation with fruits per plant (-0.396).

Weight of hundred seeds exhibited significant positive relationship with fruit polar diameter (0.528). while, it had significant negative phenotypic correlation with fruits per plant (-0.430) and yield per plant (-0.462).

4.7 PATH COEFFICIENT ANALYSIS

Genotypic correlation between yield and yield contributing characters were partitioned into different components to find out the direct and indirect contribution of each character on yield. Vine length, days to first female flower, node to first female flower, fruit equatorial diameter, fruit polar diameter, fruit weight, days to first harvest, fruits per plant, seeds per fruit and weight of hundred seeds were selected for path coefficient analysis in watermelon hybrids and varieties. The results are presented in Table 20, Fig. 4 and Table 21, Fig. 5 respectively.

Table 20. Direct and indirect effects of yield components on yield of hybrids

Character	Vine length	Days to first female flower	Node to first female flower	Fruit equatorial diameter	Fruit polar diameter	Fruit weight	Days to first harvest	Fruits per plant	Seeds per fruit	Weight of 100 seeds	Yield per plant
Vine length	**0.0611**	0.0353	0.0344	0.0047	-0.0278	-0.0227	0.0229	-0.0057	-0.0365	-0.0150	-0.1601
Days to first female flower	-0.3806	**-0.6594**	-0.5295	-0.3534	0.2012	-0.0362	-0.5664	-0.0956	0.4702	-0.0204	0.2388
Node to first female flower	0.1243	0.1770	**0.2204**	0.0937	-0.0724	0.0434	0.1298	-0.0049	-0.1781	-0.0012	0.1338
Fruit equatorial diameter	0.0238	0.1646	0.1305	**0.3070**	-0.0955	0.1075	0.0679	0.1808	-0.1182	0.1430	0.7070**
Fruit polar diameter	-0.0437	-0.0293	-0.0315	-0.0299	**0.0960**	0.0503	0.0097	-0.0117	0.0421	0.0157	0.0998
Fruit weight	-0.0702	0.0103	0.0372	0.0660	0.0989	**0.1886**	0.0525	0.0079	-0.0103	0.1063	0.4450**
Days to first harvest	0.1661	0.3799	0.2605	0.0978	0.0446	0.1230	**0.4422**	-0.1155	-0.2102	0.0426	-0.0736
Fruits per plant	-0.0863	0.1347	-0.0208	0.5469	-0.1132	0.0388	-0.2426	**0.9290**	-0.0302	-0.0543	0.8910**
Seeds per fruit	0.0238	0.0284	0.0322	0.0153	-0.0175	0.0022	0.0189	0.0013	**-0.0398**	-0.0005	-0.1122
Weight of 100 seeds	0.0217	-0.0027	0.0005	-0.0412	-0.0144	-0.0498	-0.0085	0.0052	-0.0011	**-0.0884**	0.1278

Residual effect = 0.152, Bold values indicate direct effects

Table 21. Direct and indirect effects of yield components on yield of varieties

Character	Vine length	Days to first female flower	Node to first female flower	Fruit equatorial diameter	Fruit polar diameter	Fruit weight	Days to first harvest	Fruits per plant	Seeds per fruit	Weight of 100 seeds	Yield per plant
Vine length	**-0.2101**	-0.0799	-0.1081	-0.0694	-0.1067	-0.0178	-0.1157	0.0731	-0.0631	-0.0741	-0.2137
Days to first female flower	-0.3489	**-0.9175**	-0.3248	-0.4753	-0.0350	-0.2940	-0.8281	0.4549	-0.5256	0.0759	-0.2365
Node to first female flower	-0.0878	-0.0604	**-0.1705**	-0.0457	-0.0333	0.0360	-0.0799	0.0716	-0.0373	-0.0593	-0.5300**
Equatorial diameter	-0.1659	-0.2603	-0.1346	**-0.5025**	-0.3359	-0.3357	-0.3310	0.0985	-0.3451	-0.0176	0.2859
Fruit polar diameter	-0.1882	-0.0141	-0.0724	-0.2478	**-0.3706**	-0.1258	-0.1176	0.0902	-0.1324	-0.1988	0.0825
Fruit weight	0.0603	0.2276	-0.1501	0.4746	0.2411	**0.7104**	0.2899	-0.0933	0.3938	-0.1761	0.5540**
Days to first harvest	0.8213	1.3456	0.6988	0.9822	0.4733	0.6083	**1.4909**	-0.9467	0.8388	0.1179	-0.2788
Fruits per plant	-0.5602	-0.7983	-0.6756	-0.3156	-0.3920	-0.2115	-1.0224	**1.6101**	-0.6786	-0.7580	0.7230**
Seeds per fruit	0.2007	0.3827	0.1462	0.4589	0.2387	0.3704	0.3759	-0.2816	**0.6682**	-0.1491	-0.0488
Weight of 100 seeds	0.2651	-0.0621	0.2611	0.0263	0.4030	-0.1862	0.0594	-0.3537	-0.1676	**0.7512**	-0.4880*

Residual effect = 0.181, Bold values indicate direct effects

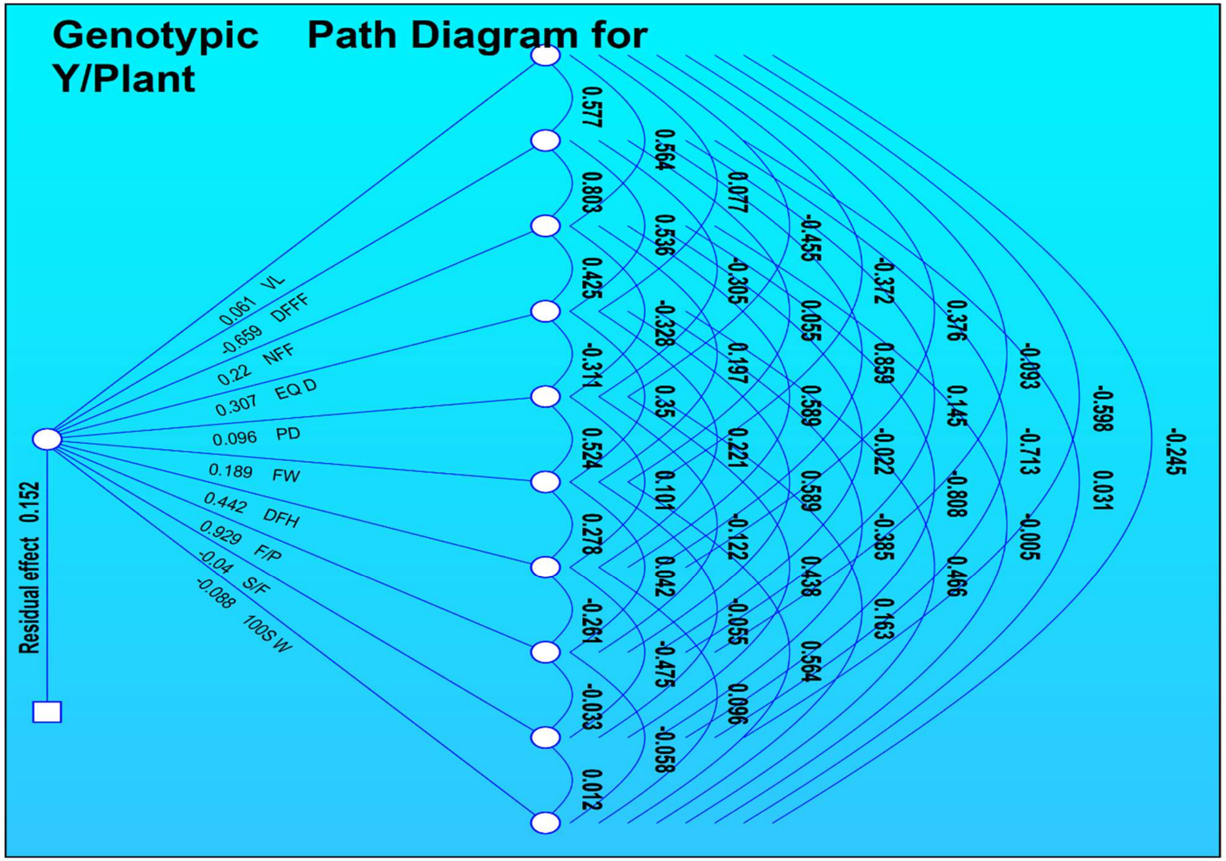


Fig. 4. Genotypic path diagram for yield per plant in watermelon hybrids

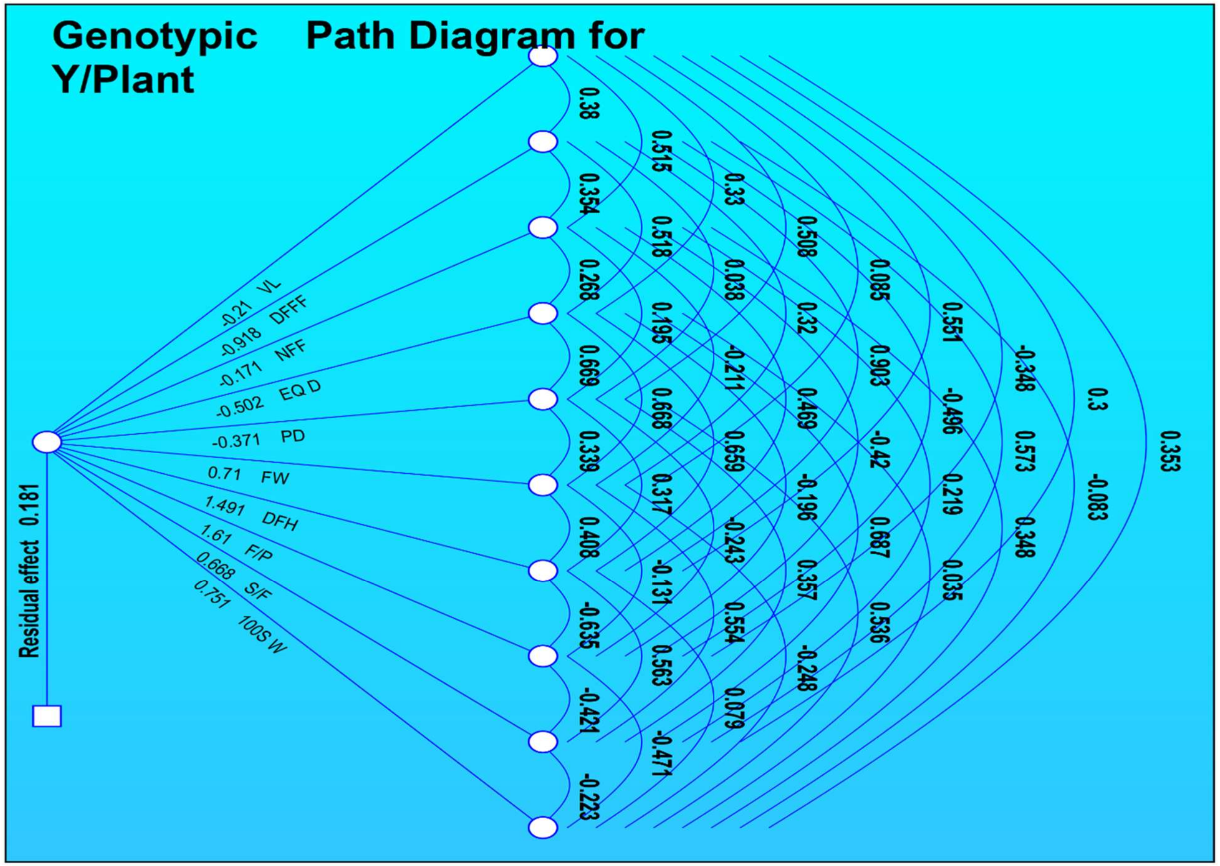


Fig. 5. Genotypic path diagram for yield per plant in watermelon varieties

4.7.1 Hybrids

Among the various components of yield, fruits per plant (0.9290) exerted the highest positive direct effect on yield followed by days to first harvest (0.4422), fruit equatorial diameter (0.3070), node to first female flower (0.2204), fruit weight (0.1886), fruit polar diameter (0.0960) and vine length (0.0611). Days to first female flower (-0.6594), seeds per fruits (-0.0398) and weight of hundred seeds (-0.0884) exhibited negative direct effect on yield.

