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SERVICES FOR SCIENCE AND EDUCATION

Heterosis of Yield and Quality Traits of Watermelon [*Citrullus lanatus* var. lanatus (Thunb.)] Hybrids and their Performance in the Sub-Tropical Region

AKM Quamruzzaman
Olericulture Division, Horticulture Research Center,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

Limu Akter
Olericulture Division, Horticulture Research Center,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

MMR Salim
Olericulture Division, Horticulture Research Center,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

Ferdouse Islam
Training and communication,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

ABSTRACT

A study was conducted in watermelon to estimate the magnitude of heterosis for yield and its nine yield-related components. Sixteen hybrids generated from eight diverged parents were evaluated in a Randomized Block Design with three replications at the Olericulture Division, Horticulture Research Center (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. Appreciable heterosis was found over better parents for all the traits studied in a desirable direction. The range of positive better parent heterosis for a number of fruits/plant and individual fruit weight was 4.50 to 30.56 percent and 7.17 to 21.05 percent, respectively, while for fruit length and fruit diameter, it was 0.63 to 11.47 percent and 2.74 to 14.40 percent, respectively. Nine hybrids showed significant positive heterotic response for TSS, while twelve hybrids for fruit yield showed positive better parent heterosis and the range was 9.38 to 51.17 %. The higher significant positive better parent heterosis was observed in hybrids F_1 104 (51.17%), F_1 105 (44.30%), F_1 801 (29.45%), F_1 102 (23.38%), F_1 401 (19.74%), F_1 103 (19.14%). Considering yield contributing characters, the hybrids viz., F_1 102, F_1 104, F_1 105, F_1 801 were found promising and may be recommended for hybrid watermelon variety for the farmers of sub-tropical countries.

Keyword: Watermelon, *Citrullus lanatus* var. lanatus (Thunb.), heterosis, hybrids, sub-tropical.

INTRODUCTION

Watermelon [*Citrullus lanatus* var. lanatus (Thunb.) is an important domestic and global fruit crop, accounting for 7% of the worldwide area devoted to fruit and vegetable production (Guo *et al.*, 2012). The highest producing countries are viz., China (79,043,138 t), Turkey (3,928,892 t) and Iran (3,813,850 t) (FAO 2018). Annual production in Bangladesh was 29.33 thousand acres with a total production of 25.37 thousand metric tons (Annon, 2019). The largest production areas were in Barishal (12487 acres), Bhola (9198 acres), Chittagong (8282 acres), Khulna (6240 acres), Rangpur (1964 acres) and Barguna (1104 acres) (Annon, 2019). The fruit of watermelon contains 6% sugar, and 92% water by weight, and is a good source of vitamins A, B, and C. It also contains lycopene. Sugar content and sweetness are critical factors in determining the quality of many watermelon cultivars (Harlair, 1999). The value of fresh market watermelons has increased in value over the last few years. As all varieties cultivated in Bangladesh are hybrids, and seeds are imported every year from abroad, So, the choice is completely dependent on the importer. Farmers often face a problem in selecting a suitable variety. Furthermore, current watermelon varieties are diverse in terms of shape, size, color, texture, and nutrient composition due to years of cultivation and selection targeting yield and desirable fruit qualities (Guo et al., 2012).

Watermelon is highly cross-pollinated and has a wide genetic diversity. In spite of a wide genetic base and an old history, very little research has been done so far for the exploitation of heterosis in Bangladesh. The exploitation of heterosis in different commercial crop hybrids has made a massive contribution to 20th-century agriculture, though the genetic basis of the phenomenon remains unclear. Plant breeders describe heterosis as the manifestation of greater vigor in height, leaf area, growth, dry matter accumulation, and yield in an F_1 hybrid in comparison with the parents (Allard, 1960; Hageman, 1967). F_1 hybrid watermelon is one of the most popular fruit crops in the subcontinent. It is well known that watermelon is a monoecious fruit crop; there is ample scope for the exploitation of hybrid vigor. Therefore, selection based on the magnitude of heterosis of more than one yield component will be highly realistic. As reported by Hageman and McDaniel (1973), heterosis is desirable for individual component characters, even to a small magnitude. It is well known that watermelon, being a monoecious vegetable, offers ample scope for exploitation of hybrid vigor. Two recent studies were run in Brazil on seven intercrossing populations with evaluation of reciprocal crosses (Ferreira et al., 2002) and tetraploid females crossed with diploid males for the production of triploid seeds (Souza et al., 2002). Heterosis is a term used to describe the superiority or the decreased value of a trait in hybrids (F.), in relation to their homozygous parents. In watermelon, the commercial exploitation of heterosis was reported by Sapovadiya et al. (2013) and Damaceno et al. (2016).

