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Transgressive segregation of F_2 population for growth, yield, quality traits in muskmelon

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Abstract
Muskmelon (*Cucumis melo* L.) is a vital crop in global agriculture, valued for its nutritional benefits and medicinal properties. This study conducted at Dr. YSRHU-College of Horticulture, Anantharajupeta, explored transgressive segregation in an F_2 population of muskmelon derived through the selfing of the F_1 hybrid. 162 F_2 plants were evaluated for morphological, yield, and quality traits. Results revealed transgressive segregants across all 24 traits studied, with varying frequencies. The significant variability in the expression of these traits underscores the potential of transgressive segregants in breeding programs, offering a promising avenue to create enhanced cultivars with desirable traits and inspiring a new wave of improvement in muskmelon cultivation.

Keywords: Muskmelon (*Cucumis melo* L.), transgressive segregation, F2 population, yield traits

Introduction
Muskmelon (*Cucumis melo* L.) is an annual vegetable crop belonging to the Cucurbitaceae family, which includes around 118 genera and 825 species (Bailey and Bailey, 1976) [2]. Globally, vegetable production totals more than 212.54 million metric tonnes from 11.30 million hectares, with muskmelon contributing 14.98 million metric tonnes from 0.67 million hectares (NHB, 2022-23). Muskmelons are renowned for their juicy, delicious taste and are valued for their nutritional and medicinal properties. Muskmelon juice is highly nutritious, diuretic, and demulcent and is believed to have aphrodisiac properties. Muskmelon plants also contain various bioactive compounds, such as elaterin, stigmasterol, spinosterol, and cucurbitacin, known for their anti-tumor properties (Duke and Ayensu, 1985) [4]. Each 100 grams of edible fruit provides approximately 17 to 26 calories, 3.5 grams of carbohydrates, 0.3 grams of protein, 32 mg of calcium, 1.4 mg of iron, and 14 mg of phosphorus, making it a valuable addition to our diet (Chakrabarti, 2011) [3].
The success of selection in cross-pollinated crops hinges on breeders' ability to stabilise transgressive segregation. High heterotic crosses tend to produce more productive transgressive segregants in subsequent generations, as noted by Arunachalam *et al.* (1979) [5]. These segregants, which surpass either parent in one or more traits, can be predicted and observed within progenies of early segregating generations. Transgressive segregation, resulting from the accumulation of favourable genes from both parental lines, is beneficial in plant breeding, particularly in F_2 or later generations.

Materials and Methods
The experiment was conducted at Dr YSRHU-College of Horticulture, Anantharajupeta, Dr Y.S.R. Horticultural University, during the 2022-23 period. This location is situated in the southern agro-climatic zone of Andhra Pradesh, at coordinates 13°05' N latitude and 79°09' E longitude. F_2 seeds were derived through the selfing of the F_1 hybrid. The experimental setup included P_1, P_2, F_1, and a population of 162 F_2 plants planted in a non-replicated manner. Following standard cultural practices, the F2 plants were spaced one meter apart in both row and plant-to-plant. Observations were recorded for each plant regarding all the morphological, yield, and quality traits of the F_2 population in muskmelon. In the present study, the data recorded on 162 individual plants for the F_2 population was used to calculate the transgressive segregants.

Results

Transgressive segregation results in hybrid offspring displaying phenotypes surpassing the parental generation. This occurs because beneficial genes from both parents accumulate through genetic segregation and recombination. Transgressive segregation is comparable to genetic engineering, as both aims to produce an organism that is more fit than the previous one. According to genetic theories, heterozygous hybrids change from heterozygosity to homozygosity when they self-pollinate and advance to successive segregating generations. During this transition, transgressive segregations in subsequent generations may arise due to an uncommon combination of genes transmitted from both parents. Individuals who inherit "minus" or "plus" alleles from both parents are likelier to exhibit extreme phenotypic traits.

Bharathi *et al.* (2019) [6] suggested that the genetic analysis for transgressive segregation in F_2 helps determine the potency of different crosses, achieving efficiency in early-generation selection and reducing population size in later generations. The favourable genes impacting yield and yield-governing traits combine to create transgressive segregants.