Regarding the indirect effects, vine length had positive effects through days to first female flower (0.0353), node to first female flower (0.0344), days to first harvest (0.0229) and fruit equatorial diameter (0.0047). The negative indirect effects were through fruit polar diameter (-0.0278), fruit weight (-0.0227), fruits per plant (-0.0057), seeds per fruit (-0.0365) and weight of hundred seeds (-0.0150).

The indirect effect of days to first female flower was positive through.seeds per fruit (0.4702) and fruit polar diameter (0.2012). The negative indirect effects were through vine length (-0.3806), node to first female flower (-0.5295), fruit equatorial diameter (-0.3534), fruit weight (-0.0362), days to first harvest (-0.5664), fruits per plant (-0.0956) and weight of 100 seeds (-0.0204).

Node to first female flower exerted positive indirect effect through days to first female flower (0.1770), days to first harvest (0.1298), vine length (0.1243), fruit equatorial diameter (0.0937) and fruit weight (0.0434) and negative through fruit polar diameter (-0.0724), fruits per plant (-0.0049), seeds per fruit (-0.1781) and weight of hundred seeds (-0.0012).

The indirect effect of fruit equatorial diameter was positive through fruits per plant (0.1808), days to first female flower (0.1646), weight of hundred seeds (0.1430), node to first female flower (0.1305), fruit weight (0.1075), days to first harvest (0.0679) and vine length (0.0238). The negative indirect effects were through fruit polar diameter (-0.0955) and seeds per fruit (-0.1182).

Fruit polar diameter exhibited positive indirect effect through fruit weight (0.0503), seeds per fruit (0.0421), weight of hundred seeds (0.0157) and days to first harvest (0.0097) and it was negative through vine length (-0.0437), days to first female flower (-0.0293), node to first female flower (-0.0315), fruit equatorial diameter (-0.0299) and number of fruits per plant (-0.0117).

The fruit weight positively influenced yield indirectly through weight of hundred seeds (0.1063), fruit polar diameter (0.0989), fruit equatorial diameter (0.0660), node to first female flower (0.0372), days to first harvest (0.0525), days to first female flower (0.0103) and fruits per plant (0.0079). The effect was negative through vine length (-0.0702) and seeds per fruit (-0.1063).

Number of days to first harvest positively influenced yield per plant indirectly through weight of hundred seeds (0.4422), days to first female flower (0.3799), node to first female flower (0.2605), vine length (0.1661), fruit weight (0.1230), fruit equatorial diameter (0.0978) and fruit polar diameter (0.0446). It was negative through fruits per plant (-0.1155) and seeds per fruit (-0.2102).

Fruits per plant exerted positive indirect effect through fruit equatorial diameter (0.5467), days to first female flower (0.1347), fruit weight (0.0388) and was negative through vine length (-0.0863), node to first female flower (-0.0208), fruit polar diameter (-0.1132), days to first harvest (-0.2426), seeds per fruit (-0.0302) and weight of hundred seeds (-0.0543).

The indirect effect of number of seeds per fruit was positive through node to first female flower (0.0322), days to first female flower (0.0284), vine length (0.0238), days to first harvest (0.0189), fruit equatorial diameter (0.0153), fruit weight (0.0022) and fruits per plant (0.0013). The indirect effect was negative through fruit polar diameter (-0.0175) and weight of hundred seeds (-0.0005).

Weight of hundred seeds exhibited positive indirect effect through vine length (0.0217), fruits per plant (0.0052) and node to first female flower (0.0005). It was negative through days to first female flower (-0.0027), fruit equatorial diameter (-0.0412), fruit polar diameter (-0.0144), fruit weight (-0.0498), days to first harvest (-0.0085) and seeds per fruit (-0.0011).

4.7.2 Varieties

Among different components, fruits per plant (1.6101) exerted maximum direct effect on yield per plant followed by days to first harvest (1.4909), weight of hundred seeds (0.7512), fruit weight (0.7104) and seeds per fruit (0.6682). Vine length (-0.2101), days to first female flower (-0.9175), node to first female flower (-0.1705), fruit equatorial diameter (-0.5025) and fruit polar diameter (-0.3706) exerted negative direct effect on yield per plant.

Vine length exhibited positive indirect effect through fruits per plant (0.0731) and negative indirect effect through days to first female flower (-0.0799), node to first female flower (-0.1081), fruit equatorial diameter (-0.0694), fruit polar diameter (-0.1067), fruit weight (-0.0178), days to first harvest (-0.1157), seeds per fruit (-0.0631) and weight of hundred seeds (-0.0741).

The indirect effect of number days to first female flower was positive through fruits per plant (0.4549) and weight of hundred seeds (0.0759) and it was negative through vine length (-0.3489), node to first female flower (-0.3248), fruit equatorial diameter (-0.4753), fruit polar diameter (-0.0350), fruit weight (-0.2940), days to first harvest (-0.8281) and seeds per fruit (-0.526).

The indirect effect of node to first female flower was positive through fruits per plant (0.0716) and fruit weight (0.0360) and negative through vine length (-0.0878), days to first female flower (-0.0604), fruit equatorial diameter (-0.0457), fruit polar diameter (-0.0333), days to first harvest (-0.0799), seeds per fruit (-0.0373) and weight of hundred seeds (-0.0593).

Fruit equatorial diameter exerted positive indirect effect through fruits per plant (0.0985) and it was negative through vine length (-0.1659), days to first female flower (-0.2603), node to first female flower (-0.1346), fruit polar diameter (-0.3359), fruit weight

(-0.3357), days to firs harvest (-0.3310), seeds per fruit (-0.3451) and weight of hundred seeds (-0.0176).

Fruit polar diameter exerted positive indirect effect through fruits per plant (0.0902) and it was negative through vine length (-0.1882), days to first female flower (-0.0141), node to first female flower (-0.0724), fruit equatorial diameter (-0.2478), fruit weight (-0.1258), days to firs harvest (-0.1176), seeds per fruit (-0.1324) and weight of hundred seeds (-0.1988).

The indirect effect of fruit weight was positive through fruit equatorial diameter (0.4746), seeds per fruit (0.3938), days to first harvest (0.2899), fruit polar diameter (0.2411), days to first female flower (0.2276) and vine length (0.060) and it was negative through node to first female flower (-0.1501), fruits per plant (-0.0933) and weight of hundred seeds (-0.1761).

Days to first harvest exhibited positive indirect effect through days to first female flower (1.3456), fruit equatorial diameter (0.9822), seeds per fruit (0.8388), vine length (0.8213), node to first female flower (0.6988), fruit weight (0.6083), fruit polar diameter (0.4733) and weight of hundred seeds (0.1179) and negative indirect effect through fruits per plant (-0.9467).

Number of fruits per plant was negatively influenced the yield indirectly through vine length (-0.5602), days to first female flower (-0.7983), node to first female flower (-0.6756), fruit equatorial diameter (-0.3156), fruit polar diameter (-0.3920), fruit weight (-0.2115), days to first harvest (-1.0224), seeds per fruit (-0.6786) and weight of hundred seeds (-0.7580).

Regarding the indirect effects, seeds per fruit had positive effects through fruit equatorial diameter (0.4589), days to first female flower (0.3827), days to first harvest (0.3759), fruit weight (0.3704), fruit polar diameter (0.2387), vine length (0.2007) and node to first female flower (0.1462). The negative indirect effects were through fruits per plant (-0.2816) and weight of hundred seeds (-0.1491).

The indirect effect of weight of hundred seeds was positive through fruit polar diameter (0.4030), vine length (0.2651), node to first female flower (0.2611), days to first harvest (0.0594) and fruit equatorial diameter (0.0263). The indirect effect was negative through days to first female flower (-0.0621), fruit weight (-0.1862), fruits per plant (-0.3537) and seeds per fruit (-0.1676).

Discussion

5. DISCUSSION

The present investigation was carried out at the Department of Vegetable Science, College of Agriculture, Vellayani, during 2020-2021 to evaluate the performance of watermelon hybrids and varieties for growth, yield and quality. The extent of variability, heritability of economically important characters, genetic advance under selection and correlation among the traits were evaluated in order to come up with suggestions to improve yield and its components genetically. Under the following headings, the most important findings of this investigation are discussed.

5.1 Analysis of Variance

5.2 Mean performance of watermelon varieties and hybrids

5.3 Sensory evaluation of watermelon genotypes

5.4 Coefficient of variation

5.5 Heritability and genetic advance

5.6 Correlation analysis

5.7 Path coefficient analysis

5.1 ANALYSIS OF VARIANCE

In the present study, variance due to genotypes was highly significant for all 25 characters studied. It indicates that the presence of enough genetic variability to be exploited in breeding programme. Similar results were also reported by Gichimu *et al.* (2010), Choudhary *et al.* (2012), Hakimi and Madidi (2015) and Nisha (2017) in watermelon; Rathod (2007) in bitter gourd; Shivakumara (2019) in muskmelon and Yogananda (2020) in bottle gourd.

5.2 MEAN PERFORMANCE OF WATERMELON VARIETIES AND HYBRIDS

5.2.1 Vegetative and Flowering Characters

Significant variation was recorded among the hybrids and varieties for all the vegetative characters *viz.*, vine length, number of branches per vine, internodal length, days to first male flower, days to first female flower, node to first male flower and node to first female flower.

Cucurbitaceous plants require more space to grow than other vegetables because of their viny growth habit. Compact plant type, with short vine length and more branches are preferred because, they require less area and more plants can be accomodated per unit area. The vine length of hybrids ranged from 2.84 m in Jannat to 5.99 m in Swarna. Among varieties and check, AHW 19 had the longest vine length (5.18 m), whereas Arka Muthu had the shortest vine length (1.40 m). Priya (2001) obtained a range of 2.20 m to 4.92 m among watermelon accessions. Similar results were also obtained by Gichimu *et al.* (2010), Danata (2014), Nisha (2017), Kumar *et al.* (2020) and Mohosina *et al.* (2020) in watermelon. This variation in vine length could be attributed to specific genetic makeup of the genotypes, inherent properties and vigour of the crop.

In the present study, among hybrids and check, the highest number of branches was produced by Prachi (16.84), while the lowest was observed in Simran (5.50). Among varieties and check, the highest number of branches was observed in Best of All (7.50). The varieties Durgapura Lal (7.34), Crimson Sweet (7.17) and the check Sugar Baby (6.84), were on par with it. Minimum number of branches was noticed in Arka Muthu (2.84). Increased branch number increases the number of possible fruiting sites in watermelon, which helps to enhance yield (Mohanta and Mandal, 2016). Variation in number of branches were also reported by Choudhary *et al.* (2012), Jadhav *et al.* (2014) and Oraegbunam *et al.* (2016) in watermelon.

Significant variation was observed among hybrids for internodal length which ranged from 5.25 cm in Jannat to 12.95 cm in Yellow Angel. Among varieties, the highest internodal length was recorded in the check Sugar Baby (9.77 cm) followed by Crimson Sweet (9.63 cm). The lowest internodal length was observed in Arka Muthu (3.30 cm). Similar results were also reported by Jaskani *et al.* (2005), Mohosina *et al.* (2020) in watermelon; Choudhary *et al.* (2014) in ridge gourd; Kalyanrao *et al.* (2016) and Yogananda (2020) in bottle gourd.

In this study, hybrid Jannat was the earliest to produce male flower (31.40

days) which was on par with Mannat (33.40 days), WHS-20011 (33.40 days) and Saraswati (33.50 days). Shonima was late (40.20 days) in flowering. Among varieties and check, Arka Shyama (29.90) was the earliest and was on par with Thar Manak (31.50 days). Duragapura Meetha was late and took 51.50 days for flowering. Early production of male flowers indicates earliness. These findings are in line with Priya (2001), Alimari *et al.* (2017) and Anumala *et al.* (2020) in watermelon.

