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# Generation mean analysis of yield and its components in muskmelon (*Cucumis melo* L.)

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**ABSTRACT :** The nature and magnitude of gene action was analysed in six generation mean for yield related characters of five crosses in muskmelon. Study indicated that magnitude of dominance effect was higher for almost all the five cross combinations for the characters *viz*., number of female flowers, days required for first harvest of fruits, number of fruits per vine, yield per vine, and weight of fruit. The additive and additive x dominance effects were equally important in some combination for most of the characters. Dominance x dominance gene effects were greater magnitude followed by additive x additive and additive x dominance for node at which days required for first harvest of fruit, fruit weight, respectively in both summer and *Kharif* season. The selection for these characters should be postponed to later generation. The gene effects revealed that there was predominance of dominance gene effects for most of the characters in most of the all combinations. Duplicate type of epistasis was observed for most of the crosses. Significant epistatic gene effects coupled with duplicate epistasis indicated that through effective selection, exploitation of heterosis breeding.

**KEY WORDS :** Generation mean analysis, Yield characters, Non-allelic interaction

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Muskmelon (*Cucumis melo* L.) is an important commercial crop of the tropics and sub tropics, grown all over the world. In India it is popular in Northern part of country especially in Uttar Pradesh and Punjab and is grown in almost every place in the plains. Muskmelon has many vernacular names, such as 'Kharbooz'(Hindi), 'Kharbuz'(Punjabi), 'Sakkatoli' (Gujarati), 'Kalinga' (Sanskrit), 'Velapalam'(Tamil) and 'Kekkarikai' (Kannada). Muskmelon (2n=24) belongs to the family Cucurbitaceae and edible melons belong to either *Cucumis melo var. reticulatus* or *Cucumis melo var. cantaloupensis*. Plants are either monoecious or andromonoecious annuals with long trailing vines with shallow lobed round leaves.Muskmelon occupies an area of 14.34 lakh ha with an annual production of 398.51 lakh tonnes in the world (Anonymous, 2010). In India, it is cultivated in an area of 1.79 ha with annual production of 16.07 lakh tonnes (Anonymous, 2010). Estimation of genetic parameters is needed to understand the genetic architecture of yield and yield contributing components. Information about the mode of inheritance, type of gene action (Hayman, 1958) and heritability (Warner, 1952) of all the yield contributing components would be of immense help for a plant breeder to decide about the proper breeding procedure to be adopted and the characters on which the selection has to be made. This can enhance the effectiveness of selection for yield and fruit quality and their contributing factors.

## RESEARCH METHODS

The experiment was carried out at the Instructional cum research farm, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during the summer 2010 and *Kharif* 2010. The seed material of five varieties of muskmelon and their five promising $F_1$ hybrids *viz*., (1) Durgapur Selection x Punjab Sunehari, (2) Hara Madhu x IVMM-3, (3) Hara Madhu x Punjab Sunehari, (4) IVMM-3 x Pusa Madhuras and (5) IVMM-3 x Punjab Sunehari. The seed of all the five parents and their five $F_1$ crosses were sown in separate plots on ridges and furrows with spacing of 2 x 1m, each entry was represented by two rows of 5 m length for production of seeds of $F_1$, $F_2$, $BC_1$, $BC_2$, $P_1$ and $P_2$ generations. A few plants of each parent and their $F_1$'s were selfed with

butter paper bags for production of $P_1$, $P_2$ and $F_2$ seeds, respectively. Five $F_1$ crosses mentioned in and their back crosses were made for obtaining the seed of $F_1$, $BC_1$, and $BC_2$ generation using following procedure.

In order to get crossed seed, the flower buds of female and male parents were bagged a day prior to anthesis. On the next day morning, bagged flower bud from desired male parent was plucked and the pollens were dusted on the receptive stigma of desired female. In order to get assured good cross seed, the pollination was done for a period of fifteen days by adopting same procedure. At the same time the parents were also selfed to obtain pure seed of each parent. In this way sufficient selfed and crossed seed were obtained. The extracted seeds were dried properly and kept in perforated paper bags (Sidhu *et al*, 1980). Seed materials of six generations, *viz*., $P_1$, $P_2$, $F_1$, $F_2$, $BC_1$ and $BC_2$ of five $F_1$ hybrids were evaluated during summer 2010 and *Kharif* 2010.

## RESEARCH FINDINGS AND DISCUSSION

The crosswise analysis of variance (Table 1) for different generations showed highly significant differences for all the characters. The crosses and generations for all the characters which indicated high degree of variability among the genetic stock of the muskmelon (*Cucumis melo* L.) selected for this study. Further estimation of components of gene action was, therefore, undertaken for number of female flowers, days required for first harvest of fruits, number of fruits per vine, yield per vine, and weight of fruit.

The mean value of parents, hybrids, $F_2$'s, $BC_1$'s and $BC_2$'s for five characters under study was averaged over replication and presented in Table 2.The parent Durgapur Selection (13.50) had maximum number of female flowers per vine in summer season whereas; in *Kharif* season parent Punjab Sunehari (10.60) had maximum number of female flowers per vine. Among the $F_2$'s, the $F_2$ of cross 5 (IVMM-3 x Pusa Madhuras) recorded highest number of female flowers per vine (13.20 and 12.20) and the $F_2$ of cross 3 (Hara Madhu x Punjab Sunehari) recorded lowest female flowers per vine (9.60 and 10.60) in both seasons. Among the parents Durgapur Selection was significantly earliest to harvest the first fruit in both the seasons with mean value of 72.00 days in summer and 66.50 days in *Kharif* season than the rest of the parents. The earliness in first fruit harvest was obtained in the hybrids, cross 1 Durgapur Selection x Punjab Sunehari (72.00 and 78.00 days) in both seasons. Amongst $F_2$'s, the $F_2$ of cross 1 Durgapur Selection x Punjab Sunehari (75.70 days) showed the earlier fruit harvest in summer season. Whereas in *Kharif* season cross 5 IVMM-3 x Punjab Sunehari (82.60 days) showed the earlier fruit harvest; while cross 3 Hara Madhu x Punjab Sunehari (91.80) was the late to harvest in summer season and cross 2 Hara Madhu x IVMM-3 (88.30 days) ) was the late to harvest in *Kharif* season.

