Plant Archives Vol. 26, Supplement 2, 2026 pp. 1893-1906 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.235

COMPARATIVE ANALYSIS OF HETEROSIS AND INBREEDING DEPRESSION FOR YIELD AND YIELD-CONTRIBUTING TRAITS IN CUCUMBER (*Cucumis sativus* L.)

Krishan Kumar[1*], Rajiv[1], Subham Singh[1], Prem Kumar[2], Ankita Tiwari[1], Rahul Kumar[1], Dharmendra Bahadur Singh[1], Rohit Rawat[1] and Vishal Yadav[1]

[1]Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) India-208002

[2]Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) India-208002

*Corresponding authors: E-mail: yadavkrishankumar62@gmail.com

(Date of Receiving : 05-04-2026; Date of Revision : 25-05-2026; Date of Acceptance : 10-06-2026)

ABSTRACT

In the current study, 73 treatments (13 parents, 30 F_1s and 30 F_2s) were set up in a Randomised Block Design with three replications at the Vegetable Research Farm, Department of Vegetable Science, Kalyanpur, C.S. Azad University of Agriculture and Technology, Kanpur, during the Summer (Zaid) Season 2023 to 2025. Ten parental lines, (VRCU-2304, VRCU-2310, VRCU-2317, VRCU-2318, VRCU-2360, VRCU-2361, VRCU-2365, VRCU-2366, VRCU-2371, VRCU-2383), three testers (Pusa Uday, Pant Kheera-1, Kalyanpur (Green) and check (Pusa Sanyog). In order to generate enough F_1 seeds from thirty cross combinations in 2023–2024, all thirteen genotypes were crossed in a Line x tester mating scheme. The extent of heterosis for fruit yield showed significant differences amongst the hybrids assessed. The most promising crosses with significant positive heterosis based on heterobeltiosis were VRCU-2318 × Pant Kheera-1 (41.56%), followed by VRCU-2304 × Kalyanpur Green (38.60%), VRCU-2371 × Pusa Uday (36.35%), VRCU-2360 × Kalyanpur Green (32.97%), VRCU-2365 × Pusa Uday (31.86%), VRCU-2366 × Pusa Uday (30.88%) and VRCU-2365 × Kalyanpur Green (29.94%). Significantly higher than the standard check were the hybrids VRCU-2318 Pant Kheera-1 (33.65%), VRCU-2371 Pusa Uday (27.25%), VRCU-2304 Kalyanpur Green (26.70%), VRCU-2371 Pant Kheera-1 (18.80%), VRCU-2360 Kalyanpur Green (17.03%), VRCU-2366 Pusa Uday (13.76%) and VRCU-2365 Kalyanpur Green (12.94%).VRCU-2317 × Kalyanpur Green had the lowest inbreeding depression (2.959%) followed by VRCU-2361 × Pusa Uday (3.853%), VRCU-2361 × Kalyanpur Green (3.899%), VRCU-2366 × Pant Kheera-1 (4.380%), VRCU-2366 × Pusa Uday (6.271%), VRCU-2304 × Kalyanpur Green (6.332%) and VRCU-2304 × Pusa Uday (6.556%).

Keywords **:** Heterosis, Inbreeding depression, Cucumber (*Cucumis sativus* L.).

Introduction

Cucumber (*Cucumis sativus* L.) is an important vegetable crop from the Cucurbitaceae family. It is a diploid species (2n = 2x = 14) that is widely farmed in tropical, subtropical and temperate locations across the world for its soft fruits, which are eaten fresh as salad, cooked as vegetables, or processed as pickles. Cucumber is said to have originated on the Indian subcontinent, namely in the Himalayan foothills, and then spread throughout Asia, Europe and the rest of the world (Mukherjee *et al.*, 2013). India's largest cucumber-producing states include West Bengal, Madhya Pradesh, Haryana, Karnataka, Bihar and Uttar Pradesh. West Bengal is the leading cucumber producing state, producing 344.64 thousand metric tonnes from 25.30 thousand hectares followed by Madhya Pradesh, which produced 272.60 thousand tonnes from 16.59 thousand hectares. Uttar Pradesh has 4.09 thousand hectares of cucumber agriculture, with an annual yield of 103.74 thousand metric tonnes. (Final Estimate, Department of Agriculture, Cooperation, and Farmer Welfare, 2022). Cucumber genetic improvement has concentrated on increasing