Therefore, selection based on the magnitude of heterosis of more than one yield component will be highly realistic. As reported by Hatcheock and McDaniel (1973), even to a small magnitude for individual component characters, is a desirable factor, as reported by Hatcheock and McDaniel (1973). There is a bright scope for the exploitation of heterosis in cucurbitaceous crops. Attempts like proper systematic breeding methods in this regard have not been made in the past. Although watermelon is grown sporadically in the warm season, unfortunately, there is no hybrid variety developed for local cultivation in Bangladesh. Very recently, BARI has released 2 OP varieties, which are not compared to imported good hybrid varieties of

watermelon. Thus, there is a farmers' need to develop a hybrid watermelon variety with good shape, size, and color that will grow year-round in Bangladesh. Thus, there is a scope to utilize the existing watermelon line for the development of a hybrid watermelon variety for year-round cultivation in Bangladesh. BARI has developed several inbreds of watermelon which are capable of developing some good quality varieties as well as growing year-round. This study aimed to estimate relative heterosis for traits of agronomic interest in watermelon genotypes, in order to develop new future cultivars. and later transplanted to the field. The hybrids were obtained by artificial crosses between parents (Dias et al. 2001). Therefore, the present study has been undertaken to assess the watermelon hybrids to develop a new watermelon hybrid variety.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Bangladesh. The experimental field was at the sub-tropical region of 23.9920º N Latitude and 90.4125º E Longitudes having an elevation of 8.2 m from sea level.

Treatments and Plant Materials

Sixteen watermelon hybrids viz., F_1 102, F_1 103, F_1 104, F_1 105, F_1 401, F_1 402, F_1 403, F_1 503, F_1 504, 801, 802, 803, 804, F_1 807, F_1 8021, F_1 2108 were incorporated in this study. The seeds of these hybrids were sown on the polypot on 05 Dec 2021. Twenty-day days old seedlings were transplanted in the main field on 25 Dec 2021.

Land Preparation and Fertilization

The experiment was laid out in a Randomized Complete Block design with three replications. The unit plot size was 10.0 x 2.0m maintaining 2.0 x 2.5m spacing and a 0.5m drain. The land was fertilized with organic manure, N, P, K, S, B, and Zn @ 10000, 80, 45, 88, 25, 1.8, and 4.5 kg/ha, respectively. Half of the organic manure and all of S, Zn, and B each of P and K @ 30 kg/ha, were applied during final land preparation. The remaining organic manure and P and K @ 15 kg/ha were applied as a base in the pit. of N and K were applied after 20 days of transplanting in 3 equal installments at a 20-day interval starting. The intercultural operations (weeding, irrigation, etc.) were done as and when necessary.

Air Temperatures and Relative Humidity of the Experimental Area

Under protected conditions, temperatures can be monitored and managed, and better plant growth can be expected. The protected nethouse condition influenced the air temperature and RH. Data for the temperatures and RH were measured at 12 pm daily during the experimental period. The average minimum and maximum temperatures varied between 25.8^0C to 36.8^0C, while relative humidity varied between 62.1% to 81.5 % of day time (Fig 1).

