Madras Agric. J., 95 (1-6): 24-31 January-June 2008
https://doi.org/10.29321/MAJ.10.100531

# Studies on heterosis expression and association of fruit yield and yield component characters among five intervarietal crosses of Vellari Melon *(Cucumis melo* L)

DEIVANAI SUBRAMANIAN
*Department of Biotechnology, Faculty of Applied Sciences, Asian Institute of Medicine, Science and Technology, Amanjaya, 08000 Sungai Petani Kedah Darul Aman, Malaysia.*

**Abstract: Vellari melon *(Cucumis melo* L.) is grown in India for its tender and ripe fruits. Lack of genetic variation limited its production potential. Heterosis has been widely used in agriculture to increase the yield. The present study aimed to exploit the heterotic vigor in Vellari melon and to find out the association of fruit yield with other fruit yield components for further crop improvement. Five crosses were made using Vellari melon and muskmelon, heterosis and correlation coefficient studies were carried out. The cross involving ARY x AJ (C5) alone recorded heterobeltiosis for fruit yield and number of fruits per vine in melon. The trait, number of fruits per vine showed positive and strong association with fruit yield. Whereas the other yield component characters were independent towards fruit yield.**

***Key words : Vellari melon, heterosis, correlation co-efficient, heterosis, yield component characters.***

## Introduction

*Cucumis melo* L. is a common crop in northern and southern India. In southern India it is mainly grown as a summer crop. There are many varietal forms of *Cucmis melo,* cultivated for various consumer requirements, *i.e.*. snap melon *(Cucmis melo* Var. *momordica* Duth and Full), Vellari melon and Long melon *(Cucmis melo* Var. *utilissimus* Duth and Full) for their tender or ripe fruits. In Tamil Nadu, the melon is grown in riverbeds and fallow wetlands. Much of importance is not given to its cultural operations. Limited popularity of the plant is due to very small number of varieties available in India. Lack of genetic variation and slow improvement in fruit production might have limited its popularity. Hence, there is a need to identify source of high fruit yielding melon. A greater emphasis should be given to generate genetic variation in this crop which could be later utilized to develop high yielding Vellari melons.

Breeding for high fruit yield has been a major objective of many cucumber-breeding programs over the last few decades (Wehner, 1989). Phenomenon of heterosis has been utilized in many crops to exploit dominance variance through the production of hybrids (Cramer and Wehner, 1999). The dominant alleles present in both the parents would favor increase in vigor (Xiao *et al.,* 1995). Heterosis for fruit size and fruit number per plant was first observed by Hayes and Jones (1916) in cucumber *(Cucumis sativus* L.). A successful cultivar must have traits other than high fruit yield. High fruit quality is one of the major important traits, which includes bright color, firm flesh texture, high sugar content and proper fruit shape (Gusmini and wehner, 2005).

**Table 1. Mean performance of parents and hybrids for various yield-contributing traits in vellari melon.**

| S.No | Parents & Hybrid combinations | Fruit length (cm) | Fruit diameter (cm) | Flesh thickness (cm) | TSS (%) | Fruit weight (kg) | No.of fruits/ plant | Yield/ plant (kg) |
|---|---|---|---|---|---|---|---|---|
| 1 | CO1 | 46.89 | 9.41 | 2.75 | 4.65 | 2.33 | 2.64 | 6.19 |
| 2 | PLR | 47.75 | 8.85 | 2.76 | 4.73 | 2.31 | 2.55 | 6.00 |
| 3 | KNM | 27.99 | 9.65 | 2.85 | 5.14 | 1.21 | 2.64 | 3.30 |
| 4 | CDM | 47.40 | 9.56 | 2.8 | 4.05 | 1.95 | 2.64 | 3.30 |
| 5 | ARY | 44.34 | 10.21 | 3.1 | 4.36 | 2.24 | 2.55 | 5.16 |
| 6 | AJ | 6.64 | 9.56 | 1.81 | 12.97 | 0.33 | 5.00 | 1.66 |
| 7 | HB | 17.20 | 11.82 | 2.88 | 11.54 | 1.24 | 2.55 | 3.25 |
| 8 | $C_1$ (CO1 x PLR) | 46.89 | 9.41 | 2.75 | 4.65 | 2.33 | 2.64 | 6.19 |
| 9 | $C_2$ (PLR x KNM) | 41.77 | 9.52 | 2.4 | 4.90 | 2.12 | 2.55 | 5.85 |
| 10 | $C_3$ (CDM x PLR) | 52.24 | 10.72 | 2.91 | 3.91 | 2.52 | 2.36 | 6.01 |
| 11 | $C_4$ (PLR x HB) | 36.45 | 10.05 | 2.84 | 7.45 | 2.25 | 2.55 | 5.89 |
| 12 | $C_5$ (ARY x AJ) | 53.55 | 14.03 | 4.14 | 5.52 | 4.94 | 2.27 | 11.15 |
| | SEd | 1.78 | 0.49 | 0.24 | 0.52 | 0.28 | 0.38 | 0.56 |
| | CD (P=0.05) | 5.54 | 1.52 | 0.74 | 1.62 | 0.86 | 1.19 | 1.73 |