In cucurbits, early opening of first female flower is a desirable parameter for early harvest. The hybrids and check differed significantly for days to first female flowering with an average of 40.58 days. Jannat took the lowest number of days to first female flowering (37.70 days) which was on par with Aarohi (37.80 days), Yellow Lion (38.20 days), Saraswati (38.30 days), Prachi (38.80 days), WHS-20011 (39.40 days), Vankat (39.50 days) and Mannat (40.10 days). Shonima (43.90 days) took longest number of days to first female flowering. Among the varieties and check, Arka Shyama was the earliest with 35.80 days for first female flower anthesis, whereas Duragapura Meetha took longest period of 60.60 days. Bhagyalekshmi (2019) noticed a similar range of 31.05 to 54.35 days for first female flowering. Similar variation in number of days for flowering was also reported by Oraegbunam *et al.* (2016), Alimari *et al.* (2017), Nisha (2017) and Biswas *et al.* (2020) in watermelon.

The node to first male flower production was found significantly different among hybrids and check and it varied from 3.20 (Yellow Lion) to 7.50 (Swarna). Among varieties and check, Arka Muthu produced the first male flower in the lowest node of 3.30 followed by Thar Manak (4.40). The highest node number of 10.30 was recorded in Durgapura Meetha. Similar results were earlier observed by Mohanta and Mandal (2016), Nisha (2017) and Anumala *et al.* (2020) in watermelon and Mandal and Mohanta (2018) in tinda.

In the present study, among hybrids and check, Yellow Angel produced the first female flower at the lowest node (8.00) whereas Swarna recorded the highest node of 16.70. The node at which first female flower appeared varied from 10.40 (Asahi Yamato) to 28.20 (Crimson Sweet) in varieties. Appearance of female flowers at lower nodes is interpreted as early type. Similar reports were made by Mohanta and Mandal (2016), Nisha (2017), Bhagyalekshmi (2019) and Biswas *et al.* (2020) in watermelon.

5.2.2 Fruit and Yield Characters

In the present study, significant variation was recorded among the hybrids and varieties for all fruit and yield characters like fruit equatorial diameter, fruit polar diameter, rind thickness, fruit weight, days to first harvest, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, crop duration, seeds per fruit and 100 seed weight.

The length of the fruit determines the shape of the fruit, which is directly related to consumer preferences. Among hybrids and check, the highest fruit equatorial diameter was observed in Devyani (17.60 cm) which was statistically on par with Shabari (17.50 cm), Jannat (16.85 cm), Anmol (16.75), Yellow Queen (16.75 cm) and Swarna (16.55 cm). Yellow Lion recorded the lowest fruit equatorial diameter of 12.85 cm. Among varieties, Durgapura Lal exhibited the highest fruit equatorial diameter of 24.05 cm and Arka Muthu (15.90 cm) recorded the lowest. The fruit polar diameter of hybrids exhibited a range of 15.70 cm in Shonima to 28.75 cm in WHS-20011. Among varieties, AHW 65 (27.80 cm) recorded the highest fruit polar diameter while, Arka Muthu (16.50 cm) recorded the lowest. The shape and size of watermelon fruit are determined by the fruit equatorial and polar diameters (Mohanta and Mandal, 2016). Similar results were recorded by Nisha (2017), Singh *et al.* (2018) and Kumar *et al.* (2020) in watermelon; Ohashi *et al.* (2009) and Shivakumara (2019) in muskmelon and Ganiger *et al.* (2014) in oriental pickling melon.

The thickness of the rind is an important trait associated with storability and transport quality of watermelon fruits. Among hybrids and check, the thickest rind was observed in WHS-20011 (2.15 cm), while the lowest rind thickness was noticed in Prachi (0.35 cm). Among varieties, the check Sugar Baby recorded the highest rind thickness of 2.10 cm, which was on par with Arka Manik (1.95 cm). Asahi Yamato and Durgapura Kesar exhibited the lowest rind thickness of 1.20 cm. These findings are in agreement with Jadhav *et al.* (2014), Hakimi and Madidi (2015), Alimari *et al.* (2017) and Rabou and Sayd (2021) in watermelon.

Fruit weight is an important character to be considered in any breeding programme because it has a direct impact on yield. The data related to fruit weight revealed the significant difference among genotypes. Hybrid Mannat exhibited the highest fruit weight of 3.34 kg and Yellow Lion recorded the lowest (1.48 kg) (Fig. 6). Among the varieties and check, the highest fruit weight was observed in Duragapura Meetha (4.76 kg), which was on par with the check Sugar Baby (4.67 kg). Lowest weight of 2.58 kg was recorded in Arka Muthu (Fig.7). The highest weight of fruits might be due to genetic capacity of the accessions to make available higher assimilates for fruit development. Similar range of average fruit weight was recorded by More *et al.* (2015) and Nisha (2017) in watermelon.

The present day market demands small to medium sized fruits, to cater the needs of nuclear families. Hence, the genotypes that produce more number of fruits with a lower fruit weight were given importance. Among hybrids, Shabari (4.20) recorded the highest number of fruits followed by Prachi (3.30). Yellow Lion recorded the lowest (1.30) (Fig.8). Among varieties and check, the highest number of 3.00 fruits per plant was recorded in Arka Shyama, while the lowest in Crimson Sweet (1.20) (Fig.9). This might be due to the genetic composition of genotypes. Mohosina *et al.* (2020) noticed a similar range of 1.50 to 4.50 fruits per plant in genetic diversity study in watermelon. Such variation in number of fruits per plant were also noticed by More *et al.* (2015), Nisha (2017), Anburani (2018), Kumar *et al.* (2020) in watermelon; Sharma and Lal (2004) and Fergany *et al.* (2011) in muskmelon and Kalyanrao *et al.* (2016) in bottle gourd.

Among the hybrids and check, Prachi was the earliest to harvest (62.00 days) followed by Jannat (65.00 days). Swarna recorded the highest number of 93.50 days for first harvest. Among varieties and check, Arka Shyama (59.00 days) was the earliest to first harvest, which was on par with Thar Manak (62.50 days) and Arka Muthu (63.50 days). Duragapura Meetha took the longest number of days for first harvesting. Lesser number of days to first harvest indicate earliness of the genotype. Early marketing will help to fetch better price. Similar results were observed by Anburani (2018), Bhagyalekshmi (2019), Anumala *et al.* (2020) and Biswas *et al.* (2020) in watermelon.

The lowest mean value for node to first fruit was recorded in the hybrid Vankat (10.40) which was on par with Prachi (10.60), Yellow Angel (10.60), Yellow Queen (10.70) and Saraswati (10.70). The highest node to first fruit was registered in the hybrid Swarna (20.40). Among varieties and check, node to first fruit ranged from 11.30 (Asahi Yamato) to 29.00 (Crimson Sweet). Similar results were observed by Shivakumara (2019) in muskmelon and Yogananda (2021) in bottle gourd.

Yield is the ultimate aim in any crop production system. Among the hybrids and check, Shabari recorded the highest yield per plant (11.80 kg) (Fig.10), yield per plot (82.90 kg) and marketable yield per plot of 79.95 kg. Among varieties and check, Arka Shyama produced the highest yield per plant (9.82 kg) (Fig.11), yield per plot (98.18 kg) and marketable yield per plot (86.84 kg). Significant difference in yield could be attributed to differences in fruit weight and number of fruits per plant, which are important components of yield. Haribabu (1985) and Murali *et al.* (1986) stated that more number of fruits with moderate weight would increase yield in cucumber and bottle gourd respectively. These findings are in collaboration with More *et al.* (2015), Nisha (2017), Anburani (2018) and Mohosina *et al.* (2020) in watermelon. Maggs-Kolling and Christiansen (2003) in Nambia and Gichimu *et al.* (2010) in Kenya noticed a wide range of variation in yield among local landraces of watermelon.

Crop duration is determined by the number of days to final harvest. Duration of the crop differed significantly among the hybrids and varieties. The longest crop duration was observed in the hybrid Swarna (120.50 days), while the shortest in Prachi (87.00 days). Among the varieties, crop duration ranged from 81.50 days in Thar Manak to 122.00 days in Durgapura Lal. Nisha (2017) observed a similar range (74.00 to 109.50 days) of variation in crop duration. The variation in crop duration might be due to the genetic composition of the genotypes.

The number of seeds per fruit showed a significant difference among the hybrids and varieties. The highest number of seeds was found in the hybrid Yellow Lion (315.00), while Shonima and Swarna were seedless. In varieties, the lowest number of seeds was observed in Arka Shyama (219.50). Sugar Baby recorded the highest number of seeds (491.50) followed by Durgapura Meetha (487.50). These findings are in line

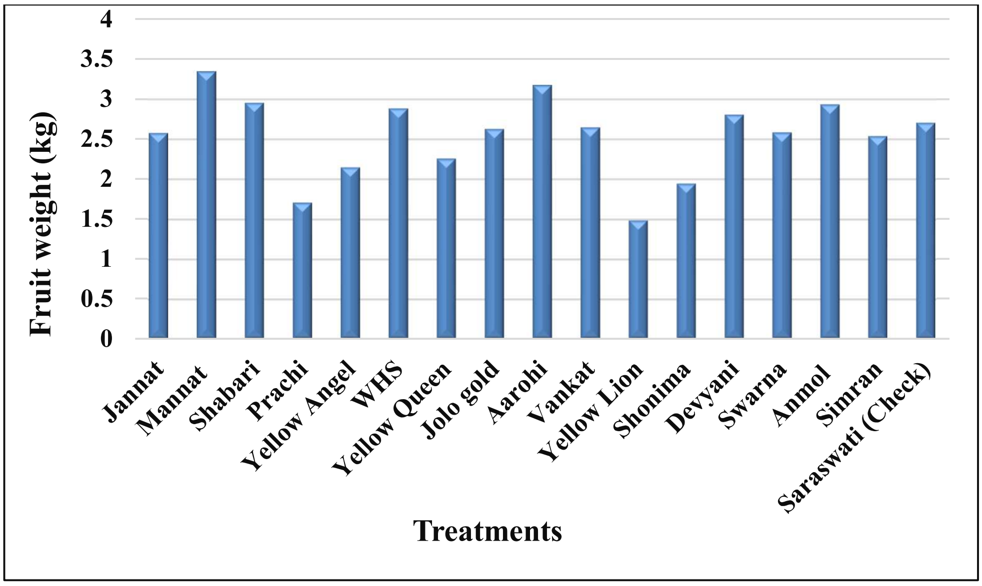


Fig. 6. Mean performance of hybrids for fruit weight (kg)

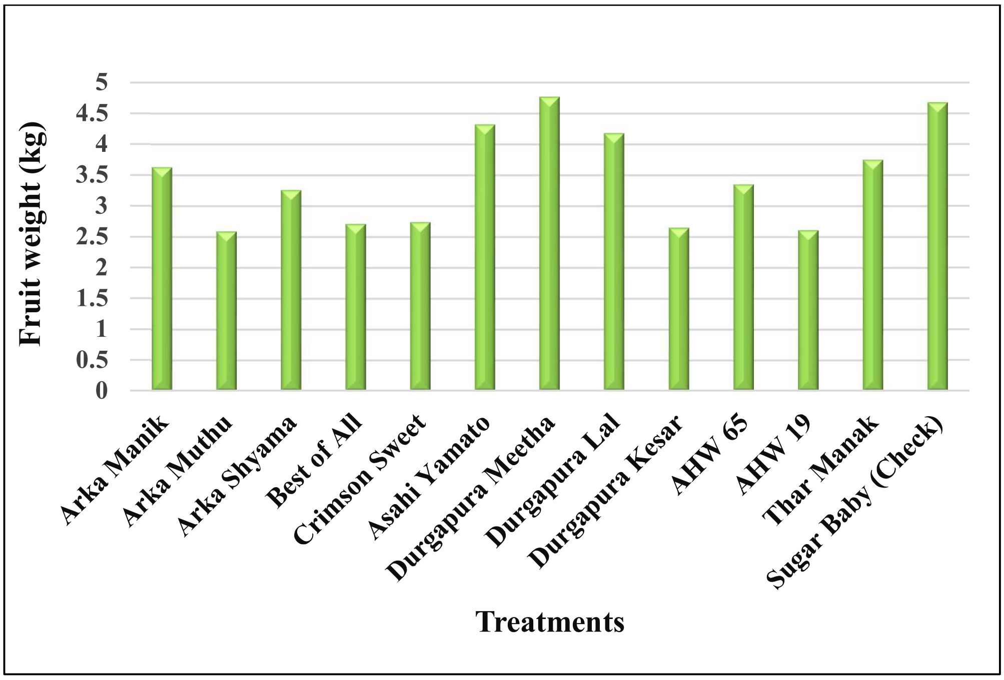


Fig. 7. Mean performance of varieties for fruit weight (kg)