yield, early maturity, fruit quality, disease resistance and tolerance to a wide range of environmental conditions. Cucumber yield is a complicated quantitative attribute determined by multiple component traits and modified by environmental conditions. As a result, leveraging genetic diversity and heterosis has emerged as a key crop development method. Heterosis, also known as hybrid vigour, occurs when F_1 hybrids outperform their parents in one or more attributes. The phenomenon has been widely used in cucumber breeding to create high-yielding hybrids with superior fruit quality and resilience to biotic and abiotic challenges (Kumari *et al.*, 2012). Thus, research on heterosis and inbreeding depression is crucial to comprehending the genetic structure of yield and its constituent characteristics. While evaluation of inbreeding depression sheds light on the degree of non-additive gene action and the durability of hybrid performance in subsequent generations, estimation of heterosis aids in the identification of suitable cross combinations for commercial hybrid production. While modest inbreeding depression shows the prospect of recovering desirable segregants by selection, significant heterosis combined with noticeable inbreeding depression supports the prevalence of dominance and over-dominance gene effects (Singh *et al.*, 2012).

Materials and Methods

The presents study involved 73 treatments (13 parents, 30F_1s, and 30 F_2s) arranged in a Randomized Block Design with three replications during the Summer *(Zaid)* Season 2023 to 2025 at the Vegetable Research Farm, Department of Vegetable Science, Kalyanpur, C.S. Azad University of Agriculture and Technology, Kanpur. The experimental material consisted of 10 parental lines (VRCU-2304, VRCU-2310, VRCU-2317, VRCU-2318, VRCU-2360, VRCU-2361, VRCU-2365, VRCU-2366, VRCU-2371, VRCU-2383), check (Pusa Sanyog) and three testers (Pusa Uday, Pant Kheera-1, Kalyanpur (Green). All the thirteen genotypes were crossed in a Line x tester mating design in all possible combinations to produce sufficient F_1 seeds of 30 cross combinations during 2023-2024. Each parent and F_1s were planted in single row and F_2s were planted double row plot bases, Spacing: 2.5 m x 0.5 m and Plot Size: 5.0 m x 2.5 m. Recommended cultural practices will be followed to raise a good crop. Observations were recorded on plot basis for Number of primary branches, days to first male flowers, days to first female flowers, node number of first male flower, node number of first female flowers, days to first fruit set, days to last fruit harvest, number of fruits per plant, fruit shape, days to marketable maturity, fruit length (cm), fruit diameter (cm), average fruit weight (g), fruit yield per plant (kg), yield per plot (kg), fruit flesh thickness (mm), total soluble solid (^{0}Brix), ascorbic acid (mg/100g fresh fruits) and shelf life of the fresh fruits (days) were recorded on 5 randomly selected plants for 30 $F_1$and 30 F_2's plants. The data was statistically analysed for each character. The magnitude of heterosis was estimated as the proportion of F_1 performance in a positive direction above the standard and better parent, as indicated by Hays *et al.* (1955). Inbreeding depression was defined as a percentage reduction in F_2 performance over F_1. The significance was assessed using the 't' test.

Result and Discussion

Heterosis is measured as a percentage increase or reduction in the mean value of an F_1 hybrid compared to the better parent (heterobeltiosis) and standard heterosis (economic heterosis). The better parent heterosis refers to F_1's superiority over better parents. Economic heterosis refers to F_1's superior performance over the best cultivated variety in a specific area or region. Inbreeding depression is the inferiority of F_2 over F_1. Pusa sanyog was utilised as a standard check parent for both standard and economic heterosis. Tables 1-9 show the estimated heterosis in percent better parent and standard check or economic heterosis (Pusa sanyog) in the F_1 generation and inbreeding depression in the F_2 generation for various yield and quality traits studied during the experiment.