The parents Punjab Sunehari (2.90 and 2.80) and IVMM-3 (2.80 and 2.40) had maximum number of fruits per vine and parent, Durgapur Selection (2.30) had minimum number of fruits per vine in summer season while in *Kharif* season Hara Madhu (2.10) had minimum number of fruits per vine. Among the hybrids, cross 5 IVMM-3 x Punjab Sunehari (3.30 and 3.20) recorded the highest number of fruits per vine in both season and cross 1 Durgapur Selection x Punjab Sunehari (3.00 and 2.50) recorded the lowest number of fruits per vine in both seasons. The parents Durgapur Selection (1.90 and 1.70), had maximum fruit yield per vine in both season. Among the hybrids cross 5 IVMM-3 x Punjab Sunehari (2.80 and 2.32) exhibited maximum fruit yield per vine in both season and cross 1 Durgapur Selection x Punjab Sunehari (2.20 and 1.77) exhibited minimum fruit yield per vine in summer season.

In the group of $F_2$'s, the $F_2$ of cross 5 IVMM-3 x Punjab Sunehari (2.60 and 2.05) recorded the highest fruit yield per vine in both seasons. The highest fruit yield per vine was recorded by cross 2 (Hara Madhu x IVMM-3) x Hara Madhu (2.20 and 1.85) amongst all $BC_1$'s while the $BC_1$ of cross 4 (IVMM-3 x Pusa Madhuras) x IVMM-3 (1.85 and 1.50) recorded the lowest fruit yield per vine in both season. Amongst the group of $BC_2$'s the highest and lowest fruit yield per vine recorded by cross 5 (IVMM-3 x Punjab Sunehari) x Punjab Sunehari (2.24 and 1.71) and cross 4 (IVMM-3 x Pusa Madhuras) x Pusa Madhuras (1.78 and 1.40), respectively. Amongst all $F_2$'s, the $F_2$ of cross 5 (IVMM-3 x Punjab Sunehari) exhibited the highest fruit weight (848.00 and 775.00) and $F_2$ of cross 4 (IVMM-3 x Pusa Madhuras) showed the lowest fruit weight (671.00 and 659.00) in both the summer and *Kharif* seasons. In all $BC_1$'s, the $BC_1$ of cross 1 (Durgapur Selection x Punjab Sunehari) x Durgapur Selection recorded the highest fruit weight (782.00 and 771.70) and $BC_1$ of cross 4 (IVMM-3 x Pusa Madhuras) x IVMM-3 expressed lowest fruit weight (660.00 and 643.00) in both season. In case $BC_2$'s, the $BC_2$ of cross 5 (IVMM-3 x Punjab Sunehari) x Punjab Sunehari recorded the highest fruit weight (758.00 and 692.00) and $BC_2$ of cross 3 (Hara Madhu x Punjab Sunehari) x Punjab Sunehari showed the minimum fruit weight (626 and 570.50) in both the summer and *Kharif* seasons.

The overall performance of different population *viz.*, parents $F_1$'s, $F_2$'s, $BC_1$'s and $BC_2$'s revealed that Punjab Sunehari among the parents, had exhibited highest number of female flowers, days required for first harvest of fruits, number of fruits per vine, yield per vine, and weight of fruit in both the seasons.

Significance of the scaling and Cavalli's joint scaling tests (Table 3 and 4) strongly suggest that there were non-allelic interaction and failure of additive and dominance model in all the five crosses for number of female flowers, days required for first harvest of fruits, number of fruits per vine, yield per vine, and weight of fruit whereas in cross 4 for number of fruits per vine indicated presence of non-additive and failure of additive model in both summer and *Kharif* season.

The estimates of the six parameters for five characters

are presented (Table 5). Among the three types of digenic interactions the values of additive x additive (i), additive x dominance (j) and dominance x dominance (l) were significant in cross 1 (Durgapur Selection x Punjab Sunehari) and cross 3 (Hara Madhu x Punjab Sunehari) in both summer and *Kharif* season for number of female flowers per vine. The additive x additive (i) and dominance x dominance (l) gene interactions showed significant in cross 1 (Durgapur Selection x Punjab Sunehari), cross 3 (Hara Madhu x Punjab Sunehari) and cross 5 (IVMM-3 x Punjab Sunehari) in both summer and *Kharif* season. The additive x dominance (j) gene effects were found to be significant in cross 1 (Durgapur Selection x Punjab Sunehari) and cross 3 (Hara Madhu x Punjab Sunehari) in both summer and *Kharif* season. The signs of *h* and *l* were in opposite direction and hence, duplicate type of interaction was noticed except cross 5 (IVMM-3 x Punjab Sunehari) in both summer and *Kharif* season.