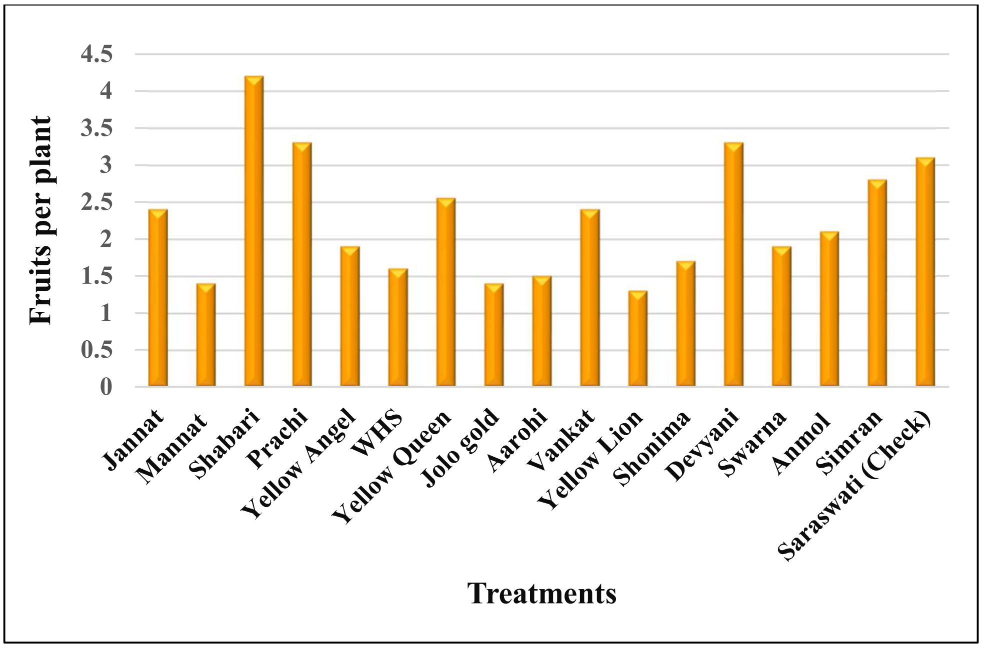


Fig. 8. Mean performance of hybrids for fruits per plant

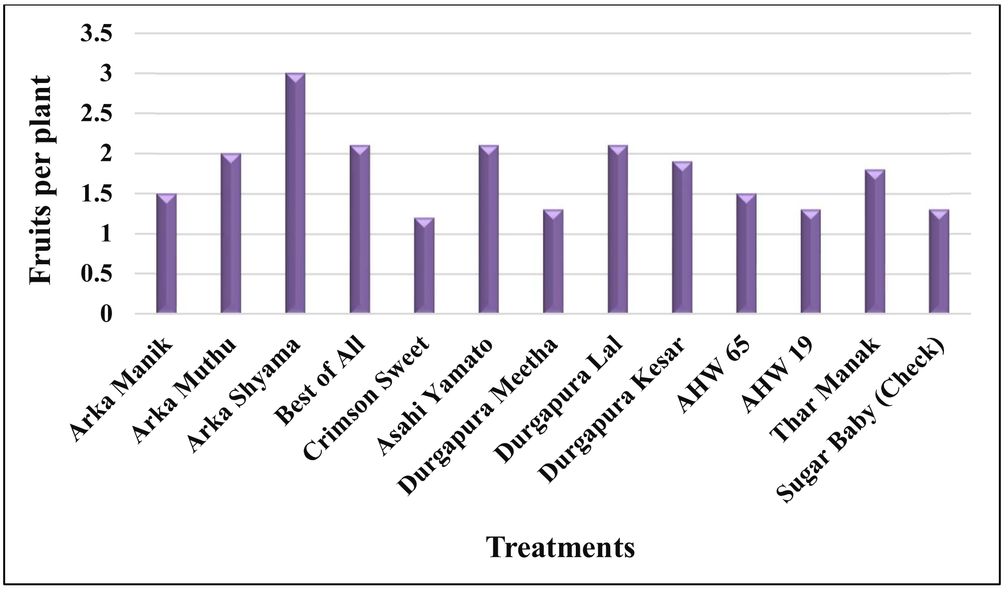


Fig. 9. Mean performance of varieties for fruits per plant

Mohosina *et al.* (2020) in watermelon. Maggs-Kolling and Christiansen (2003) in Nambia and

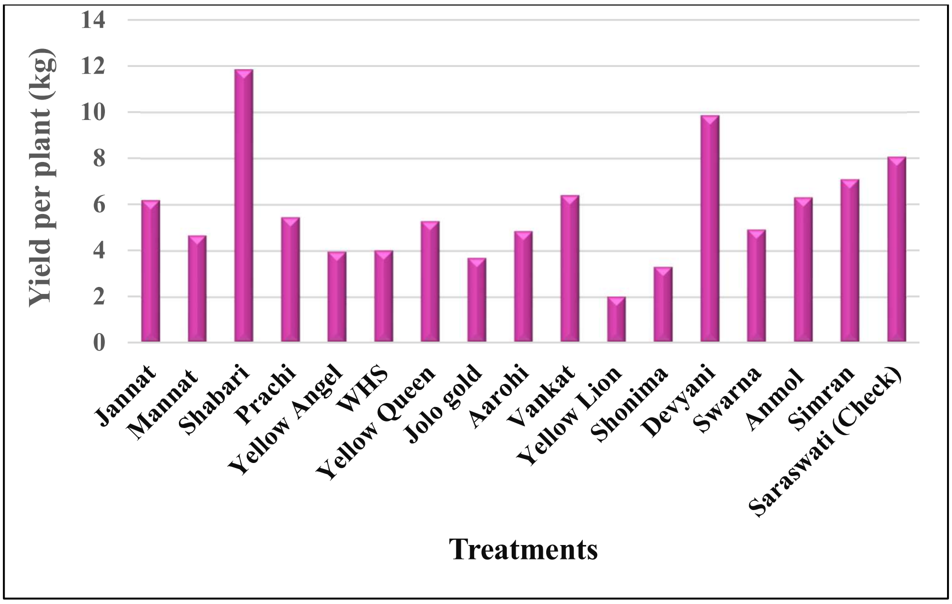


Fig. 10. Mean performance of hybrids for yield per plant (kg)

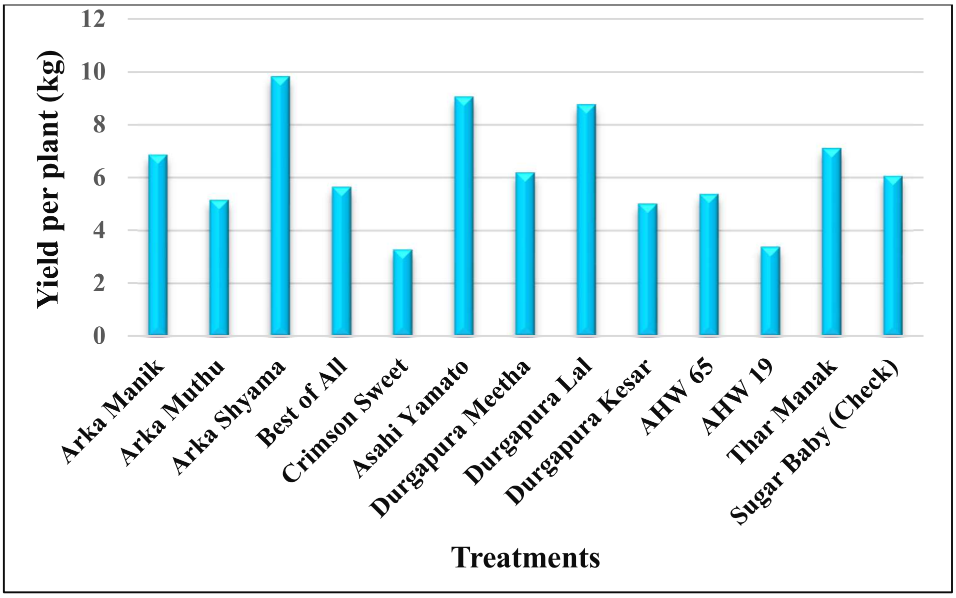


Fig. 11. Mean performance of varieties for yield per plant (kg)

with Jadhav *et al.* (2014), Alimari *et al.* (2017) and Rabou and Sayd (2021) in watermelon. Tetraploid watermelon genotypes had fewer seeds per fruit than diploid genotypes (Jaskani *et al.*, 2005).

Among hybrids and check, Mannat exhibited the highest 100 seed weight of 5.05 g which was on par with Anmol (4.90 g), Jannat (4.85 g) and Devyani (4.70 g). The lowest weight of 2.85 g was observed in Yellow Lion. Among the varieties, Crimson Sweet recorded the highest 100 seed weight (12.50 g) which was on par with Thar Manak (12.11 g). Lowest weight was recorded in Asahi Yamato (2.25 g). A similar range of observations was recorded by Singh *et al.* (2018) and Bhagyalekshmi (2019) in watermelon; Ganiger *et al.* (2017) and Shivakumara (2019) in muskmelon.

5.2.3 Quality Characters

The hybrids and the varieties recorded significant differences for quality characters such as total soluble solids (TSS), lycopene, ascorbic acid, reducing sugars and non reducing sugars.

Total soluble solids content is an important trait which determines the quality and consumer preference for watermelon. TSS content varied significantly among different hybrids. The highest TSS content was observed in the check Saraswati (12.25 ^{0}B), which was on par with Shabari (11.50 ^{0}B) and the lowest in WHS-20011 (6.75 ^{0}B) (Fig.12). In varieties, the TSS content ranged from 7.35 ^{0}B in Durgapur Kesar to 12.65 ^{0}B in Arka Shyama. Six varieties exhibited higher TSS values than the average of 9.64 ^{0}B (Fig.13). This is in confirmation with the findings of Nagal *et al.* (2012), Mohanta and Mandal (2016), Nisha (2017) and Sabeeta *et al.* (2017).

Lycopene is the major carotenoid which is present in watermelon flesh and is the major health promoting bioactive component. In this study, red fleshed genotypes recorded highest lycopene than yellow fleshed ones. The highest lycopene content was recorded in Mannat (7.61 mg 100 g^{-1}) and lowest in Jolo Gold (0.54 mg 100 g^{-1}). observed in Mannat (7.61 mg 100 g^{-1}) and lowest in Jolo Gold (0.54 mg 100 g^{-1}). Lycopene content in varieties varied from 2.77 mg 100 g^{-1} in Durgapura Kesar to 6.40 mg 100 g^{-1} in Arka Shyama. Choo and Sin (2012), Nisha (2017) and Wehner *et al.* (2017) stated that red fleshed watermelon contained more lycopene than the yellow fleshed. Similar variations in lycopene content were also noticed by Davis *et al.* (2004)

and Nagal *et al.* (2012) in watermelon.

Ascorbic acid plays an important role in antioxidative defence mechanism in cells and tissues. In this study, among the hybrids and check, Prachi recorded the highest ascorbic acid content of 6.35 mg 100 g^{-1} and Yellow Lion (2.76 mg 100 g^{-1}) the lowest. In varieties, the ascorbic acid content was highest in Arka Shyama (5.10 mg 100 g^{-1}) and the lowest in Crimson Sweet (3.04 mg 100 g^{-1}). Similar results were also reported by Sahu *et al.* (2011), Choo and Sin (2012) and Singh *et al.* (2018) in watermelon.