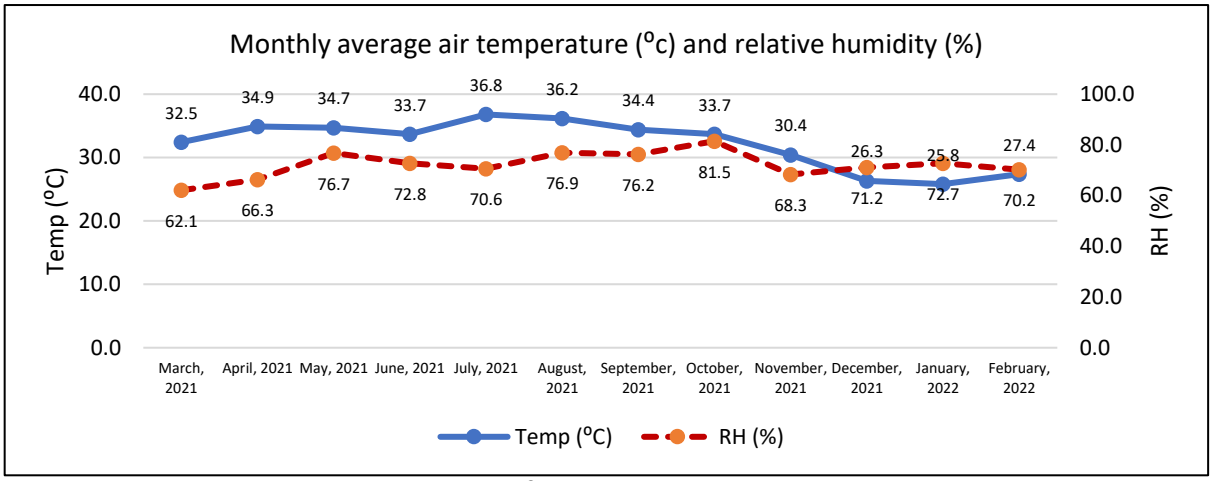


Fig 1: Monthly average air temperature (^{0}c) and relative humidity (%) at 12 hrs during March 2021 to Feb 2022

Data Collection and Statistical Analysis

Data on number of fruits/plants, individual fruit weight (kg), fruit yield/ plant (kg), fruit yield (t/ha), length of fruit (cm), breadth of fruit (cm), TSS (%), rind thickness (cm), taste, crispiness, fruit shape, flesh color, and fruit color were recorded from three randomly selected plants per plot. The information on different characters was statistically analyzed. The significance of the increase or decrease in F_1 hybrids over their corresponding better parents was tested by comparing their means with the help of appropriate standard error values in percentage.

RESULTS AND DISCUSSION

A significant difference among hybrids was observed for all the characters studied (Table 1). Better parent heterosis in watermelon was studied in 16 hybrids of watermelon. The heterosis percent over better parent for yield and yield contributing characters of the 16 hybrids are presented in Table 1. In the case of vine length, 11 hybrids showed significantly positive better parent heterosis, indicating the higher length of the vine which will provide more flowers and fruits. The estimates of positive better parent heterosis ranged from 2.86 to 31.43 percent. The range of positive better parent heterosis for each branch per plant was 2.00 to 34.21 percent, which indicates a wide range of branches were observed. Among 16 crosses, 3 hybrids showed more than 15% significant positive heterotic response over the better parent for a number of fruits/plants, while the positive heterosis range was 4.50 to 30.56 percent. For the number of fruits per plant, Tiago et al., 2018 reported heterosis was positive in 13.0 % of the hybrids, especially for 'CHG x ORA' (22.8 %), while Souza et al. (2005) and Santos et al. (2017), who observed that the heterosis for the trait in question was above 50.0 %. Possibly, such a contrast in the results could be attributed to the genetic differences of the populations studied. The range of positive better parent heterosis for individual fruit weight was 7.17 to 21.05 percent, while 5 hybrids (F_1 102, F_1 103, F_1 104, F_1 503, and F1 801) performed more than 15 percent heterotic effect. Rajput *et al.* (1984) observed 56% heterosis over the better parent for mean fruit weight. Better parent heterosis for fruit weight was also reported by Quamruzzaman *et al.* (2006), Dahiya *et al.* (1984), and Patil and Shinde (1984). The F1 hybrid evaluated had 22% more total fruit weight and 32% more total fruit number than 'Jubilee', the best parent (Gusmini

and. Wehner, 2004). The highest heterobeltiosis value (30.5 %) was reported by Tiago et al., 2018.

Table 1: Heterosis (%) over better parent for yield and yield contributing characteristics of watermelon hybrids