For the days required for first harvest of fruits as regards the epistasis digenic interaction the values of additive x additive (i), additive x dominance (j) and dominance x dominance (l) were significant in cross 1 (Durgapur Selection x Punjab Sunehari) and cross 3 (IVMM-3 x Punjab Sunehari) in both summer and *Kharif* season. The additive x additive (i) gene effects were significant for all the crosses except 2 (Hara Madhu x IVMM-3) in both summer and *Kharif* season. The magnitude of additive x dominance (j) gene effects were found to be significant in cross 1(Durgapur Selection x Punjab Sunehari) and cross 3 (IVMM-3 x Punjab Sunehari) in both summer and *Kharif* season. The dominance x dominance (l) gene effects were found to significant in all the crosses except cross 2 (Hara Madhu x IVMM-3) and cross 4 (IVMM-3 x Pusa Madhuras) in both summer and *Kharif* season.

Both the additive and dominance gene effects were almost equally important in respect of fruit yield per vine. The cross 3 (Hara Madhu x IVMM-3) recorded the highest magnitude of additive gene effects in both summer and *Kharif* season. The dominance gene effects were found to be significant for all the crosses in both summer and *Kharif* season. The magnitude of dominance gene effects was greater than those of additive gene effects in the crosses cross 1(Durgapur Selection x Punjab Sunehari) and cross 2 (Hara Madhu xx IVMM-3) in both summer and *Kharif* season.

The highest fruit weight was recorded by parent Durgapur Selection (780.00 and 770.00) in both seasons. Among the hybrids, cross 5 IVMM-3 x Punjab Sunehari) (930.00 and 855.00) recorded highest fruit weight in both seasons. Amongst all $F_2$'s, the $F_2$ of cross 5 (IVMM-3 x Punjab Sunehari) exhibited the highest fruit weight (848.00 and 775.00) and $F_2$ of cross 4 (IVMM-3 x Pusa Madhuras) showed the lowest fruit weight (671.00 and 659.00) in both the summer and *Kharif* seasons. In all $BC_1$'s, the $BC_1$ of cross 1 (Durgapur Selection x Punjab Sunehari) x Durgapur Selection recorded

**Table 1 : Analysis of variance for five characters in muskmelon during summer and *Kharif* 2010-2011**

| Source | d.f. | Number of female flowers per vine | | Days required for 1st harvest of fruits | | Number of fruits per vine | | Yield per vine (kg) | | Weight of fruit (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* |
| **Cross 1** | | | | | | | | | | | |
| Replication | 1 | 0.03 | 0.01 | 0.09 | 0.05 | 0.01 | 0.01 | 0.02 | 0.01 | 17.52 | 9.47 |
| Treatment | 5 | 19.44** | 3.88** | 21.91** | 58.45** | 0.53** | 0.49** | 0.26** | 0.22** | 669.81** | 654.78** |
| Error | 5 | 0.10 | 0.02 | 0.13 | 0.08 | 0.01 | 0.01 | 0.01 | 0.04 | 1.10 | 0.90 |
| **Cross 2** | | | | | | | | | | | |
| Replication | 1 | 0.02 | 0.01 | 0.03 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 49.00 | 31.00 |
| Treatment | 5 | 1.09** | 2.13** | 18.13** | 21.15** | 0.14* | 0.09* | 0.064* | 0.05* | 153.14* | 162.36** |
| Error | 5 | 0.01 | 0.01 | 0.16 | 0.09 | 0.02 | 0.01 | 0.04 | 0.01 | 25.94 | 21.32 |
| **Cross 3** | | | | | | | | | | | |
| Replication | 1 | 0.92 | 0.69 | 0.08 | 0.06 | 0.01 | 0.01 | 0.01 | 0.02 | 27.30 | 19.22 |
| Treatment | 5 | 22.01** | 6.20** | 16.08** | 15.59** | 0.38** | 0.21** | 0.22** | 0.19** | 725.92** | 843.22** |
| Error | 5 | 0.08 | 0.05 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 16.72 | 11.42 |
| **Cross 4** | | | | | | | | | | | |
| Replication | 1 | 0.02 | 0.01 | 0.09 | 0.09 | 0.04 | 0.05 | 0.01 | 0.01 | 4.94 | 3.54 |
| Treatment | 5 | 1.29** | 2.49** | 5.18** | 3.48** | 0.08* | 0.06* | 0.04* | 0.03* | 2794.59** | 2743.32** |
| Error | 5 | 0.01 | 0.01 | 0.06 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 2.80 | 2.20 |
| **Cross 5** | | | | | | | | | | | |
| Replication | 1 | 0.49 | 0.32 | 0.02 | 0.01 | 0.10 | 0.05 | 0.03 | 0.01 | 0.12 | 0.07 |
| Treatment | 5 | 23.22** | 6.10** | 24.99** | 106.07** | 0.32** | 0.19** | 0.22** | 0.18** | 6091.60** | 6141.67** |
| Error | 5 | 0.34 | 0.21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.001 | 0.14 | 0.09 |