The present study is therefore attempted to cross snap melon *(Cucmis melo* Var. *momordica* Duth and Full) and long melon *(C. melo* Var. *utilissimus* Duth and Full) with musk melon *(C. melo* Var. *reticulates* Naud.) to obtain more number of fruits with appropriate size to suit the consumer's need with high sweetness. The objective of this experiment is to examine the amount of heterosis for fruit yield and yield components and to associate the relationship among the fruit yield components to determine the efficiency of selection.

## Materials and Methods

Five local melons namely CO-1, CDM, PLR, ARY, KNM and two muskmelon types-Arka jeet (AJ) and Hales Best (HB) which are having high total soluble solids (TSS) and keeping quality were involved in the study.

*Planting techniques:*

Pits of size 30 x 30 x 30cm were prepared in a well-ploughed soil after application of farmyard manure (FYM). Pits were filled with sand and FYM mixture (1:1). The spacing between pits was 2 meters and within row of pits was 1.5 meters. Seven to eight seeds were sown in each pit. On the 10$^{th}$ day 3 to 4 seedlings were retained in each pit and the rest were thinned out. A manurial schedule of 40:20:40kg NPK per ha was followed; 50 percent of the dosage was applied as basal

**Table 2. Percentage Heterosis in Muskmelon Crosses**

| Characters | | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ |
|---|---|---|---|---|---|---|
| Fruit length | hi | 0.61 | 10.30* | 9.82* | 12.26* | 110.08* |
| | hii | -0.21 | -12.52* | 9.40* | -23.67* | 20.77* |
| | hiii | 1.43 | -11.09* | 11.20* | -22.41* | 13.99* |
| Fruit diameter | hi | 6.46 | 2.92 | 16.39* | -2.80 | 42.00* |
| | hii | 3.29 | -1.35 | 12.13* | -14.97* | 37.41* |
| | hiii | 3.29 | 1.17 | 13.92* | 6.80 | 49.09* |
| Flesh thickness | hi | -4.36 | -13.17 | 4.67 | 0.71 | 68.29* |
| | hii | -4.71 | -14.38 | 3.93 | -1.39 | 33.55* |
| | hiii | -4.36 | -11.27 | 5.82 | 3.27 | 50.54* |
| TSS | hi | -5.97 | -0.81 | -10.93 | -15.82* | -30.56* |
| | hii | -6.76 | -4.67 | -17.34 | -42.56* | -52.16* |
| | hiii | -5.16 | 5.37 | -15.91 | 60.22* | 18.71 |
| Fruit weight | hi | 15.52 | 20.45 | 18.31 | 27.12 | 285.94* |
| | hii | 15.02 | -8.23 | 9.09 | -2.59 | 120.54* |
| | hiii | 15.02 | -9.01 | 8.15 | -3.43 | 112.02* |
| Number of fruits per vine | hi | -9.23 | -1.92 | -9.23 | - | -40.26* |
| | hii | -10.61 | -3.41 | -10.61 | - | 54.60* |
| | hiii | -10.61 | -3.41 | -10.61 | 3.41 | -14.02* |
| Fruit yield per vine | hi | 4.84 | 25.82* | 4.89 | 27.21* | 206.32* |
| | hii | 3.23 | -2.50 | 0.17 | -1.83 | 98.75* |
| | hiii | 3.23 | -5.49 | -2.19 | -4.85 | 80.13* |