The reducing sugar content of hybrids ranged from 2.32 per cent in Devyani to 3.23 per cent in Shabari. Among the varieties, Arka Manik had the highest reducing sugar content of 3.23 per cent, which was on par with Arka Shyama (3.09 per cent), Sugar Baby (3.02 per cent), Durgapura Kesar (2.99 per cent) and AHW 65 (2.96 per cent). The lowest content was recorded in Durgapura Lal (2.34 per cent). Similar variation in reducing sugar content was reported earlier by Pardo *et al.* (1997), Sahu *et al.* (2011), Soumya and Rao (2014) and Oberoi and Sogi (2017) in watermelon.

The highest content of non reducing sugar in hybrids was observed in Jannat (3.75 per cent) which was on par with Anmol (3.74 per cent), Aarohi (3.72 per cent) and Shabari (3.68 per cent). The lowest value was recorded in Shonima (3.17 per cent). Among the varieties and check, the highest non reducing sugar content was recorded by Arka Manik (3.85 per cent) followed by Arka Muthu (3.59 per cent), which were on par and the lowest by Crimson Sweet (3.10 per cent). Similar results were also noticed by Pardo *et al.* (1997), Sahu *et al.* (2011), Soumya and Rao (2014) and Oberoi and Sogi (2017) in watermelon.

5.3 SENSORY EVALUATION OF WATERMELON GENOTYPES

Colour, flavour, texture and nutritional value are the important factors in determining consumer acceptance of fresh cut fruits and vegetables (Barrett *et al.*, 2010). For determining critical quality attributes, both instrumental and sensory measurements are used. According to Bach *et al.* (2012), sensory analysis is a technique that uses human senses in the evaluation of product qualities.

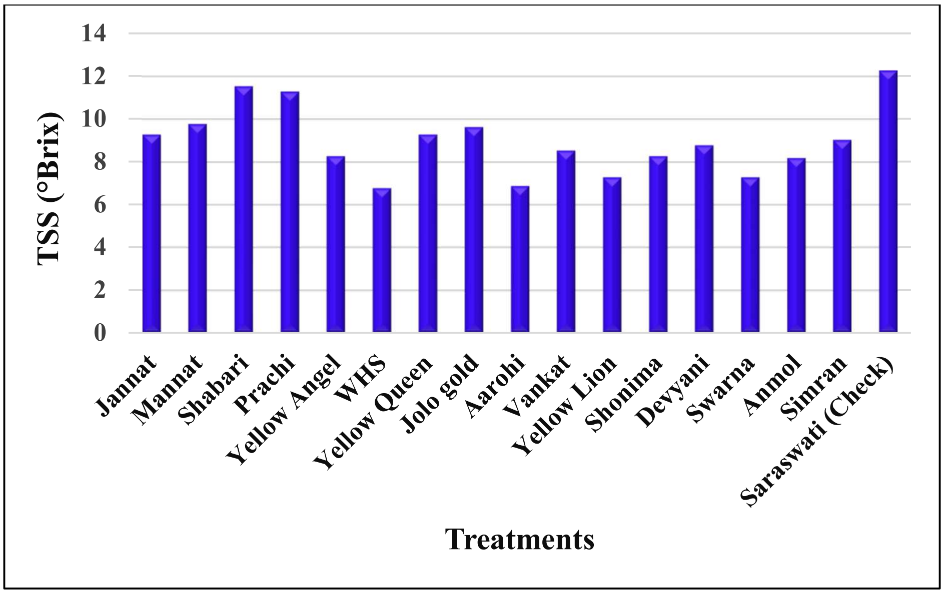


Fig. 12. Mean performance of hybrids for TSS (°Brix)

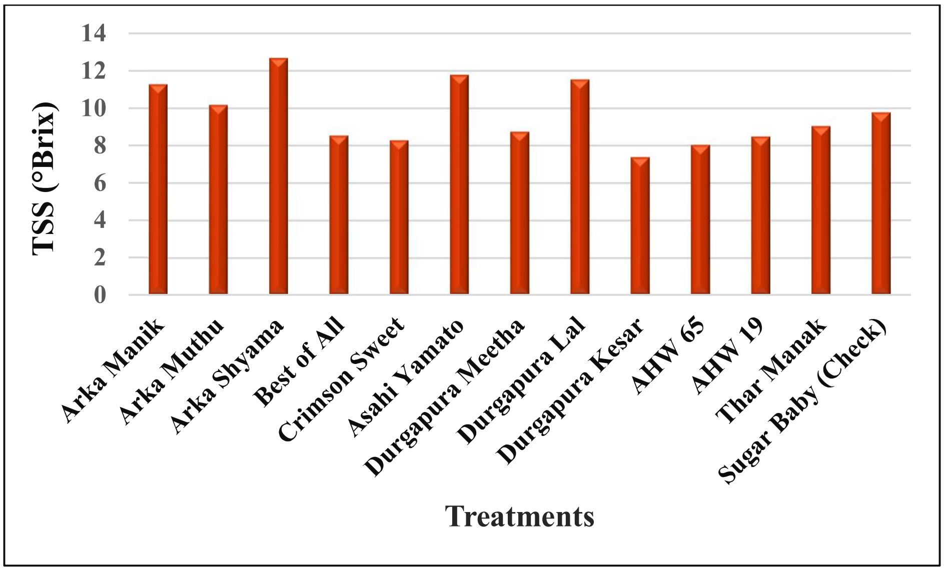


Fig. 13. Mean performance of varieties for TSS (°Brix)

The sensory analysis of watermelon hybrids and varieties was conducted and Kruskal-Wallis test confirmed significant difference among the hybrids and varieties. Mean sensory score values revealed that the hybrid Shabari was superior to other hybrids in sensory parameters like appearance, colour, flavour, taste, texture and overall acceptability (Fig.14). Among the varieties and check, Arka Shyama recorded the highest mean score for all the sensory parameters (Fig.15). Variations in sensory parameters among genotypes have been reported by Nisha (2017) in watermelon and Shivakumara (2019) in muskmelon.

As small to medium sized fruits with high TSS content are preferred by consumers, it can be concluded that the hybrids Shabari, Saraswati and Devyani (Plate 5) and the varieties Arka Shyama, Arka Muthu and Sugar Baby (Plate 6) are promising under South Kerala conditions.

5.4 COEFFICIENT OF VARIATION

Plant breeders rely on genetic variability to generate new varieties in any crop. It is important to determine how much of the observed performance is caused by genetic factors, which demands the estimation of genetic variability. The extent of genetic diversity is more essential than total variance, because the greater the genetic variability, the better the selection possibilities. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) are used to measure variability.

In the present study, even though the phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the traits, only a modest difference between PCV and GCV was observed. This revealed greater stability of the characters against environmental fluctuation. As a result, phenotype based selection is more reliable. For majority of the traits, GCV contributed a major portion of PCV, implying that the observed variation was primarily due to genetic factors. This similarity between PCV and GCV was reported earlier by Priya *et al.*, (2004), Sundaram *et al.* (2011) and Mahla and Choudhary (2013) in watermelon; Rakhi and Rajamony (2005) in culinary melon; Deepthi *et al.* (2016) and Rana *et al.* (2018) in bottle gourd and Pushpalatha *et al.* (2016) in cucumber.

High phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for the characters vine length, number of branches per plant, internodal length, node to first male and female flower, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, seeds per fruit and lycopene in both hybrids and varieties. In addition to this, rind thickness and ascorbic acid content of hybrids and fruit weight and weight of 100 seeds of varieties also recorded high GCV and PCV, which indicates greater phenotypic and genotypic variability among the genotypes and responsiveness of the attributes to further improvement through selection. Similar observations were recorded by Nisha *et al* (2018), Jamatia *et al.* (2019), Rabou and Sayd (2021) in watermelon; Tomar *et al.* (2008) and Choudhary *et al.* (2011) in muskmelon and Basavarajeshwari *et al.* (2014) in cucumber.

Estimates for PCV and GCV were moderate for fruit polar diameter, fruit weight, days to first harvest, 100 seed weight and TSS of hybrids. Varieties exhibited moderate GCV and PCV for days to first male flower, days to first female flower, fruit equatorial diameter, fruit polar diameter, rind thickness, days to first harvest, crop duration, TSS, ascorbic acid and reducing sugar. Similar results were reported by Nisha *et al.* (2018) for days to first harvest and reducing sugar. Bhagyalekshmi (2019) reported moderate GCV and PCV for days to first male flower and days to first female flower in watermelon and Kamagoud *et al.* (2018) in oriental pickling melon for fruit diameter and flesh thickness.

Moderate PCV and low GCV were noted for fruit equatorial diameter, crop duration and reducing sugar of hybrids. Low values of PCV and GCV were observed for days to first male flower, days to first female flower and non reducing sugar content of hybrids. Low GCV and PCV were recorded for non reducing sugar content in varieties, which indicates the narrow genetic variability. This implies the need for generation of variability, either through introduction, exploration, or hybridization, in order to achieve substantial gain in their improvement.

5.5 HERITABILITY AND GENETIC ADVANCE

Estimation of GCV alone does not reveal the extent of variation that is heritable. So, in order to assess the proportion of total genetic variation, heritability in a broad