* and ** indicate significance of values at P=0.05 and 0.01, respectively

**Table 2 : Mean performance of parents, $F_1$'s, $F_2$'s and back crosses for five characters in muskmelon during summer and *Kharif* 2010-2011**

| Cross/ | $P_1$ | | $P_2$ | | $F_1$ | | $F_2$ | | $BC_1$ | | $BC_{2s}$ | | S.E.± | | C.D. (P=0.05) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| characters | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* |
| **Number of female flowers per vine** | | | | | | | | | | | | | | | | |
| Cross 1 | 13.50 | 8.90 | 13.00 | 10.60 | 13.10 | 11.00 | 10.30 | 10.70 | 12.70 | 9.80 | 12.50 | 10.70 | 0.10 | 0.13 | 0.38 | 0.49 |
| Cross 2 | 10.80 | 8.50 | 10.90 | 10.20 | 13.50 | 11.20 | 12.60 | 10.90 | 12.20 | 9.50 | 12.10 | 10.40 | 0.08 | 0.10 | 0.27 | 0.37 |
| Cross 3 | 10.80 | 8.50 | 13.00 | 10.60 | 15.00 | 10.30 | 9.60 | 10.60 | 10.30 | 9.40 | 11.10 | 10.90 | 0.20 | 0.23 | 0.73 | 0.84 |
| Cross 4 | 10.90 | 10.20 | 9.80 | 9.20 | 13.30 | 11.92 | 13.00 | 11.20 | 12.30 | 10.50 | 11.80 | 10.00 | 0.09 | 0.11 | 0.33 | 0.41 |
| Cross 5 | 10.90 | 10.20 | 13.00 | 10.60 | 13.70 | 12.50 | 13.20 | 12.20 | 11.80 | 10.70 | 12.50 | 11.20 | 0.41 | 0.44 | 1.50 | 1.58 |
| **Days required for 1st harvest of fruits** | | | | | | | | | | | | | | | | |
| Cross 1 | 72.00 | 66.50 | 83.30 | 74.00 | 72.00 | 78.00 | 75.70 | 82.50 | 71.10 | 72.30 | 76.80 | 78.70 | 0.26 | 0.29 | 0.94 | 1.05 |
| Cross 2 | 92.50 | 76.90 | 86.50 | 77.50 | 79.80 | 80.90 | 84.70 | 88.30 | 86.30 | 82.77 | 83.30 | 78.40 | 1.81 | 1.84 | 6.59 | 6.67 |
| Cross 3 | 92.50 | 76.90 | 83.30 | 74.00 | 91.50 | 84.40 | 91.80 | 84.72 | 91.90 | 85.80 | 87.30 | 78.50 | 0.11 | 0.15 | 0.41 | 0.53 |
| Cross 4 | 86.50 | 77.50 | 87.50 | 79.02 | 82.00 | 84.70 | 84.90 | 85.65 | 84.30 | 84.90 | 84.80 | 81.50 | 0.05 | 0.07 | 0.18 | 0.25 |
| Cross 5 | 86.50 | 77.50 | 83.30 | 74.00 | 77.00 | 80.30 | 82.00 | 82.60 | 81.70 | 80.30 | 80.00 | 78.80 | 0.10 | 0.12 | 0.35 | 0.44 |
| **Number of fruits per vine** | | | | | | | | | | | | | | | | |
| Cross 1 | 2.30 | 2.20 | 2.90 | 2.80 | 3.00 | 2.50 | 2.60 | 2.40 | 2.50 | 2.40 | 2.80 | 2.80 | 0.10 | 0.13 | 0.36 | 0.47 |
| Cross 2 | 2.60 | 2.10 | 2.80 | 2.40 | 3.10 | 2.80 | 2.70 | 2.50 | 2.80 | 2.20 | 2.90 | 2.60 | 0.11 | 0.14 | 0.41 | 0.51 |
| Cross 3 | 2.60 | 2.10 | 2.90 | 2.80 | 3.20 | 2.95 | 2.50 | 2.50 | 2.80 | 2.58 | 2.80 | 2.78 | 0.12 | 0.15 | 0.42 | 0.54 |
| Cross 4 | 2.80 | 2.40 | 2.60 | 2.30 | 3.10 | 2.60 | 2.80 | 2.80 | 2.90 | 2.35 | 2.80 | 2.65 | 0.08 | 0.10 | 0.28 | 0.36 |
| Cross 5 | 2.80 | 2.40 | 2.90 | 2.80 | 3.30 | 3.20 | 3.00 | 2.90 | 3.00 | 2.60 | 2.90 | 2.85 | 0.08 | 0.11 | 0.31 | 0.39 |
| **Yield per vine (kg)** | | | | | | | | | | | | | | | | |
| Cross 1 | 1.90 | 1.70 | 1.70 | 1.50 | 2.20 | 1.77 | 2.00 | 1.60 | 1.98 | 1.51 | 1.94 | 1.70 | 0.07 | 0.10 | 0.24 | 0.35 |
| Cross 2 | 1.80 | 1.40 | 1.75 | 1.45 | 2.79 | 1.90 | 2.50 | 1.80 | 2.20 | 1.85 | 2.20 | 1.45 | 0.07 | 0.10 | 0.25 | 0.35 |
| Cross 3 | 1.80 | 1.40 | 1.70 | 1.50 | 2.22 | 1.88 | 2.07 | 1.40 | 1.90 | 1.60 | 1.80 | 1.43 | 0.08 | 0.11 | 0.29 | 0.41 |
| Cross 4 | 1.75 | 1.45 | 1.50 | 1.25 | 2.23 | 1.70 | 2.05 | 1.74 | 1.85 | 1.50 | 1.78 | 1.40 | 0.05 | 0.07 | 0.19 | 0.27 |
| Cross 5 | 1.75 | 1.45 | 1.70 | 1.50 | 2.80 | 2.32 | 2.60 | 2.05 | 2.15 | 1.77 | 2.24 | 1.71 | 0.05 | 0.08 | 0.19 | 0.28 |
| **Weight of fruit (g)** | | | | | | | | | | | | | | | | |
| Cross 1 | 780.00 | 770.00 | 583.00 | 542.30 | 798.00 | 773.00 | 778.00 | 764.30 | 782.00 | 771.70 | 590.00 | 654.00 | 0.74 | 0.77 | 2.70 | 2.82 |
| Cross 2 | 686.00 | 658.30 | 621.00 | 607.30 | 880.00 | 775.00 | 777.00 | 740.00 | 688.00 | 680.50 | 634.00 | 615.20 | 3.60 | 3.63 | 13.09 | 13.17 |
| Cross 3 | 686.00 | 658.30 | 583.00 | 542.30 | 730.00 | 687.70 | 706.00 | 661.50 | 692.00 | 660.00 | 626.00 | 570.50 | 2.89 | 2.92 | 10.51 | 10.56 |
| Cross 4 | 621.00 | 607.30 | 578.00 | 550.00 | 704.00 | 681.00 | 671.00 | 659.00 | 660.00 | 643.00 | 637.00 | 622.00 | 1.18 | 1.21 | 4.31 | 4.33 |
| Cross 5 | 621.00 | 607.30 | 583.00 | 542.30 | 930.00 | 855.00 | 848.00 | 775.00 | 775.00 | 708.70 | 758.00 | 692.00 | 0.27 | 0.29 | 0.98 | 1.06 |