Number of primary branches

The magnitude of heterosis over better parent ranged from -13.32 to 44.10 per cent. The top performing crosses for better parent heterosis included VRCU-2304 × Kalyanpur Green (44.10%), VRCU-2318 × Pant Kheera-1 (43.10%), VRCU-2371 × Pusa Uday (28.79%), VRCU-2304 × Pusa Uday (27.61%), VRCU-2317 × Pusa Uday (27.61%), VRCU-2383 × Pant Kheera-1 (24.75%) and VRCU-2383 × Kalyanpur Green (25.61%). The magnitude of heterosis over economic heterosis (Pusa sanyog) ranged from -28.19 to 18.44 per cent, indicating a comparatively lower magnitude of heterotic expression against the standard check. The top best crosses over the standard check were VRCU-2318 × Pant Kheera-1 (18.44%), VRCU-2371 × Pusa Uday (11.23%), VRCU-2304 × Kalyanpur Green (10.67%), VRCU-2304 × Pusa Uday (10.21%) and VRCU-2317 × Pusa Uday (10.21%). The magnitude of inbreeding depression ranged from 0.160% (VRCU-2361 × Kalyanpur Green) to 13.931% (VRCU-2310 × Pusa Uday). The top best crosses exhibiting the lowest inbreeding depression were

VRCU-2361 × Kalyanpur Green (0.160%) followed by VRCU-2383 × Pant Kheera-1 (0.543%), VRCU-2366 × Pant Kheera-1 (0.779%), VRCU-2366 × Kalyanpur Green (0.963%), VRCU-2304 × Pant Kheera-1 (1.129%), VRCU-2366 × Pusa Uday (1.292%) and VRCU-2383 × Kalyanpur Green (1.376%). All thirty crosses showed positive inbreeding depression, suggesting the predominance of non-additive gene action and loss of vigour due to inbreeding. These findings were supported by Al-Jebory and Almashhadani (2018), Kumar *et al.* (2008).

Days to first male flowers

Heterosis over the better parent range varied from -34.90 to -5.77 per cent, indicating that almost all crosses exhibited negative heterosis. The top best crosses for better parent heterosis were VRCU-2304 × Kalyanpur Green (-34.90%), VRCU-2318 × Pant Kheera-1 (-34.37%), VRCU-2371 × Pusa Uday (-33.26%), VRCU-2304 × Pusa Uday (-32.12%), VRCU-2317 × Pusa Uday (-29.68%), VRCU-2317 × Kalyanpur Green (-23.64%) and VRCU-2317 × Pant Kheera-1 (-23.28%). Heterosis over the standard heterosis (Pusa sanyog), the values ranged from -19.36 to 15.77 per cent. The top best crosses based on desirable significant negative heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (-19.36%), VRCU-2304 × Kalyanpur Green (-16.51%), VRCU-2371 × Pusa Uday (-15.58%), VRCU-2304 × Pusa Uday (-14.14%), VRCU-2317 × Pusa Uday (-11.05%), VRCU-2317 × Pant Kheera-1 (-5.73%) and VRCU-2310 × Pusa Uday (-5.35%). The magnitude of inbreeding depression ranged from -52.717% (VRCU-2371 × Pusa Uday) -6.416% (VRCU-2318 × Pusa Uday). The top best crosses with maximum desirable negative inbreeding depression were VRCU-2371 × Pusa Uday (-52.717%), VRCU-2304 × Kalyanpur Green (-41.299%), VRCU-2318 × Pant Kheera-1 (-34.180%), VRCU-2317 × Pusa Uday (-30.634%), VRCU-2304 × Pusa Uday (-28.988%), VRCU-2361 × Pusa Uday (-27.452%) and VRCU-2310 × Pusa Uday (-24.939%). All crosses exhibited negative inbreeding depression. Similar types of findings for this trait were reported by Bairagi *et al.* (2002), Kanwar *et al.* (2003) for different crosses.