The study of transgressive segregants in muskmelon reveals significant genetic variations across various traits, with findings aligning closely with similar studies in other crops. For instance, lower transgressive segregants were observed in muskmelon for characteristics such as fruit weight (0.62%), cavity width (1.23%), total sugars (1.85%), rind thickness (1.85%), fruit width (3.09%), yield per plant (5.56%), β-carotene (5.56%), total soluble solids (6.17%), fruit length (6.79%), shelf life at room temperature (9.26%), ascorbic acid (11.73%), flesh thickness (14.81%), number of fruits per plant (16.05%), physiological loss in weight (28.40%), cavity length (28.40%), sex ratio (30.86%), days to the first appearance of perfect flower (37.04%), node number at which the first male flower appears (38.89%), and fruit firmness (46.30%). These observations correspond to similar studies on tomatoes by Kabas *et al.* (2023) [8] and Patil *et al.* (2021) [9] and on cowpeas by Patil *et al.* (2022) [10]. Additionally, higher transgressive segregants in muskmelon were noted for node number at which the first male flower appears (38.89%), days to the first appearance of a male flower (72.22%), titrable acidity (98.77%), days to the first harvest (100.00%), and days to the last harvest (100.00%), aligning with findings by Nayak *et al.* (2024) [12] in mungbean. These correlations underscore the potential for genetic improvement in muskmelon breeding programs, reflecting the broader genetic diversity and potential for trait enhancement across various crops.

The ability to obtain the desired transgressive segregants depends on the genetic recombination of linked and unlinked alleles (Briggs and Allard, 1953) [7]. Therefore, all these traits were enhanced beyond their parental genotypes' capability due to transgressive segregants in each character. It was concluded that when the desired level of improvement in a trait is not attainable from the parent genotypes alone, transgressive breeding can effectively broaden the range of expression of that trait in specific cross combinations (Ramkete *et al.*, 2022) [11].

Table 1: Estimates of transgressive segregants for growth, floral and yield attributes in the F2 segregating population of Muskmelon

Traits	Threshold value	Range of threshold value	No of transgressive segregants	Frequency of transgressive segregation (%)
Plant growth parameters				
Node number at which first male flower appears	3.26	01-04	63	38.89
Node number at which the first perfect flower appears	6.60	02-07	87	53.70
Days to the first appearance of the male flower	41.95	20-35	117	72.22
Days to the first appearance of the perfect flower	43.25	27-41	60	37.04
Sex ratio (%)	11.85	3.31-37	50	30.86
Yield parameters				
Number of fruits per vine	3.26	02-09	26	16.05
Fruit length (cm)	13.58	4.78-16.00	11	6.79
Fruit width (cm)	11.34	4.32-13.42	5	3.09
Fruit weight (g)	1.07	105-1212	1	0.62
Yield per plant (kg)	2.41	0.223-4.920	9	5.56
Days to first fruit harvest	91.22	70-89	162	100.00
Days to last fruit harvest	105.95	76-91	162	100.00
Cavity length (cm)	7.29	2.31-10.52	46	28.40
Cavity width (cm)	7.12	2.41-7.79	2	1.23
Flesh thickness (cm)	2.63	0.18-3.68	24	14.81
Quality parameters				
Total soluble solids (º Brix)	11.26	2.9-15.6	10	6.17
Ascorbic acid(mg/100g)	20.52	0.9-36	19	11.73
Total sugars (%)	17.50	1.21-32.88	9	1.85
Titrable acidity (%)	0.86	0.064-1.280	160	98.77
Beta carotene (µg/g)	16.43	0.67-27.73	3	5.56
Shelf life parameters				
Shelf life (days) at room temperature	16.11	7-26	15	9.26
Fruit firmness (kg/cc)	3.46	0.72-6-49	75	46.30
Rind thickness (mm)	0.71	0.80-8.00	3	1.85
Physiological loss in weight (%)	6.38	2.83-16.47	46	28.40

Conclusion

In conclusion, the investigation into transgressive segregants across the F_2 population revealed significant variability in the expression of 24 traits in the studied plant species. The frequency of transgressive segregants varied widely, with the F_2 population showing lower frequencies in characteristics such as fruit weight, cavity width, and total sugars and higher frequencies in traits like days to first and last fruit harvest. These findings underscore the genetic complexity underlying trait inheritance and highlight the potential for breeding programs to harness transgressive segregants to develop improved cultivars with desirable agronomic traits.

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