the highest fruit weight (782.00 and 771.70) and $BC_1$ of cross 4 (IVMM-3 x Pusa Madhuras) x IVMM-3 expressed lowest fruit weight (660.00 and 643.00) in both season. In case $BC_2$'s, the $BC_2$ of cross 5 (IVMM-3 x Punjab Sunehari) x Punjab Sunehari recorded the highest fruit weight (758.00 and 692.00) and $BC_2$ of cross 3 (Hara Madhu x Punjab Sunehari) x Punjab Sunehari showed the minimum fruit weight (626 and 570.50) in both the summer and *Kharif* seasons.

The dominance gene effects were higher than additive gene effects in all the crosses for number of female flowers per vine. Among the epistatic gene effects (i, j, and l) were found to be significant in all the crosses except cross 2 (Hara Madhu x IVMM-3) and cross 4(IVMM-3 x Pusa Madhuras) in both summer and *Kharif* season. Duplicate gene interactions were observed in all the crosses Cross 1(Durgapur Selection x Punjab Sunehari), cross 2 (Hara Madhu x IVMM-3) cross 3 (Hara Madhu x Punjab Sunehari) and cross 4(IVMM-3 x Pusa Madhuras) and cross 5(IVMM-3 x Punjab Sunehari) showed complementary gene interaction. Similar observation was also made by Sahni *et al.* (1987) in ridge gourd for number of female flowers per vine. The estimates of six parameter model showed that in the cross 1 (Durgapur Selection x Punjab Sunehari) and cross 3 (Hara Madhu x Punjab Sunehari) additive, dominance and epistasis interaction played a significant role in the expression for days required for first harvest of fruit. While dominance and dominance x dominance gene effects played predominant role in the cross 5 (IVMM-3 x Punjab Sunehari) showed greater dominance effects in both summer and *Kharif* season, followed by cross 3 (Hara Madhu x Punjab Sunehari) and cross 1(Durgapur Selection x Punjab Sunehari). In the same crosses dominance x dominance gene effects was of greater magnitude followed by additive x additive.

Duplicate epistasis was observed in the entire cross combinations. Similar type of results were also reported by Munshi and Verma (1998) in muskmelon; Dineshkumar (2001) in cucumber; Janakiram and Sirohi (1990) and Singh *et al.* (2000) in bottle gourd. The additive gene effects were higher than dominance gene effects in all the crosses for number of fruits per vine. The additive and dominance gene effects were found to be significant in cross 2 (Hara Madhu x IVMM-3) and cross 3(Hara Madhu x Punjab Sunehari) for number of fruits per vine in summer and *Kharif* seasons. The additive x

**Table 3 : Estimates of scaling tests for the different five characters in muskmelon during summer and *Kharif* 2010-2011**

| Crosses | Scaling test | Number of female flowers per vine | | Days required for 1st harvest of fruits | | Number of fruits per vine | | Yield per vine (kg) | | Weight of fruit (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* |
| Cross 1 | A | -0.62** | -0.69** | -1.47** | -2.01** | 1.50** | 1.31** | 1.01** | 0.97** | 16.90** | 11.54** |
| | B | -5.16** | -6.27** | 2.65** | 2.34** | -0.20** | -0.18** | -0.24** | -0.19* | -35.90** | -42.14** |
| | C | -1.69** | -2.09** | 2.80** | 2.51** | 0.60** | 0.54** | 0.65** | 0.64** | 123.55** | 104.21** |
| Cross 2 | A | 0.03 | 0.03 | -4.30** | -4.63** | 0.95** | 0.76** | 0.67** | 0.51** | 22.05** | 14.62** |
| | B | -0.78** | -0.91** | 0.40** | -6.02 | -0.42** | -0.72** | -0.32** | -0.24** | -31.40** | -38.00** |
| | C | -0.24* | -0.23* | -5.22* | -11.86* | 1.22** | 0.98* | 0.74** | 0.42** | -16.10** | -28.45** |
| Cross 3 | A | 4.65** | 0.35 | -7.00** | -7.31* | 1.50** | 1.24** | 1.11** | 0.82* | 49.00** | 43.16** |
| | B | -9.50** | -9.17** | 3.90** | 2.82** | -1.10** | -1.18* | -0.92** | -1.24** | -76.50** | -84.25** |
| | C | 0.41 | -2.73** | -0.30* | -1.61* | 0.20 | 0.31 | 0.01 | -0.36* | -35.00** | -44.56** |
| Cross 4 | A | 1.29** | -3.18 | -5.80** | -5.24** | 0.02 | -0.17 | -0.17** | -0.29** | -85.50** | -85.24** |
| | B | -0.48** | -0.64** | -1.37** | -1.53** | -0.01 | -0.20 | 0.31** | 0.08 | 116.80** | 108.24** |
| | C | 0.68** | -4.21 | -0.44* | 0.28 | 0.10 | -0.23 | 0.45** | 0.11* | 145.70** | 142.35** |
| Cross 5 | A | 6.75** | 2.14** | -10.60** | -20.27* | -0.17** | -0.42* | -0.25** | -0.48** | -67.20** | -67.35** |
| | B | -6.40** | -5.47** | -1.20** | -1.24** | -0.40** | -0.72** | 0.32** | 0.01 | 202.80** | 196.24** |
| | C | 0.83 | -2.19** | -3.93** | -14.25* | -0.95** | -1.69* | -0.15* | -0.43** | 166.76** | 161.24** |