Days to first Female flowers

Heterosis over better parent heterosis, the range varied from -32.24 to -3.24 per cent. The top best crosses based on better parent heterosis were VRCU-2371 × Pusa Uday (-32.24%), VRCU-2304 × Kalyanpur Green (-31.58%), VRCU-2318 × Pant Kheera-1 (-31.46%), VRCU-2317 × Pusa Uday (-29.45%), VRCU-2304 × Pusa Uday (-28.71%), VRCU-2310 × Pusa Uday (-24.75%) and VRCU-2310 × Kalyanpur Green (-22.61%). Heterosis over the standard check (Pusa sanyog), the values ranged from -24.70 to 6.31 per cent. The top best crosses with desirable significant negative heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (-24.70%), VRCU-2371 × Pusa Uday (-22.03%), VRCU-2304 × Kalyanpur Green (-21.31%), VRCU-2317 × Pusa Uday (-18.82%), VRCU-2304 × Pusa Uday (-17.97%), VRCU-2310 × Pusa Uday (-13.41%) and VRCU-2317 × Pant Kheera-1 (-13.26%). The magnitude of inbreeding depression ranged from -48.689% (VRCU-2371 × Pusa Uday) to -3.205% (VRCU-2318 × Pusa Uday). The top best crosses were VRCU-2371 × Pusa Uday (-48.689%), VRCU-2304 × Kalyanpur Green (-33.512%), VRCU-2317 × Pusa Uday (-33.221%), VRCU-2318 × Pant Kheera-1 (-29.565%), VRCU-2304 × Pusa Uday (-26.679%), VRCU-2310 × Pant Kheera-1 (-24.699%) and VRCU-2361 × Pusa Uday (-23.173%). All thirty crosses showed negative inbreeding depression. Similar finding was reported by Srivastava and Singh (2004) for this trait.

Node number to first male flower

Heterosis over better parent heterosis, the range varied from -46.57 to 61.61 per cent. The top best crosses with significant positive heterosis were VRCU-2365 × Pusa Uday (61.61%), VRCU-2318 × Kalyanpur Green (36.09%), VRCU-2366 × Kalyanpur Green (31.17%), VRCU-2365 × Kalyanpur Green (28.65%), VRCU-2318 × Pusa Uday (28.62%), VRCU-2371 × Kalyanpur Green (24.22%) and VRCU-2361 × Kalyanpur Green (23.80%). Heterosis over the standard check (Pusa sanyog), the values ranged from -38.81 to 39.90 per cent. The top best crosses with high and significant positive heterosis over the standard check were VRCU-2365 × Pusa Uday (39.90%), VRCU-2360 × Pusa Uday (31.04%), VRCU-2360 × Kalyanpur Green (30.25%), VRCU-2366 × Kalyanpur Green (26.87%), VRCU-2361 × Kalyanpur Green (15.42%), VRCU-2366 × Pant Kheera-1 (15.52%) and VRCU-2318 × Kalyanpur Green (12.94%). The magnitude of inbreeding depression ranged from -6.824% to -58.537%. The top best crosses showing maximum negative inbreeding depression were VRCU-2318 × Pant Kheera-1 (-58.537%), followed by VRCU-2304 × Kalyanpur Green (-50.649%), VRCU-2371 × Pusa Uday (-47.489%), VRCU-2383 × Kalyanpur Green (-32.786%), VRCU-2383 × Pusa Uday (-31.921%), VRCU-2383 × Pant Kheera-1 (-31.707%) and VRCU-2310 × Pusa Uday (-30.959%). Similar finding this trait reported by Jat *et al.*, (2015).

Node number to first Female flower

Heterosis over the better parent, the range varied from -38.60 to 31.30 per cent. The top best crosses with significant positive heterosis were VRCU-2371 × Kalyanpur Green (31.30%), VRCU-2361 × Pant Kheera-1 (25.29%), VRCU-2361 × Kalyanpur Green (20.46%), VRCU-2371 × Pant Kheera-1 (18.52%), VRCU-2318 × Kalyanpur Green (16.74%), VRCU-2366 × Kalyanpur Green (12.07%) and VRCU-2317 × Pant Kheera-1 (9.62%). Heterosis over the economic standard check (Pusa sanyog), the values ranged from -26.36 to 75.39 per cent, showing a high magnitude of variation. The top best crosses with high and significant positive heterosis over the economic parent were VRCU-2365 × Pusa Uday (75.39%), VRCU-2366 × Kalyanpur Green (69.31%), VRCU-2361 × Pant Kheera-1 (68.38%), VRCU-2361 × Kalyanpur Green (61.89%), VRCU-2371 × Kalyanpur Green (61.59%), VRCU-2366 × Pant Kheera-1 (62.51%) and VRCU-2360 × Kalyanpur Green (50.57%). The magnitude of inbreeding depression ranged from 3.059 %to -44.958%. The top best crosses with maximum negative inbreeding depression were VRCU-2318 × Pant Kheera-1 (-44.958%), VRCU-2304 × Kalyanpur Green (-38.462%), VRCU-2383 × Pusa Uday (-33.796%), VRCU-2371 × Pusa Uday (-32.090%), VRCU-2366 × Pusa Uday (-27.184%), VRCU-2310 × Kalyanpur Green (-27.184%) and VRCU-2310 × Pant Kheera-1 (-25.517%). Singh *et al.* (2012), Kumar *et al.* (2010) observed a wide range of heterosis and inbreeding depression for this trait in cucumber.