Hybrids	Vine length (cm)	Branch/plant	Number of fruits/ plants	Individual fruit weight (kg)	Fruit length (cm)
F_1 102	8.57**	0.00	-9.52**	18.42**	11.27**
F_1 103	28.57**	4.00*	15.17**	21.05**	2.65
F_1 104	0.00	2.00	30.56**	15.79**	-10.60**
F_1 105	-2.86	-16.00**	6.82*	10.53**	0.98
F_1 401	2.86	-18.00**	16.67**	-11.36**	11.47**
F_1 402	5.88*	37.21**	-16.67**	-18.86**	6.31*
F_1 403	0.00	34.21**	-12.50**	-2.27	10.00**
F_1 503	19.35**	-23.26**	-27.08**	15.78**	-12.05**
F_1 504	11.76**	2.33	-11.36**	-20.45**	0.98
F_1 801	31.43**	2.00	-6.52*	20.26**	-8.49**
F_1 802	7.20**	7.50**	6.50*	10.14**	5.14*
F_1 803	-3.08	-4.79*	-3.00	7.17**	-11.17**
F_1 804	5.55*	7.47**	4.50	9.10**	4.30*
F_1 807	-17.07**	13.04**	-4.35	-33.33**	3.77
F_1 8021	22.58**	15.22**	-6.52*	-8.33**	6.92*
F_1 2108	16.13**	-2.17	-8.70**	-6.25*	0.63
S.E.	1.74	2.70	3.2	2.75	3.2
C.D value (0.05)	4.25	3.10	4.85	3.90	3.80
C.D value (0.01)	6.98	5.47	7.43	6.33	7.21

The range of positive better parent heterosis for fruit length and fruit diameter was 0.63 to 11.47 percent and 2.74 to 14.40 percent, respectively, while more than 10 percent heterotic effect was observed in 3 hybrids (F_1 102, F_1 401, F_1 403) and 2 hybrids (F_1 103, F_1 801), respectively. According to Santos et al. (2017), for forage watermelon, the most recommended fruit length/ width ratio is higher than 1.0, since it indicates elongated fruits. However, in sweet watermelons, consumers prefer fruits with a fruit length/width ratio near 1.0, once they are easier to transport and store. Significant positive heterosis for fruit length was obtained by Quamruzzaman *et al.* (2006), Dahiya *et al.* (1984); Patil and Shinde (1984), and Rajput *et al.* (1984). Significant changes were observed in flesh diameter and rind thickness in this study.

The range of positive better parent heterosis for flesh diameter was 3.00 to 11.67 percent, while negative better parent heterosis for rind thickness was -2.60 to -17.37 percent. There was significant observation in the TSS parameter, while 9 hybrids showed a significant positive heterotic response over the better parent. The higher positive better parent heterosis percent was observed from the hybrids F_1 102 (13.00%), F_1 105 (10.00 %), F_1 804 (9.00%), F_1 8021 (10.58%), F_1 2108 (11.54%). In the case of fruit yield/ plant, the significant positive better parent heterosis was observed in 12 crosses, while the higher significant hybrids were viz., F_1 104 (51.17%), F_1 105 (44.30%), F_1 801 (29.45%), F_1 102 (23.38%), F_1 401 (19.74%), F_1 103 (19.14%). Such crosses are likely to give better transgressive segregants and could be used for

further crop improvement. (Fonseca and Patterson, 1968; Rajendran and Thamburaj, 1993; Rajan et al., 2002) have also reported high values of heterosis for fruit yield in watermelon

Table 1 Contd.

Hybrids	Fruit diameter (cm)	Flesh diameter (cm)	Rind thickness (cm)	TSS (%)	Fruit yield/ plant (kg)
F_1 102	4.80*	3.00**	-2.60	13.00**	23.38**
F_1 103	14.40**	10.00**	3.20	8.00**	19.14**
F_1 104	0.00	-4.29**	-6.08**	5.00*	51.17**
F_1 105	-1.71	6.67**	-11.55**	10.00**	44.30**
F_1 401	-13.48**	-7.14*	-12.27**	-2.00	19.74**
F_1 402	-10.11**	-7.14*	-2.92	-4.95*	-9.85**
F_1 403	-2.70	4.29**	-4.84*	8.91**	1.69
F_1 503	-17.03**	11.67**	-7.03**	-7.84**	-17.03**
F_1 504	-10.11**	-7.14*	-7.98**	-23.24**	10.80**
F_1 801	11.71**	10.00**	3.87	0.00	29.45**
F_1 802	2.74*	6.00*	-5.20*	6.00**	13.14**
F_1 803	-1.67	-4.29*	-3.08	-5.00*	11.17**
F_1 804	6.50**	-8.67**	4.55*	9.00**	14.30**
F_1 807	-27.37**	10.00**	-17.37**	-15.38**	-24.64**
F_1 8021	-6.12*	-9.29**	-6.12**	10.58**	9.49**
F_1 2108	-5.19**	8.57**	-5.19*	11.54**	9.38**
S.E.	3.29	3.45	2.80	3.25	3.65
C.D value (0.05)	1.55	4.12	3.93	3.96	4.25
C.D value (0.01)	2.75	7.34	5.89	5.34	7.56