* and ** indicate significance of values at P=0.05 and 0.01, respectively

**Table 4 : Estimates joint scaling tests for different five characters in muskmelon during summer and *Kharif* 2010-2011**

| Crosses | Number of female flowers per vine | | Days required for 1st harvest of fruits | | Number of fruits per vine | | Yield per vine (kg) | | Weight of fruit (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* |
| Cross 1 | 12456.38** | 12390.39** | 5749.25** | 4572.99** | 673.41** | 750.66** | 785.51** | 21918.18** | 10424.98** | 10508.73** |
| Cross 2 | 1154.96** | 1121.96** | 4197.33** | 1919.92** | 1037.47** | 644.32** | 1488.44** | 819.77** | 11768.06** | 12465.92** |
| Cross 3 | 9165.95** | 4011.53** | 5478.57** | 1270.46** | 3652.34** | 2465.28** | 5612.57** | 8499.13** | 17740.39** | 19466.93** |
| Cross 4 | 907.68** | 1531.50** | 6178.96** | 5002.93** | 5.05 | 12.72 | 264.60** | 1678.89** | 435881.20** | 432895.40** |
| Cross 5 | 13249.45** | 4470.84** | 3249.14** | 2180.40** | 214.88** | 264.74** | 854.05** | 791.90** | 1656410.00** | 1381302.00** |

* and ** indicate significance of values at P=0.05 and 0.01, respectively

**Table 5 : Estimates of gene effects for different five characters in five crosses of muskmelon during summer and *Kharif* 2010-2011**