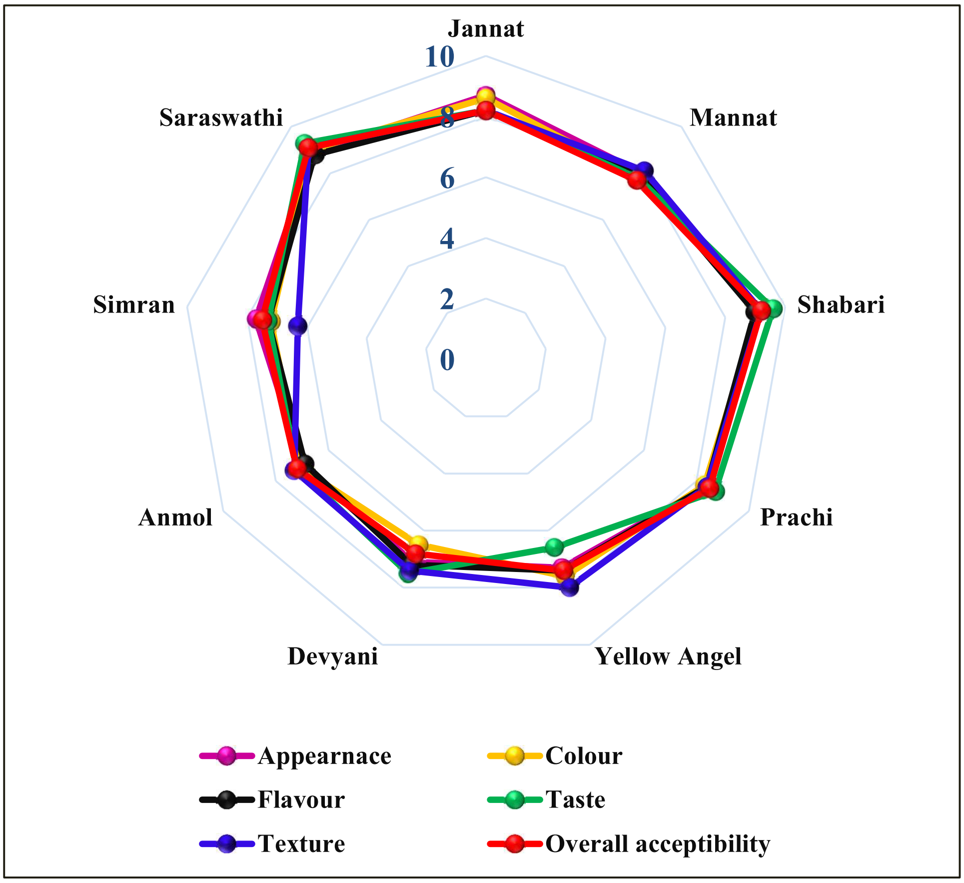


Fig. 14. Sensory evaluation of hybrids

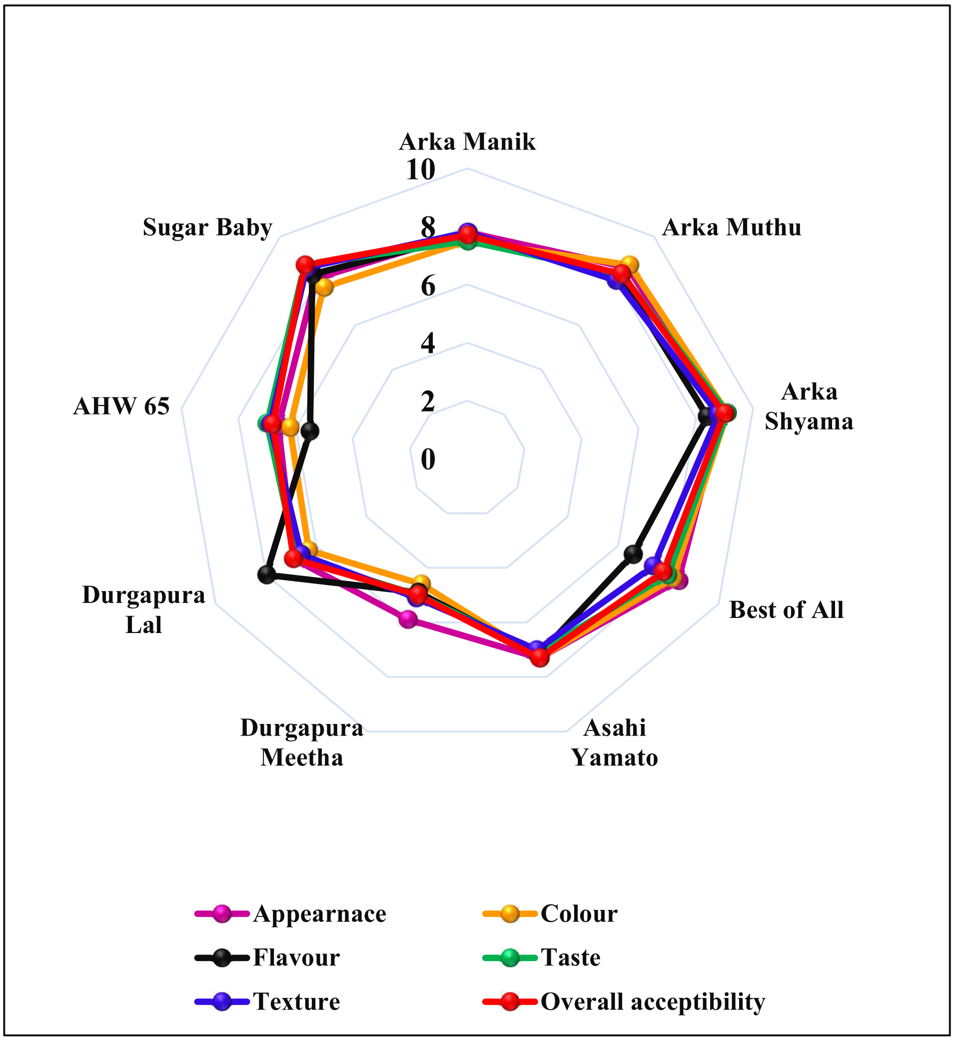


Fig. 15. Sensory evaluation of varieties

Shabari

Saraswati

Devayani

Plate 5. Best performing hybrids

Arka Shyama

Arka Muthu

Sugar Baby

Plate 6. Best performing varieties

sense must be estimated, which includes both additive and non additive gene effects. Higher heritability of character suggests that it is more stable in varied environments, providing a better opportunity for selecting a favourable genotype (Randhawa *et al.*, 1975). In general, heritability is determined by the amount of genetic variations present in a population as well as the conditions under which the genotypes are assessed. According to Panse (1957), only additive gene action can result in high GA. Therefore, heritability combined with GA would be more effective than heritability alone in selecting effective genotypes.

In the present study, high heritability was observed for all the characters studied. The magnitude of heritability of hybrids ranged from 54.25per cent to 99.66 per cent. The highest heritability was noticed for lycopene content followed by marketable yield per plot, yield per plot, node to first female flower, fruit weight, seeds per fruit, fruit polar diameter, node to first fruit, ascorbic acid, days to first harvest, number of branches per vine, node to first male flower, yield per plant, vine length, internodal length, fruits per plant, TSS, 100 seed weight, rind thickness, fruit equatorial diameter, reducing sugar, non reducing sugar, days to first male flower, days to first female flower and crop duration.

The magnitude of heritability of varieties ranged from 72.76 per cent to 99.65 per cent. The highest heritability was observed for seeds per fruit followed by fruit weight, yield per plot, internodal length, node to first fruit, vine length, marketable yield per plot, node to first male flower, 100 seed weight, node to first female flower, days to first male flower, fruit polar diameter, lycopene, days to first female flower, days to first harvest, fruit equatorial diameter, ascorbic acid, TSS, yield per plant, crop duration, number of branches per vine, fruits per plant, reducing sugar, rind thickness and non reducing sugar. High heritability indicates that the phenotype of the trait strongly reflects the genotype, implying that the genotypic constitution plays a significant role in the expression of characters. So, consistent selection could be made for these characters on the basis of phenotypic expression. Similar results were reported by Priya *et al.* (2004), Choudhary *et al.* (2012), Mahla and Choudhary (2013), Nisha *et al.* (2018) and Rabou and Sayd (2021) in watermelon; Choudhary *et al.* (2011) and Shivakumara (2019) in muskmelon and Singh *et al.* (2017) in bottle gourd.

High heritability coupled with high genetic advance as per cent of mean was observed for all characters in varieties except reducing sugars and non reducing sugars which had moderate genetic advance as per cent of mean. The traits *viz.,* vine length, number of branches per vine, internodal length, node to first male flower, node to first female flower, fruit polar diameter, rind thickness, fruit weight, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, seeds per fruit, 100 seed weight, TSS, lycopene and ascorbic acid content exhibited high heritability combined with high genetic advance as percent of mean in hybrids. This indicates that the additive genetic component plays a predominant role in the governance of these traits. Hence, there is scope for improvement of these traits via phenotypic selection. These results are in line with that of Prasad *et al.* (2002), Sundaram *et al.* (2011) and Anburani (2018) in watermelon; Pandey *et al.* (2005) in muskmelon and Islam *et al.* (2009) and Kumari *et al.* (2018) in bitter gourd.

Despite high heritability, genetic advance as per cent of mean was low to moderate for days to first male flower, days to first female flower, fruit equatorial diameter, crop duration, reducing sugar and non reducing sugar in hybrids which indicates non-additive gene action. Similar results were reported by Hakimi and Madidi (2015), Nisha *et al.* (2018) and Jamatia *et al.* (2019) in watermelon; Ramana (2000) in oriental pickling melon and Pandey and Singh (2007) in sponge gourd.

5.6 CORRELATION STUDIES

The yield of watermelon is a complex character, which is influenced by many other quantitative traits. For improvement of yield, selection based on yield components will be more beneficial. Correlation studies gives an information about nature and extent of relation between various quantitative traits which contributes to the yield. Positive or negative correlation can exist between the characters. Positive correlation allows for the simultaneous improvement in two or more traits, whereas, negative association indicates the need to compromise between desirable characters.

In this study, genotypic correlations were found to be higher than phenotypic correlations. This could be due to the masking effect of environment in modifying the total expression of the genotype, resulting in reduced phenotypic expression (Nandpuri *et al.*, 1973). This is in line with earlier findings by Priya (2001), Said and Fatiha (2015) and Nisha (2017) in watermelon.

Among hybrids, fruit yield per plant had significant positive association at genotypic and phenotypic levels with fruit equatorial diameter, fruit weight and fruits per plant. Positive correlation of fruit yield with fruit weight and fruits per plant was also reported by Mondal *et al.* (1989), Choudhary *et al.* (2012), Nisha *et al.* (2018), Anumala *et al.* (2020) and Bhagyalekshmi *et al.* (2020) in watermelon; Dey *et al.* (2005) and Kumari *et al.* (2018) in bitter gourd and Rukam *et al.* (2008), Tomar *et al.* (2008) and Mehta *et al.* (2009) in muskmelon. Vine length had highly significant positive correlation with days to first female flower, node to first female flower and days to first harvest. Days to first female flower was positively and significantly correlated with days to first harvest, node to first female flower, vine length and fruit equatorial diameter. This is in agreement with the findings of Gopal *et al.* (1996), Sundaram *et al.* (2011) and Nisha (2017) in watermelon; Ramana (2000) in oriental pickling melon and Harshawardhan *et al.* (2011) in muskmelon. Number of days to first harvest showed a significant positive correlation with days to first female flower, node to first female flower and vine length. This association might be useful in incorporating earliness in genotypes. These results are in line with the results of Sundaram *et al.* (2011) and Nisha (2017) in watermelon and Choudhary *et al.* (2004) in muskmelon. Fruit weight had significant positive interaction with fruit polar diameter, weight of hundred seeds and fruit equatorial diameter. Thus, any improvement in fruit weight would increase the fruit equatorial and polar diameters (Bhagyalekshmi *et al.*, 2020).

Among varieties, fruit yield per plant had significant positive association at genotypic and phenotypic levels with fruit weight and number of fruits per plant. Positive correlation of fruit yield with fruit weight and fruits per plant was also reported by Mondal *et al.* (1989), Choudhary *et al.* (2012), Nisha *et al.* (2018), Anumala *et al.* (2020) and Bhagyalekshmi *et al.* (2020) in watermelon. Vine length was positively and significantly correlated with node to first female flower, fruit polar diameter and days to first harvest. Number of days to first female flower showed a positive significant correlation with fruit equatorial diameter, days to first harvest and seeds per fruit. This is in line with the findings of Sundaram *et al.* (2011), Nisha (2017) and Bhagyalekshmi

(2019) in watermelon. Number of days to first harvest exhibited a significant positive interaction with vine length, days to first female flower, node to first harvest, fruit equatorial diameter, fruit weight and seeds per fruit which indicates that the application of selection pressure for shortest number of days to first harvest for getting small to medium sized fruits of market preference will be effective. These results are in agreement with Choudhary *et al.* (2012) and Bhagyalekshmi (2019) in watermelon and Ibrahim and Ramadan (2013) in sweet melon. Correlation of fruit weight with fruit equatorial diameter was positive and significant (Kumar and Wehner, 2011), while, it had non significant negative relationship with node to first female flower, fruits per plant and weight of 100 seeds. Selection for plants with highest fruit weight would improve fruit diameter but reduces the number of fruits.

5.7 PATH COEFFICIENT ANALYSIS

Correlation studies provide information about the positive and negative associations of various traits with yield as well as among themselves. However, the nature and extent of contribution of these characters to yield is uncertain. The total correlation between yield and its component characters can be misleading at some point of time because it can be a miscalculation or underestimation of its association with other traits that are also associated with economic yield. Path coefficient analysis, which considers both direct and indirect effects of the various yield components, can provide a more realistic picture of relationships between different traits.

Among yield attributes of hybrids and varieties, fruits per plant exerted the highest positive direct effect on yield per plant followed by days to first harvest. Fruit weight also exhibited the direct positive effect on yield. Since fruits per plant and fruit weight had a significant positive relationship with yield per plant, direct selection based on fruits per plant and fruit weight would result in increased yield per plant. These findings are in agreement with the studies of Choudhary *et al.* (2012), Nisha *et al.* (2018) and Bhagyalekshmi *et al.* (2020) in watermelon; Rahman *et al.* (2002) in snake gourd; Choudhary *et al.* (2004) in muskmelon; Kumar *et al.* (2018) in cucumber; Sulthana *et al.* (2018) in bottle gourd and Talukder *et al.* (2018) and Tyagi *et al.* (2018) in bitter gourd.

Among yield components of hybrids, fruit equatorial diameter, node to first female flower, fruit polar diameter and vine length also exhibited positive direct effect on yield per plant which is in accordance with Kumar *et al.* (2005) in pumpkin; Gayen and Hossain (2007) and Janaranjani and Kanthaswamy (2015) in bottle gourd and Nisha *et al.* (2018) in watermelon. Days to first female flower, seeds per fruits and weight of hundred seeds exhibited negative direct effect on yield. Nisha *et al.* (2018) also reported the negative direct effect of seeds per fruits and weight of hundred seeds on yield in watermelon.