* Significant at 5% level, ** Significant at 1% level

Gusmini &Wehner (2004), evaluating yield in a watermelon hybrid, did not observe heterosis higher than 50 %. However, in the present study, ten hybrids for fruit yield showed positive better parent heterosis, while the range was 1.69 to 51.17 %. The higher better parent significant positive heterosis was observed in hybrids F_1 104 (51.17%), F_1 105 (44.30%), F_1 801 (29.45%), F_1 102 (23.38%), F_1 401 (19.74%), F_1 103 (19.14%) (Fig 2). Tiago et al., 2018 reported heterosis above this level was observed for the hybrids 'PEA x JNY' (101.8 %), 'PEA x ORA' (89.8 %), 'SOL x PEA' (71.3 %), and 'PEA x SOL' (51.5 %). Possibly, such a contrast in the results could be attributed to the genetic differences of the populations studied. Quamruzzaman *et al.* (2006) reported 105.12%, Singh *et al.* (1982) reported 140.19%. Singh and Kumar (1988) observed 162.5% and Rashid *et al.* (1988) reported 48.27% heterosis over better parent for yield.

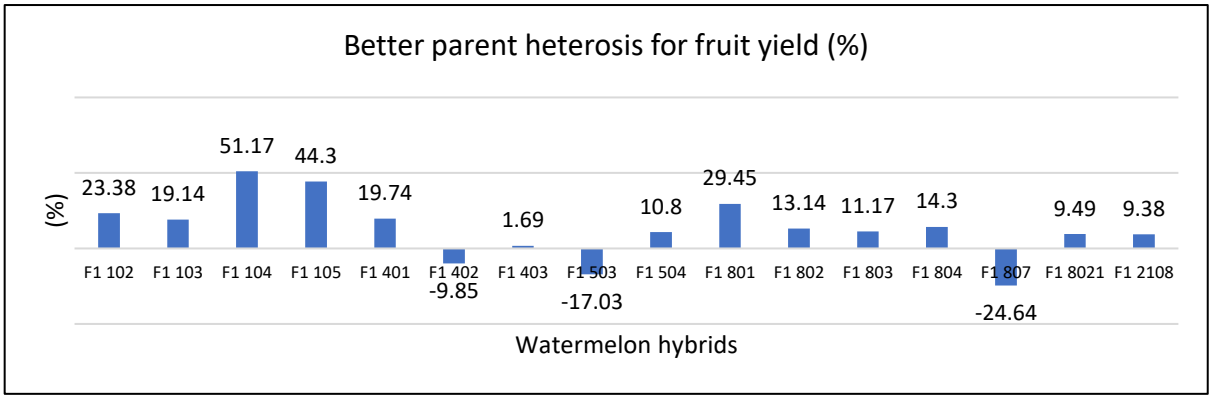


Fig 2: Better parent heterosis for fruit yield of 16 watermelon hybrids

CONCLUSION

The above findings indicated that the parental inbreds with strong heterotic capability for important traits associated with yield in order to achieve higher gains in F_1 hybrids through the exploitation of heterosis. There was significant variability observed among the eight watermelon hybrids. The range of positive better parent heterosis for a number of fruits/ plant and individual fruit weight was 4.50 to 30.56 percent and 7.17 to 21.05 percent, respectively, while for fruit length and fruit, the diameter was 0.63 to 11.47 percent and 2.74 to 14.40 percent, respectively. Nine hybrids showed significant positive heterotic response for TSS, while twelve hybrids for fruit yield showed positive better parent heterosis and the range was 9.38 to 51.17 %. The higher significant positive better parent heterosis was observed in hybrids F_1 104 (51.17%), F_1 105 (44.30%), F_1 801 (29.45%), F_1 102 (23.38%), F_1 401 (19.74%), F_1 103 (19.14%). Considering the heterosis of yield and quality traits of watermelon, the watermelon hybrids viz., F_1 102, F_1 104, F_1 105, and F_1 801 were found promising and may be recommended for hybrid watermelon variety for the farmers of sub-tropical country.

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