| Cross/ | m | | d | | h | | i | | j | | l | | Type of |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| characters | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | Summer | *Kharif* | epistasis |
| **Number of female flowers per vine** | | | | | | | | | | | | | |
| Cross 1 | 10.30** | 11.00** | 0.37 | 0.28 | -3.62** | -3.73** | -4.10** | -4.21** | 2.27** | 2.16** | 9.89** | 9.48** | D |
| | (0.006) | (0.006) | (0.21) | (0.21) | (0.05) | (0.04) | (0.03) | (0.03) | (0.03) | (0.03) | (0.10) | (0.08) | |
| Cross 2 | 12.90** | 10.90** | 0.10 | 0.07 | -0.46** | -0.41** | -0.51 | -0.56 | 0.40 | 0.29 | 1.26 | 1.16 | D |
| | (0.002) | (0.003) | (0.07) | (0.05) | (0.04) | (0.04) | (0.41) | (0.41) | (0.3) | (0.2) | (0.8) | (0.8) | |
| Cross 3 | 9.60** | 11.60** | 2.30** | 2.19** | -2.38** | -3.76** | -5.26** | -5.33** | 7.07** | 4.30** | 10.11** | 12.86** | D |
| | (0.10) | (0.10) | (0.06) | (0.05) | (0.45) | (0.45) | (0.44) | (0.42) | (0.07) | (0.07) | (0.54) | (0.54) | |
| Cross 4 | 13.00** | 11.20** | 0.38 | 0.25 | 1.98** | -0.90** | 0.13 | 0.07 | 0.88 | -1.19 | -0.94 | 1.21 | D |
| | (0.004) | (0.004) | (0.26) | (0.26) | (0.05) | (0.05) | (0.2) | (0.2) | (0.63) | (0.63) | (0.9) | (0.09) | |
| Cross 5 | 12.60** | 12.20** | 2.10** | 2.04** | 4.19** | 2.82** | -0.48** | -0.54** | 0.57 | 0.80 | 0.13** | 2.88** | C |
| | (0.003) | (0.003) | (0.03) | (0.03) | (0.34) | (0.34) | (0.06) | (0.05) | (0.5) | (0.5) | (0.68) | (0.68) | |
| **Days required for 1st harvest of fruits** | | | | | | | | | | | | | |
| Cross 1 | 75.70** | 82.70** | -1.36** | -1.41** | -2.97** | -3.05** | -1.62** | -1.71** | -2.06** | -2.11** | 3.41** | 3.54** | D |
| | (0.01) | (0.01) | (0.02) | (0.02) | (0.12) | (0.09) | (0.06) | (0.05) | (0.10) | (0.09) | (0.23) | (0.23) | |
| Cross 2 | 84.70** | 88.30** | -1.60 | 1.76 | -6.13** | -9.19** | 1.32 | 1.18 | -1.35 | 0.71 | 2.58 | 2.71 | D |
| | (0.71) | (0.71) | (0.91) | (0.90) | (2.87) | (2.87) | (0.87) | (0.81) | (0.84) | (0.5) | (1.87) | (1.87) | |
| Cross 3 | 91.80** | 84.72** | -2.20** | -2.27** | -7.35** | -7.76** | -2.80** | -2.91** | -5.45** | -5.03** | 5.90** | 6.73** | D |
| | (0.007) | (0.008) | (0.02) | (0.02) | (0.09) | (0.09) | (0.05) | (0.06) | (0.03) | (0.03) | (0.17) | (0.17) | |
| Cross 4 | 84.90** | 85.65** | -0.21** | -0.28** | -7.43** | -7.01** | -6.73** | -6.81** | -1.21 | -0.87 | 1.07 | 1.09 | D |
| | (0.03) | (0.03) | (0.003) | (0.006) | (0.16) | (0.16) | (0.14) | (0.14) | (0.76) | (0.6) | (0.72) | (0.6) | |
| Cross 5 | 82.00** | 82.60** | -0.20** | -0.24** | -11.16** | -15.81** | -7.86** | -7.95** | -1.70 | -1.35 | 19.66** | 28.96** | D |
| | (0.004) | (0.002) | (0.007) | (0.005) | (0.04) | (0.05) | (0.008) | (0.01) | (0.93) | (0.93) | (0.09) | (0.09) | |
| **Number of fruits per vine** | | | | | | | | | | | | | |
| Cross 1 | 2.60** | 2.50** | 0.25 | 0.18 | -0.20* | -0.10** | 0.70 | 0.61 | 0.85** | 0.78** | -2.00** | -2.20** | C |
| | (0.01) | (0.01) | (0.2) | (0.2) | (0.09) | (0.009) | (0.9) | (0.8) | (0.04) | (0.04) | (0.15) | (0.15) | |
| Cross 2 | 2.70** | 2.50** | 0.70** | 0.59** | -1.03** | -1.10** | -0.70 | -0.77 | 0.68 | 0.70 | 0.17 | 0.30 | D |
| | (0.02) | (0.02) | (0.01) | (0.01) | (0.13) | (0.13) | (0.51) | (0.71) | (0.62) | (0.51) | (0.18) | (0.19) | |
| Cross 3 | 2.80** | 2.80** | 0.75** | 0.64** | -0.55** | -0.05** | 0.20** | 0.16** | 1.30 | 1.21 | -0.60** | -0.80** | C |
| | (0.03) | (0.03) | (0.01) | (0.01) | (0.15) | (0.005) | (0.14) | (0.12) | (0.92) | (0.92) | (0.16) | (0.17) | |
| Cross 4 | 2.50** | 2.50** | -0.24 | -0.27 | 0.17** | 0.06** | --- | --- | --- | --- | --- | --- | |
| | (0.01) | (0.01) | (0.6) | (0.5) | (0.05) | (0.006) | | | | | | | |
| Cross 5 | 2.90** | 3.00** | -1.45 | -1.52 | 0.64** | 0.53** | 0.38** | 0.32** | 0.11** | 0.09* | 0.59** | 0.42** | C |
| | (0.003) | (0.003) | (0.82) | (0.92) | (0.06) | (0.06) | (0.04) | (0.03) | (0.03) | (0.03) | (0.12) | (0.12) | |
| **Yield per vine (kg)** | | | | | | | | | | | | | |
| Cross 1 | 2.00** | 1.88** | 0.18 | 0.12 | 0.47** | 0.38** | 0.12** | 0.15** | 0.62 | 0.59 | -0.89** | -1.06** | D |
| | (0.01) | (0.002) | (0.12) | (0.15) | (0.06) | (0.01) | (0.06) | (0.01) | (0.32) | (0.37) | (0.10) | (0.02) | |
| Cross 2 | 2.50** | 1.80** | 0.48 | 0.44 | 0.60** | 0.66** | -0.40 | -0.42 | 0.49 | 0.46 | -0.05 | -0.21 | D |
| | (0.01) | (0.01) | (0.31) | (0.28) | (0.07) | (0.07) | (0.66) | (0.66) | (0.61) | (0.61) | (0.11) | (0.8) | |
| Cross 3 | 2.67** | 1.40** | 0.60** | 0.57** | 0.55** | 0.41** | 0.33** | 0.19** | 1.01 | 0.97 | -0.37** | -0.16** | D |
| | (0.02) | (0.007) | (0.007) | (0.006) | (0.10) | (0.01) | (0.10) | (0.03) | (0.61) | (0.61) | (0.11) | (0.05) | |
| Cross 4 | 2.55** | 1.54** | -0.37** | -0.33** | -0.30** | -0.27** | -0.32** | -0.26** | -0.24** | -0.20** | -0.13 | -0.05 | C |
| | (0.007) | (0.002) | (0.005) | (0.005) | (0.04) | (0.01) | (0.03) | (0.01) | (0.02) | (0.006) | (0.66) | (0.62) | |
| Cross 5 | 2.30** | 2.05** | -0.69** | -0.54** | 0.16** | 0.01** | 0.22** | 0.15** | -0.29** | -0.17** | -0.29** | -0.13** | D |
| | (0.002) | (0.01) | (0.01) | (0.006) | (0.03) | (0.06) | (0.02) | (0.05) | (0.01) | (0.006) | (0.07) | (0.07) | |
| **Weight of fruit (g)** | | | | | | | | | | | | | |
| Cross 1 | 778.00** | 764.30** | 7.40** | 7.33** | -142.62** | -147.52** | -142.60** | -142.72** | 26.42** | 26.34** | 161.65** | 171.45** | D |
| | (0.37) | (0.37) | (0.28) | (0.26) | (1.71) | (1.70) | (1.61) | (1.60) | (0.37) | (0.36) | (2.21) | (2.20) | |
| Cross 2 | 777.00** | 740.00** | 15.97** | 15.83** | -23.60** | -19.50** | 6.75** | 6.62** | 6.72 | 6.62 | 2.60** | 12.80** | D |
| | (1.49) | (1.49) | (0.18) | (0.16) | (6.00) | (6.00) | (1.06) | (1.06) | (6.25) | (6.24) | (0.05) | (6.05) | |
| Cross 3 | 706.00** | 661.50** | 42.25** | 42.10** | 10.00** | 15.50** | 7.50* | 7.41* | 62.75** | 65.25** | 20.00** | 29.00** | C |
| | (3.34) | (0.80)** | (0.47) | (0.45) | (3.73) | (3.73) | (3.33) | (3.33) | (0.50) | (0.48) | (5.00) | (5.00) | |
| Cross 4 | 671.00** | 659.00** | -85.40** | -85.50** | -171.95** | -169.75** | -114.40** | -114.54** | -101.15** | -101.04** | 83.10** | 78.70** | D |
| | (0.09) | (0.09) | (0.07) | (0.06) | (0.65) | (0.65) | (0.41) | (0.41) | (0.50) | (0.48) | (1.11) | (1.12) | |
| Cross 5 | 848.00** | 775.00** | -144.75** | -144.88** | -105.11** | -105.41** | -31.16** | -31.24** | -135.00** | -132.50** | 104.44** | 103.84** | D |
| | (0.01) | (0.02) | (0.05) | (0.06) | (0.13) | (0.20) | (0.09) | (0.18) | (0.11) | (0.12) | (0.30) | (0.38) | |