Among yield traits of varieties, weight of hundred seeds and seeds per fruit exhibited positive direct effect on yield per plant. Bhagyalekshmi *et al.* (2020) reported similar results in watermelon. Vine length, days to first female flower, node to first female flower, fruit equatorial diameter and fruit polar diameter exerted negative direct effect on yield. Bhagyalekshmi (2019) also reported the similar results.

Number of fruits per plant and average fruit weight were the most important factors affecting the fruit yield per plant as they showed positive direct effects. Characters with a high positive correlation and direct effect at the genotypic level are useful for selection from the perspective of the breeder. Therefore, direct selection for these traits would be beneficial for increasing fruit yield per plant in watermelon.

Summary

6. SUMMARY

The present investigation entitled "Evaluation of watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] genotypes for growth, yield and quality" was carried out at the Department of Vegetable science, College of Agriculture, Vellayani from December 2020 to April 2021 with the objective to evaluate watermelon genotypes in Kerala for growth, yield and quality and thereby its adaptability.

In the experiment, 30 watermelon genotypes, including seventeen hybrids and thirteen varieties collected from public and private sectors were evaluated for yield and quality. Saraswati, the best performing hybrid and Sugar Baby the best performing variety from the previous research work conducted at Department of Vegetable Science was used as standard check for hybrids and varieties respectively. The evaluation was done in randomized block design with two replications. The extent of variability, heritability and genetic advance of genotypes were assessed. The degree and direction of association between various characters and the direct and indirect effects of various components on yield were also analyzed. The salient findings of the investigation are summarized below.

Observations were recorded throughout the cropping period. Vegetative and flowering characters like vine length, number of branches per vine, internodal length, days to first male flower, days to first female flower, node to first male flower and node to first female flower. Fruit and yield characters like fruit equatorial diameter, fruit polar diameter, rind thickness, fruit weight, days to first harvest, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, crop duration, seeds per fruit and 100 seed weight and quality characters such as total soluble solids (TSS), lycopene, ascorbic acid, reducing sugars and non reducing sugars were recorded. The incidence of pests and diseases were also monitored.

The results pertaining to the analysis of variance revealed significant differences among the seventeen hybrids and the thirteen varieties for all the characters studied. Among hybrids and check, the longest vine length was observed in Swarna (5.99 m) and the shortest in Jannat (2.84 m). The hybrid Prachi produced highest number of branches per vine (16.84). The highest internodal length was recorded in Jannat (12.95 cm). Jannat was the earliest to first male flower production (31.40 DAS), which was on par with Mannat (33.40 DAS), WHS -20011 (33.40 DAS) and Saraswati (33.50 DAS). The hybrid Jannat took least number of days to first female appearance (37.70 DAS), which was on par with Aarohi (37.80 DAS), Yellow Lion (38.20 DAS), Saraswati (38.30 DAS), Prachi (38.80 DAS), WHS-20011 (39.40 DAS), Vankat (39.50 DAS) and Mannat (40.10 DAS). The lowest node to first male flower was recorded in Yellow Lion (3.20) and the hybrids WHS-20011 (3.50), Prachi and Yellow Angel (3.60) were on par with it. The hybrid Yellow Angel produced the first female flower at earliest node (8.00), which was on par with Prachi (8.10).

The highest fruit equatorial diameter was observed in the hybrid Devyani (17.60 cm), which was on par with Shabari (17.50 cm), Jannat (16.85 cm), Anmol (16.75), Yellow Queen (16.75 cm) and Swarna (16.55 cm). The hybrid WHS-20011 recorded the highest fruit polar diameter (28.75 cm). The thickest rind was observed in WHS-20011 (2.15 cm) while the lowest rind thickness in Prachi (0.35 cm). The highest fruit weight was recorded in Mannat (3.34 kg). Prachi (62.00 DAS) took lowest number of days to first harvest and Jannat (65.00 DAS) was on par with it. The lowest mean value for node to first fruit was recorded by Vankat (10.40), which was on par with Prachi (10.60), Yellow Angel (10.60), Yellow Queen (10.70) and Saraswati (10.70). Shabari recorded the highest number of fruits per plant (4.20), yield per plant (11.84 kg), yield per plot (82.90) and marketable yield per plot (79.95 kg). The longest crop duration was observed in Swarna (120.50 days) and the shortest in Prachi (87.00 days). The highest number of seeds per fruit was noticed in the hybrid Yellow Lion (315.00), whereas Shonima and Swarna were seedless. Hybrid Mannat exhibited the highest 100 seed weight of 5.05 g, which was on par with Anmol (4.90 g), Jannat (4.85 g) and Devyani (4.70 g).

T.S.S content was highest for the hybrid Saraswati (12.25 ^{0}B), which was on par with Shabari (11.50 ^{0}B). The highest lycopene content was recorded by Mannat (7.61 mg

100g^{-1}). The highest ascorbic content was noticed in Prachi (6.35 mg 100g^{-1}). Reducing sugar content was highest in Shabari (3.23 per cent). The highest non reducing sugar content was recorded in hybrid Jannat (3.75 per cent). Sensory evaluation revealed the superiority of Shabari for appearance, colour, taste, texture and overall acceptability over other hybrids. The check Saraswati and Jannat ranked second and third in appearance and colour. But for parameters flavour, taste and texture, the check Saraswati and Prachi ranked second and third. Regarding overall acceptability, the highest mean score was recorded by Shabari (9.20) followed by the check Saraswati (9.10) and Prachi (8.50).

Among varieties and check, AHW 19 recorded the highest vine length of 5.18 m. Best of All (7.50) produced highest number of branches per vine. Arka Shyama took lowest number of 29.90 days to first male flower appearance followed by Thar Manak (31.50 DAS). Arka Shyama took shortest period of 35.80 days for first female flower anthesis. The lowest node to first male flower was recorded in Arka Muthu (3.30) and female flower in Asahi Yamato (10.40), which was on par with Thar Manak (10.60).

Durgapura Lal had the highest fruit equatorial diameter of 24.05 cm and AHW 65 recorded highest fruit polar diameter (27.80 cm). Check variety Sugar Baby had the highest rind thickness of 2.10 cm, which was on par with Arka Manik (1.95 cm) whereas, Asahi Yamato and Durgapura Kesar exhibited the lowest rind thickness of 1.20 cm. The highest fruit weight was noticed in Durgapura Meetha (4.76 kg), which was on par with Sugar Baby (4.67 kg). Arka Shyama (59.00 days) was the earliest for first harvest, which was on par with Thar Manak (62.50 days) and Arka Muthu (63.50 days). Asahi Yamato produced the first fruit at lowest node (11.30). Arka Shyama recorded the highest number of fruits per plant (3.00), yield per plant (9.82 kg), yield per plot (98.18 kg), marketable yield per plot (86.84 kg) and the lowest number of seeds (219.50). The highest crop duration was observed in Durgapura Lal (122.00 days). Crimson Sweet recorded the highest 100 seed weight (12.50 g), which was on par with Thar Manak (12.11 g).

Arka Shyama recorded the highest T.S.S (12.65 ^{0}B) and lycopene contents (6.4 mg 100g^{-1}). The highest reducing sugar (3.23 per cent) and non reducing sugar (3.85 per cent) was observed in Arka Manik. Sensory evaluation revealed the superiority of the the variety Arka Shyama for appearance, colour, taste, texture and overall acceptability over other varieties. The varieties Arka Muthu and Best of All ranked second and third for appearance and colour. But for the parameters flavour, taste and texture, the check Sugar Baby and Arka Muthu ranked second and third. Regarding overall acceptability, the highest mean score was recorded by Arka Shyama (9.00) followed by the check Sugar Baby (8.70) and Arka Muthu (8.30).

In hybrids, high phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for the characters vine length, number of branches per plant, internodal length, node to first male and female flower, rind thickness, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, seeds per fruit, lycopene and ascorbic acid content. Among the varieties, High GCV and PCV was observed for vine length, number of branches per plant, internodal length, node to first male and female flower, fruit weight, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, seeds per fruit, hundred seed weight and lycopene content. High estimates of heritability coupled with moderate to high genetic advance as per cent of mean were recorded for all the characters in varieties except reducing sugars and non reducing sugars which had moderate genetic advance as per cent of mean. The traits *viz.,* vine length, number of branches per vine, internodal length, node to first male flower, node to first female flower, fruit polar diameter, rind thickness, fruit weight, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, seeds per fruit, 100 seed weight, TSS, lycopene and ascorbic acid content exhibited high heritability combined with high genetic advance as percent of mean in hybrids, which indicates the additive gene action.

Yield per plant exhibited significant positive correlation at genotypic and phenotypic levels with fruit equatorial diameter, fruit weight and fruits per plant in hybrids, whereas in varieties, fruit weight and fruits per plant exhibited positive correlation with yield. Path analysis of hybrids revealed that fruits per plant (0.9290) exerted the highest positive direct effect on yield followed by days to first harvest (0.4422), fruit equatorial diameter (0.3070), node to first female flower (0.2204), fruit weight (0.1886), fruit polar diameter (0.0960) and vine length (0.0611). Days to first female flower (-0.6594), seeds per fruits (-0.0398) and weight of hundred seeds (-0.0884) exhibited negative direct effect on yield. In varieties, fruits per plant (1.6101) exerted maximum direct effect on yield per plant followed by days to first harvest (1.4909), weight of hundred seeds (0.7512), fruit weight (0.7104) and seeds per fruit (0.6682). Vine length (-0.2101), days to first female flower (-0.9175), node to first female flower (-0.1705), fruit equatorial diameter (-0.5025) and fruit polar diameter (-0.3706) exerted negative direct effect to yield per plant.

Based on the mean performance and sensory evaluation, the hybrids Shabari, Saraswati and Devyani and the varieties Arka Shyama, Arka Muthu and Sugar Baby were found best performing and suitable for growing under Vellayani condition.

FUTURE LINE OF WORK

The superior hybrids identified *viz.*, Shabari, Devyani and Saraswati and the superior varieties, Arka Shyama and Arka Muthu can be taken for multi location trials and if found superior can be recommended for commercial cultivation.

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Abstract

EVALUATION OF WATERMELON [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] GENOTYPES FOR GROWTH, YIELD AND QUALITY

by

PAVITHRA M.O.

(2019-12-006)

Abstract of the thesis

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

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COLLEGE OF AGRICULTURE

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KERALA, INDIA

2021

ABSTRACT

The present investigation entitled "Evaluation of watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] genotypes for growth, yield and quality" was carried out at the Department of Vegetable science, College of Agriculture, Vellayani from December 2020 to April 2021 to evaluate the performance of watermelon genotypes for growth, yield and quality.

The experimental material consisted of 30 watermelon genotypes, including seventeen hybrids and thirteen varieties. Saraswati, the best performing hybrid and Sugar Baby the best performing variety from the previous research work conducted at Department of Vegetable Science was used as standard check for hybrids and varieties respectively. The experiment was laid out in RBD with two replications. Analysis of variance revealed significant difference among the seventeen hybrids and the thirteen varieties for all the characters studied. Among hybrids and check, the longest vine length was observed in Swarna (5.99 m) and the shortest in Jannat (2.84 m). The hybrid Prachi produced highest number of branches per vine (16.84). The highest internodal length was recorded in Jannat (12.95 cm). Jannat was the earliest to first male and female flower production (31.40 DAS and 37.70 DAS respectively), which was on par with Mannat, WHS-20011 and Saraswati. The lowest node to first male flower was recorded in Yellow Lion (3.20) and the hybrids WHS-20011 (3.50), Prachi and Yellow Angel (3.60) were on par with it. The hybrid Yellow Angel produced the first female flower at earliest node (8.00), which was on par with Prachi (8.10).