* Significance at P = 0.05.

dressing and the remaining 50 percent was applied in split doses, one on 15$^{th}$-day and the other on 30$^{th}$ day after sowing. Periodical weeding and irrigation were made as and when required. Furadan granules were applied at the time of sowing to avoid the occurrence of red pumpkin beetle *(Aulocophora foveicollis* L.) and endosulphon spray during flowering period to control fruit fly incidence. Bavistin and Dithane M-45 were sprayed to control powdery mildew and Anthracnose diseases.

*Hybridization Techniques:*

Mature hermaphrodite/pistillate flower buds that would open on the next day were chosen in the female parent. The hermaphrodite flower buds were emasculated with the help of fine forceps and bagged to prevent the contamination of foreign pollen. The pistillate flower buds were simply bagged. Mature staminate flower buds were also bagged. The staminate flowers were collected from the respective male parent and pollen was dusted over the stigma of the emasculated hermaphrodite/ pistillate flower of the female parent. The pollinated flowers were re-bagged and labeled. The crossed flowers were observed daily for successful fruit set.

*Heterosis estimation:*

Five crosses namely COlx PLR (Cl), PLR x KNM (C2), CDM x PLR (C3), PLR x HB (C4), and ARY x AJ (C5) were made. Seeds of the seven parental lines and five hybrid combinations were raised in randomized block design replicated twice. Observations were made on single plant basis for seven characters *viz.*, fruit length (cm), fruit diameter (cm), flesh thickness (cm), total soluble solids (TSS), (%) fruit weight (kg), number of fruits per vine and fruit yield per vine (kg). The mean performance of the parents and hybrids were studied and the results are presented in table - 1. Hybrid vigor was estimated for the seven characters in five cross combinations (table - 2) and expressed as percentage over mid-parent (hi _ relative heterosis), better parent (hii - heterobeltiosis), and standard variety - CO1 (hiii - standard heterosis).

*Correlation studies:*

Information on the correlation among different plant characteristics is of primary importance in crop improvement program. In many crops, yield has been portioned into its various components to better understand the factors that influence yield. Association among various fruit traits of melon was calculated for both the parents and the $F_1$ and is presented in table - 3.

**Result and Discussion:**

Five local types involved in this study were found to be poor yielder with 2.54 - 2.64 mean number of fruits per vine (Table-1). Among these, KNM had smaller fruit (1.21 kg) followed by CDM (1.95kg). Other three parents had fruit size of 2.24 -2.33kg. All the five parents are poor in TSS content ranging from 4.05 to 5.14 percent. The muskmelon AJ had a yield of five fruit per vine. But the fruit size was considerably small with high sugar content of about 12.97 percent. Hales Best also recorded high TSS of 11.54% with the same number of fruits and fruit size as CDM and KNM local types. Plants with large differences in their yield components were required for heterosis. Hence it was expected by crossing these parents a valuable recombination could be achieved. Further, sources of these parents were diverse and they were genetically different having contrasting characters. So the parents chosen were appropriate and relevant for genetic study.

**Table 3. Correlation coefficient (r) of single plant yield (kg) Vs other yield component traits observed in parents and hybrids**