* and ** indicate significance of values at P=0.05 and 0.01, respectively (C- Complimentary, D- Duplicate)

additive and dominance x dominance gene interactions showed significant in cross 3 (Hara Madhu x Punjab Sunehari) and cross 5 (IVMM-3 x Punjab Sunehari). The cross 3 (Hara Madhu x Punjab Sunehari) and cross 5 (IVMM-3 x Punjab Sunehari) also showed complementary type of interaction. Similar results were also reported by Chadha *et al.* (1972), Munshi and Verma (1998), Arvindkumar (2004), Moon *et al.* (2004), Zalpa *et al.* (2006), Tomar *et al.* (2008) in muskmelon. The number of fruits per vine was largely controlled by the additive and additive x additive (i) component, Sirohi and Choudhary (1979) and Singh and Singh (1998) also reported similar results in bitter gourd. Musmade (1994) reported that additive gene effect was greater than dominance component for this trait in cucumber.

Both the additive and dominance gene effects were almost equally important in respect of fruit yield per vine. The both additive and dominance gene effects were significant in the crosses cross 3 (Hara Madhu x Punjab Sunehari), cross 4 (IVMM-3 x Pusa Madhuras) and cross 5(IVMM-3 x Punjab Sunehari). The additive gene effects were greater than dominance gene effects in the same crosses. The additives x additive epistatic interaction were found significant in all the crosses except cross 2 (Hara Madhu x IVMM-3). Duplicate types of gene interaction were also observed in entire cross combinations while complementary gene interaction was observed in cross 4 (IVMM-3 x Pusa Madhuras). Similar results were reported by Chadha *et al.* (1972), Dhaliwal *et al.* (1996) Munshi and Verma (1998) Arvindkumar (2004), Zalpa *et al.* (2006), Tomar *et al.* (2008) in muskmelon and Singh *et al.* (2000) in bottle gourd. The importance of pure line selection for this trait having additive gene effects at significant level and heterosis breeding where non additive gene effects found pre dominant effect may be exploited.

Additive (d) and dominance (h) were found to be significant in all the crosses for weight of fruit in both summer and *Kharif* season. The relative contribution of additive gene effects to the mean effect was higher than that of the dominance gene effects in the cross 3(Hara Madhu x Punjab Sunehari) and cross 5 (IVMM-3 x Punjab Sunehari) in both summer and *Kharif* season. All the estimates of six parameter model showed that in all the crosses except cross 2 (Hara Madhu x IVMM-3). Additive x additive and dominance x dominance interaction was significant in all the crosses except cross 2 (Hara Madhu x IVMM-3). The dominance x dominance interaction exhibited high magnitude followed by additive x additive and additive x dominance. Complementary type of interaction was observed in cross 3 (Hara Madhu x Punjab Sunehari). The character could be exploited through heterosis breeding as well as selection. Similar results were confirmed by Arvindkumar (2004), Zalpa *et al.* (2006) in muskmelon, Sirohi *et al.* (1986) in bottle gourd, Sanandia *et al.* (2010) in sponge gourd.

**Conclusion:**

The selection of high-yielding muskmelon genotypes is complicated by often occurrence of duplicate epistasis. Higher number of epistatic gene effects estimated for muskmelon fruit weight comparing to number of fruits per vine, duplicate type of epistasis confirmed for fruit weight, as well as additive gene effects and stable additive/ dominance epistatic effects noted for number of female flowers, days required for first harvest of fruits, number of fruits per vine, yield per vine, and weight of fruit increase as the most efficient strategy for increasing muskmelon yielding ability. However, fruit weight has to meet the standards proposed by growers and market.

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