The highest fruit equatorial diameter was observed in the hybrid Devyani (17.60 cm), which was on par with Shabari (17.50 cm), Jannat (16.85 cm), Anmol (16.75), Yellow Queen (16.75 cm) and Swarna (16.55 cm). The hybrid WHS-20011 recorded the highest fruit polar diameter (28.75 cm) and rind thickness (2.15 cm). The highest fruit weight was recorded in the hybrid Mannat (3.34 kg). Prachi (62.00 DAS) took lowest number of days to first harvest and Jannat (65.00 DAS) was on par with it. Shabari recorded the highest number of fruits per plant (4.20), yield per plant (11.84 kg), yield per

plot (82.90) and marketable yield per plot (79.95 kg). The longest crop duration was observed in Swarna (120.50 days) and the shortest in Prachi (87.00 days). The highest number of seeds per fruit was noticed in the hybrid Yellow Lion (315.00), whereas Shonima and Swarna were seedless. Hybrid Mannat exhibited the highest 100 seed weight of 5.05 g, which was on par with Anmol (4.90 g), Jannat (4.85 g) and Devyani (4.70 g). T.S.S content was highest for the hybrid Saraswati (12.25 ^{0}B), which was on par with Shabari (11.50 ^{0}B). The highest lycopene content was recorded by Mannat (7.61 mg 100g^{-1}). The highest ascorbic content was noticed in the hybrid Prachi (6.35 mg 100g^{-1}). Reducing sugar content was highest in the hybrid Shabari (3.23 per cent). The highest non reducing sugar content was recorded in hybrid Jannat (3.75 per cent).

Among varieties and check, AHW 19 recorded the highest vine length of 5.18 m. Best of All (7.50) produced highest number of branches per vine. Arka Shyama was the earliest for male and female flower production (29.90 DAS and 35.80 DAS respectively). The lowest node to first male flower was recorded in Arka Muthu (3.30) and female flower in Asahi Yamato (10.40), which was on par with Thar Manak (10.60). Durgapura Lal had the highest fruit equatorial diameter of 24.05 cm and AHW 65 recorded highest fruit polar diameter (27.80 cm). Check variety Sugar Baby had the highest rind thickness of 2.10 cm, which was on par with Arka Manik (1.95 cm). The highest fruit weight was noticed in Durgapura Meetha (4.76 kg), which was on par with Sugar Baby (4.67 kg). The variety Arka Shyama (59.00 days) was the earliest for first harvest, which was on par with Thar Manak (62.50 days) and Arka Muthu (63.50 days). Arka Shyama recorded the highest number of fruits per plant (3.00), yield per plant (9.82 kg), yield per plot (98.18 kg) and marketable yield per plot (86.84 kg) and the lowest number of seeds (219.50) The highest crop duration was observed in Durgapura Lal (122.00 days). Crimson Sweet recorded the highest 100 seed weight (12.50 g), which was on par with Thar Manak (12.11 g). Arka Shyama recorded the highest T.S.S (12.65 ^{0}B) and lycopene contents (6.40 mg 100g^{-1}). The highest reducing sugar (3.23 per cent) and non reducing sugar (3.85 per cent) was observed in Arka Manik.

High phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for the characters vine length, number of branches per plant, internodal length, node to first male and female flower, node to first fruit, fruits per plant, yield per plant, yield per plot, marketable yield per plot, seeds per fruit and lycopene in both hybrids and varieties. High estimates of heritability coupled with moderate to high genetic advance as per cent of mean were recorded for all the yield components, indicating additive gene action. Yield per plant exhibited significant positive correlation at genotypic and phenotypic levels with fruit equatorial diameter, fruit weight and fruits per plant in hybrids, whereas in varieties, fruit weight and fruits per plant exhibited positive correlation with yield. Path analysis of hybrids revealed that fruits per plant exerted the highest positive direct effect on yield followed by days to first harvest, fruit equatorial diameter, node to first female flower, fruit weight, fruit polar diameter and vine length. In varieties, fruits per plant exhibited highest direct effect on yield followed by days to first harvest, weight of hundred seeds, fruit weight and seeds per fruit.

Based on the mean performance and sensory evaluation, the hybrids Shabari, Saraswati and Devyani and the varieties Arka Shyama, Arka Muthu and Sugar Baby were found best performing and suitable for growing under Kerala conditions.

സംഗ്രഹം

'തണ്ണിമത്തന്റെ വിവിധ ഇനങ്ങളുടെ വളർച്ച, വിളവ്, ഗുണമേന്മ എന്നിവയുടെ മൂല്യനിർണ്ണയം' എന്ന വിഷയത്തെ സംബന്ധിച്ച ഒരു പഠനം വെള്ളായണി കാർഷിക കോളേജിലെ പച്ചക്കറി ശാസ്ത്ര വിഭാഗത്തിൽ ഡിസംബർ 2020 മുതൽ ഏപ്രിൽ 2021 വരെ നടത്തി. വളർച്ച, വിളവ്, ഗുണനിലവാരം എന്നിവ അടിസ്ഥാനമാക്കി കേരളത്തിൽ തണ്ണിമത്തൻ ഇനങ്ങളുടെ പ്രകടനം വിലയിരുത്തുക എന്നതായിരുന്നു ഈ പഠനത്തിന്റെ ഉദ്ദേശ്യം.

പതിനേഴു സങ്കരയിനങ്ങളും പതിമൂന്നു ഇനങ്ങളും ഉൾപ്പെടെ 30 തണ്ണിമത്തൻ ജനിതകയിനങ്ങളായിരുന്നു പഠനത്തിന് ഉപയോഗിച്ചത്. മുൻഗവേഷണ പ്രവർത്തനങ്ങളിൽ മികച്ച പ്രകടനം കാഴ്ചവെച്ച സരസ്വതിയും ഷുഗർ ബേബിയും യഥാക്രമം സങ്കരയിനങ്ങൾക്കും ഇനങ്ങൾക്കും സ്റ്റാൻഡേർഡ് ചെക്ക് ആയി ഉപയോഗിച്ചു.

സങ്കരയിനങ്ങളിൽ ഏറ്റവും നീളം കൂടിയ വള്ളി സ്വർണയിലും കുറവ് നീളം ജന്നത്തിലും രേഖപ്പെടുത്തി. ആൺപൂക്കളും പെൺപൂക്കളും ആദ്യം ഉണ്ടായതു ജന്നത്തിലാണ്. ഏറ്റവും വീതി കൂടിയ കായ്കൾ ദേവയാനിയിൽ രേഖപ്പെടുത്തി. തൂക്കം കൂടിയ കായ്കൾ മന്നത്തിൽ രേഖപ്പെടുത്തി. കായ്കളുടെ എണ്ണം, വിളവ്, വിപണനയോഗ്യമായ വിളവ് എന്നിവ ഏറ്റവും കൂടുതൽ ശബരിയിൽ നിരീക്ഷിക്കപ്പെട്ടു. സെൻസറി നിർണ്ണയത്തിൽ രുചി, നിറം എന്നിവയിൽ സങ്കരയിനം ശബരി മുന്നിട്ടു നിന്നു.

ഇനങ്ങളിൽ ഏറ്റവും നീളം കൂടിയ വള്ളി AHW 19 ൽ രേഖപ്പെടുത്തി. ആൺപൂക്കളും പെൺപൂക്കളും ആദ്യം ഉണ്ടായതു അർക്ക ശ്യാമയിലാണ്. റ്റി എസ് എസ് അളവിലും സെൻസറി നിർണയത്തിലും അർക്ക ശ്യാമ മുന്നിട്ടു നിന്നു. ഏറ്റവും കൂടുതൽ വിളവ്, ഒരു ചെടിയിൽ നിന്നും ഏറ്റവും കൂടുതൽ കായ്കൾ, വിപണനയോഗ്യമായ വിളവ് എന്നിവയെല്ലാം അർക്ക ശ്യാമ രേഖപ്പെടുത്തി. തൂക്കം കൂടിയ കായ്കൾ ദുർഗാപുര മീത്ത, ഷുഗർ ബേബി എന്നിവ രേഖപ്പെടുത്തി. ആദ്യ വിളവെടുപ്പിനു ഏറ്റവും

കുറഞ്ഞ ദൈർഘ്യം രേഖപ്പെടുത്തിയ ഇനങ്ങൾ അർക്ക ശ്യാമ, താർ മനക്, അർക്ക മുത്തു എന്നിവ.

വള്ളിയുടെ നീളം, ചെടിയുടെ ശാഖകളുടെ എണ്ണം, ഒരു ചെടിയിലെ വിളവ്, വിപണനയോഗ്യമായ വിളവ്, ഓരോ കായിലെയും വിത്തുകൾ എന്നിവയിൽ ബാഹ്യ പ്രകടന വ്യത്യാസങ്ങൾക്കു പുറമെ ജനിതക വ്യത്യാസവും രേഖപ്പെടുത്തി. പാത്ത് കോഎഫിഷിയെൻറ വിശകലനത്തിൽ, സങ്കരയിനങ്ങളിൽ, ഓരോ ചെടിയിലെയും കായ്കളുടെ എണ്ണം, ആദ്യ വിളവെടുപ്പ് ദൈർഘ്യം, കായ് വീതി, നീളം, തൂക്കം, ആദ്യമായി പെൺപൂവുണ്ടാകുന്ന മുട്ട്, ചെടി നീളം എന്നിവ ഓരോ ചെടിയിൽ നിന്നും ലഭിക്കുന്ന ശരാശരി വിളവുമായി ബന്ധപ്പെട്ടിരിക്കുന്നതായി കണ്ടെത്തി. ഇനങ്ങളിൽ, വിളവ് നിർണ്ണയിക്കുന്നതിൽ ഏറ്റവും പ്രധാന ഘടകം കായ്കളുടെ എണ്ണമാണെന്നു കണ്ടെത്തി.

ശരാശരി പ്രകടനത്തിന്റെയും സെൻസറി മൂല്യനിർണയത്തിന്റെയും അടിസ്ഥാനത്തിൽ സങ്കരയിനങ്ങളിൽ ശബരി, സരസ്വതി, ദേവയാനി എന്നിവയും ഇനങ്ങളിൽ അർക്ക ശ്യാമ,അർക്ക മുത്തു, ഷുഗർ ബേബി എന്നിവയും കേരളത്തിലെ സാഹചര്യങ്ങളിൽ വളർത്താൻ അനുയോജ്യമാണെന്ന് കണ്ടെത്തി.

Appendices

APPENDIX I

Standard week wise weather parameters during cropping period

(December 2020 to April 2021)

Standard weeks	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm)
	Maximum	Minimum	Maximum	Minimum		
52	33.2	23.6	89.8	74.0	0.0	3.0
1	32.0	23.6	95.0	84.0	32.2	2.2
2	30.4	24.0	94.0	88.0	37.7	1.3
3	32.0	24.2	93.0	77.0	1.4	2.5
4	32.6	22.2	92.0	72.0	0.0	3.6
5	33.0	23.7	91.0	69.1	0.0	3.9
6	33.0	21.4	92.0	72.0	0.0	4.2
7	33.0	20.4	89.0	71.0	0.0	4.3
8	33.3	23.4	91.0	72.0	0.0	4.6
9	33.4	22.5	88.0	68.0	0.0	4.4
10	34.0	20.4	90.0	66.0	0.0	4.6
11	34.3	23.0	88.0	65.0	0.0	4.8
12	34.1	25.4	88.9	68.3	0.0	4.2
13	34.1	25.8	90.0	72.0	70.5	3.7
14	34.3	26.4	88.3	76.1	0.0	4.9
15	33.4	25.6	90.9	79.0	64.3	3.5
16	33.4	25.4	87.3	79.3	10.5	4.0
17	34.1	26.1	88.0	77.3	6.4	4.4

APPENDIX II

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF WATERMELON

Name of the student: Pavithra M.O. (2019-12-006)

Title of thesis: Evaluation of watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] genotypes for growth, yield and quality

Criteria	**SAMPLES**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Appearance								
Colour								
Flavour								
Texture								
Taste								
Overall acceptability								

SCORE

Like Extremely	-9
Like Very Much	-8
Like Moderately	-7
Like Slightly	-6
Neither Like nor Dislike	-5
Dislike Slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Date: Name and Signature