| Parents | Fruit length | Fruit diameter | Flesh thickness | Fruit cavity size | No.of seeds per fruit | Total soluble solids | Fruit weight | No.of fruits per vine |
|---|---|---|---|---|---|---|---|---|
| CO-1 | 0.220 | 0.001 | 0.008 | -0.008 | 0.008 | 0.225 | -0.199 | 0.842** |
| PLR | 0.004 | 0.425 | 0.286 | 0.220 | 0.172 | -0.166 | 0.430 | 0.606** |
| CDM | 0.172 | -0.005 | -0.332 | 0.507 | -0.119 | -0.484 | 0.003 | 0.765** |
| KNM | 0.374 | 0.397 | 0.269 | 0.438 | 0.511 | -0.558 | 0.279 | -0.142 |
| ARY | -0.413 | -0.134 | -0.272 | -0.005 | -0.203 | -0.003 | -0.335 | 0.439 |
| AJ | 0.435 | 0.378 | -0.001 | 0.474 | -0.001 | -0.01 | -0.395 | 0.947** |
| HB | 0.229 | 0.345 | 0.534 | -0.007 | 0.275 | -0.751** | 0.194 | 0.984** |
| Crosses | | | | | | | | |
| $C_1$ | 0.646* | 0.625* | 0.594 | -0.528 | 0.517 | 0.452 | 0.366 | 0.993** |
| $C_2$ | 0.263 | 0.327 | 0.244 | 0.417 | 0.244 | 0.454 | 0.270 | 0.738** |
| $C_3$ | -0.214 | -0.138 | -0.106 | -0.218 | -0.243 | -0.002 | -0.329 | 0.859** |
| $C_4$ | -0.217 | -0.002 | 0.001 | -0.009 | -0.346 | -0.004 | 0.009 | 0.892** |
| $C_5$ | -0.007 | -0.267 | 0.005 | -0.687* | -0.001 | -0.006 | -0.006 | 0.950** |

* Significance at P = 0.05 ** Significance at P = 0.01

Heterosis has been widely used in agriculture to increase yield and to broaden adaptability of hybrid varieties. A hybrid should exhibit high heterobeltiosis for economic characters for successful commercial exploitation. The relative heterosis will only help to understand the genetic status of the characters (Moll and Stuber, 1974). In the present investigation relative heterosis (hi), heterobeltiosis (hii) and standard heterosis (hiii) were estimated for assessing the hybrid value for seven characters (Table 2).

High and positive heterobeltiosis was recorded for fruit length in the cross C3 (9.4%) and C5 (20.77%). While considering the relative heterosis all the hybrids except C1 exhibited positive relative heterosis. Positive relative heterosis for fruit length in melon was already reported (Mallick, 1981; Babu and Reddy, 1983; Kalb and Davis, 1984; Ganesan, 1988; and Monforte *et al.*, 2005).

For fruit diameter, the crosses C3 and C5 showed heterobeltiosis. It was interesting in the cross C4. According to Ganesan (1988) small diameter is always dominant over wider. Hence it is reasonable that this character is showing a negative heterosis. Lippert and Hall (1982) observed high variation for fruit size and suggested that this trait was amenable for quick improvement.

The cross C5 alone expressed significant heterobeltiosis for flesh thickness, while it was absent in all the others. Absences of heterobeltiosis were recorded for flesh thickness in earlier reports of Ganesan (1988) and Monforte *et al.* (2005).

TSS is the best indicator of fruit quality and probably the most important character with reference to consumer preferences (Kalb and Davis, 1984). All the crosses showed negative heterobeltiosis for TSS; particularly significant for the crosses C4 and C5. It was clear from the study that high TSS appeared to be recessive over low TSS. Several workers (Mallick, 1981; Kalb and Davis, 1984; Ganesan, 1988; and Monforte *et al.*, 2005) reported similar results in crosses involving other melon cultivars. Mishra and Seshadri (1985) and Abadia *et al.* (1985) found TSS to be intermediate in $F_1$ when compared with their parental performance.

The cross C5 again showed positive and significant heterobeltiosis for fruit weight, while in the other crosses the heterobeltiosis was absent. Babu and Reddy (1983) reported positive heterosis for fruit weight. On contrary to this report Monforte *et al.* (2005) observed highly variable heterosis from negative to positive values for fruit weight in some melon crosses. According to Pharr *et al.* (1985), the development of first fruit limits the supply of photosynthate and permit only one fruit to grow at a time. Hence high parent heterosis for fruit weight could be observed with no change in yield components over generations (Crammer and Wehner, 1999).

For the number of fruits per vine, the cross C5 recorded a significant heterobeltiosis while the relative heterosis was negative. It is understandable that the male parent in the cross-produced relatively more number of fruits. On the other hand, Kitroongruang *et al.* (1992) reported favorable heterosis over female parent for number of fruits per vine in melon crosses. Firpo *et al.* (1998) reported superior heterosis for total number of fruits per vine in crosses between Inbred lines derived from summer squash *(C. pepo)* population. Inter population crosses were reported to increase heterosis (Miranda and Fihlo, 1997) Heterobeltiosis for fruit yield (kg)/ vine was significant with 98.75% in cross C5 (ARY x AJ) while for all the others traits the heterobeltiosis was absent. Manifestation of heterosis for fruit yield over better parent is possible due to choice of wider array of parents used in hybridization programme (More and Seshadri, 1980).

The present investigation showed that only the cross C5 involving the parent ARY and AJ carried significant heterobeltiosis for all the yield component characters. It had also combined significant heterosis for fruit weight and fruit number. It was reflected in the total *per se* fruit per vine (98.75% heterobeltiosis).

Since all the quantitative characters are complexly inherited, simultaneous selections for all these characters with high expression always pose difficulty. However, if correlation coefficients are high for any two traits it will help in deciding the selection procedure. In the present study, correlation coefficient (r) was estimated between single plant yield on one hand and other fruit characters namely fruit length (cm), fruit diameter (cm), flesh thickness (cm), fruit cavity size (cm), fruit weight (g), number of seeds per fruit, TSS and number of fruits per vine on the other. Correlation coefficient was significant in yield per vine and number of fruits per vine, irrespective of parents and crosses (Table 3). Hence selection based on the basis of these traits would lead to an improvement in yield. Such high association between yield and number of fruits per vine was reported by Swamy *et al.* (1985) and Vijay (1987). Gusmini and Wehner (2005) noticed that the number of fruits per vine was more stable than fruit weight for yield measurement in cucumber and to develop new cultivars. It was also noted that character, number of fruits was not associated with all other yield components and yield *per se.* Further it was also to be noted that individual fruit weight was not associated wither *per se* yield per plant,

The other seven component characters behaved independently with yield, as evidenced by the absence of significant association among them. Other fruit characters such as fruit length, fruit diameter, flesh thickness, fruit weight and number of seeds per fruit were intercorrelated among themselves. Similar results were reported by earlier workers (Swamy *et al.*, 1985; More *et al.*, 1987 and Taha *et al.*, 2003). Contrary to this, Mallick (1981) reported negative relationship among fruit size, fruit weight, flesh thickness and TSS.

In the present study, TSS had no significant association with the fruit characters. Where as Kalyanasundaram (1976) reported negative relationship of TSS with all the fruit characters. He observed significant association only with fruit weight and seed number. The study revealed that any improvement in fruit characters like fruit size, fruit weight and flesh thickness would decrease the TSS. There may be undesirable linkage between these traits, which has to be broken and eliminated by biparental mating breeding procedure.

The study showed that the cross C5 recorded 98.75% of heterobeltiosis in the total *per se* fruit yield per vine and 54.60% in number of fruit per wine. Though the cross-recorded negative heterosis for TSS it carried significant heterobeltiosis for all the yield component characters. Hence it was suggested that cross C5 involving the parent ARY and AJ might be further exploited for improvement in fruit yield and TSS as it had high breeding value. And it was obvious from the study that the fruit size and other fruit character as well as TSS content were independent of per plant yield in inheritance. Whereas, number of fruits per vine which by itself independent of other fruit character was the only character that influenced the yield. Hence, while taking up the crop improvement program in this vellari melon, it should be attempted as simultaneous improvements on number of fruits on one hand and fruit size and TSS on the other might be considered.

## References

Abadia, J., Gomez, G.M.L., Caurtero, J. and Nuez, F. (1985). Inheritance of melon fruit characters. *Cucurbit Genetic Cooperative Report*, **38:** 34-35.

Babu, K.H, and Reddy, V.P. (1983). Heterosis in cucumber. *Andhra Agric. J.*, **30 (1):** 43-46.

Cramer, C.S. and Wehner, T.C. (1999). Little heterosis for yield and yield components in hybrids of six cucumber inbred. *Euphytica,* **110** : 99-108.

Firpo, I.T., Lopez Anido, F., Garcia, S.M. and Cointry, E. (1998). Heterosis in summer squash (*Cucurbita pepo* L.) *Cucubit Genetic Cooperative Report*, **21 :** 43-45.

Ganesan, J. (1988). Genetic studies on certain characters of economic importance in muskmelon *(Cucumis melo.* L). Ph.D. Thesis, Annamalai Univ., Tamil Nadu, India.

Hayes, H.K. and Jones, D.F. (1916). First generation crosses in cucumbers. *Conn. Agr. Exp Stn. Ann. Rep.*, 319-322.

Gusmimi, G. and Whener, T.C. (2005).. Foundation of yield improvement in watermelon. *Crop Sci.,* **45:** 141-146.

Lippert, L.F and Hall, M.O. (1982). Heritabilities and correlations in muskmelon from parent offspring regression analysis. *J.Amer. Soc. Hort. Sci.,* **107 (1):** 217-221.

Kalb, I.J.H. and Davis, D.W. (1984). Evaluation of combining ability, heterosis and genetic variance for maturity and plant characteristics in bush muskmelon. *J. Amer. Soc. Hort. Sci.,* **109(3):** 411-415.

Kalayanasundaram, P. (1976). Evaluation of three muskmelon cultivars *(Cucmis melo* L. var *reticulates* Nand.). *South Indian Hort.,* **24 (1):** 18-23.

Kitroongruang, N, Poo-Swang, W. and Tokumasu, S. (1992). Evaluation of combining ability, heterosis and genetic variation for plant growth and fruit quality characteristics of Thai-melon *(Cucumis melo* L., var. *acidulous* Naud.) *Scientia Hoticulturae,* **50 (1-2):** 79- 87.

Mallick, M.F.R. (1981). Studies on the physiology, biochemistry and genetics of acidity and certain other fruit character in muskmelon *(Cucumis melo* L.) Ph.D. Thesis, Annamalai Univ., Tamil Nadu, India.

Mishra, J.P. and Seshadri, V.S. (1985). Male sterility in muskmelon. II. Studies on heterosis. *Genetics Agraria,* **39 (40):** 367-376.

Miranda and Fihlo, J.B. (1997). Inbreeding and heterosis. In the genetics and exploitation of heterosis in crops. An international symposium, CIMMYT, Mexico D.F., Mexico, 12-13.

Moll, R.H. and Stuber, C.W. (1974). Quantitative genetics empherical results relevant to plant breeding. *Adv. Agron.,* **26:** 277-313.

Monforte, J. Eduardo, I., Abad, S and Arus, P. (2005). Inheritance mode of fruit traits in melon: heterosis for fruit shape and its correlation with genetic distance. *Euphytica,* **144 (1-2):** 31-38.

More, T.A and Seshardri, V.S. (1980). Studies on heterosis in Muskmelon *(Cucumis melo* L.). *Veg. Sci.,* **8 (1):** 27-40.

More, T.A., Mishra, J.P., Seshadri, V.S., Doshi, S.P. and Sharma, J.C. (1987). Association of fruit shape with flesh area and flesh proportion in muskmelon. *Ann. Agrl. Res.,* **8 (2):** 237-242.

Pharr, D.M., Huber, S.C. and Sox, H.N. (1985). Leaf carbohydrate status and enzymes of translocate synthesis in fruiting and vegetative plants of *Cucumis sativus* L. *Plant Physiology,* **77:** 104-108.

Swamy, K.R.M., Dutta, O.P., Ramachandran, P.R. and Wahi, S.D. (1985). Variability studies in muskmelon *(Cucumis melo.* L). *Madras Agric. J.,* **72 (1):** 1-5.

Taha, M., Omara, K. and El Jack, A. (2003). Correlation among growth, yield and quality characters in *Cucumis melo* L. *Cucurbit Genetics Cooperative report.,* **26:** 9-11.

Vijay.O.P. (1987). Genetic variability, correlation and path analysis in muskmelon *(Cucumis melo.* L) *Indian J. Hort.,* **44 (3-4):** 233-238.

Wehner, T.C. (1989). Breeding for improved yield in cucumber. Plant Breed. Rev. (Ed.) J. Janick **(9):** 323-359.

Xiao, J., Li, J., Yuan, L. and Tanksley, S.D. (1995) Dominance is the major genetic basis of heterosis in rice revealed by QTL analysis using molecular markers. *Genetics,* **140:** 745-754.