Days to first fruit set

Heterosis over the better parent, the range varied from -30.56 to 3.39 per cent. The top best crosses based on significant negative heterosis were VRCU-2318 × Pant Kheera-1 (-30.56%), VRCU-2371 × Pusa Uday (-27.18%), VRCU-2304 × Kalyanpur Green (-23.62%), VRCU-2317 × Pusa Uday (-23.43%), VRCU-2304 × Pant Kheera-1 (-20.60%), VRCU-2304 × Pusa Uday (-18.10%) and VRCU-2310 × Pant Kheera-1 (-17.31%). Heterosis over the standard check (Pusa sanyog), the values ranged from -22.08 to 12.06 per cent. The top best crosses with desirable significant negative heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (-22.08%), VRCU-2371 × Pusa Uday (-19.46%), VRCU-2304 × Kalyanpur Green (-17.70%), VRCU-2317 × Pusa Uday (-15.31%), VRCU-2304 × Pant Kheera-1 (-10.90%), VRCU-2310 × Kalyanpur Green (-10.46%) and VRCU-2304 × Pusa Uday (-9.41%). The magnitude of inbreeding depression ranged from -2.700% to -49.144%. The top best crosses showing maximum negative inbreeding depression were VRCU-2371 × Pusa Uday (-49.144%), followed by VRCU-2304 × Kalyanpur Green (-31.972%), VRCU-2318 × Pant Kheera-1 (-27.870%), VRCU-2317 × Pusa Uday (-26.346%), VRCU-2310 × Kalyanpur Green (-25.978%), VRCU-2304 × Pusa Uday (-25.024%) and VRCU-2304 × Pant Kheera-1 (-22.963%). Naik *et al.* (2019) observed a wide range of heterosis for this trait in cucumber.

Days to marketable maturity

Heterosis over the better parent, the range varied from -16.46 to 11.25 per cent. The top best crosses with desirable significant negative heterosis were VRCU-2360 × Pant Kheera-1 (-16.46%), VRCU-2366 × Pusa Uday (-14.85%), VRCU-2360 × Kalyanpur Green (-14.83%), VRCU-2365 × Kalyanpur Green (-14.80%), VRCU-2318 × Pant Kheera-1 (-11.09%), VRCU-2361 × Pusa Uday (-11.34%) and VRCU-2366 × Pant Kheera-1 (-10.73%). Heterosis over the economic parent (Pusa sanyog), the values ranged from -16.48 to 5.15 per cent. The top best crosses with desirable significant negative heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (-16.48%), VRCU-2371 × Pusa Uday (-14.70%), VRCU-2304 × Kalyanpur Green (-13.38%), VRCU-2366 × Pusa Uday (-13.26%), VRCU-2365 × Kalyanpur Green (-11.49%), VRCU-2366 × Pant Kheera-1 (-9.06%) and VRCU-2366 × Kalyanpur Green (-9.11%). The magnitude of inbreeding depression ranged from -24.218% to 9.632%. The top best crosses showing maximum negative inbreeding depression were VRCU-2318 × Pant Kheera-1 (-24.218%) followed by VRCU-2371 × Pusa Uday (-16.364%), VRCU-2360 × Pant Kheera-1 (-16.360%), VRCU-2304 × Kalyanpur Green (-11.999%), VRCU-2366 × Pusa Uday (-8.017%), VRCU-2317 × Pusa Uday (-5.880%) and VRCU-2371 × Kalyanpur Green (-5.571%). Similar findings also reported by Tiwari and Singh, (2016), Bhutia *et al.* (2018).

Days to last fruit harvest

Heterosis over the better parent, the range varied from -17.70 to 8.53 per cent. The top best crosses with significant negative heterosis were VRCU-2310 × Pant Kheera-1 (-17.70%), VRCU-2383 × Kalyanpur Green (-16.84%), VRCU-2366 × Pant Kheera-1 (-14.65%), VRCU-2383 × Pant Kheera-1 (-14.10%), VRCU-2304 × Pant Kheera-1 (-13.71%), VRCU-2317 × Pant Kheera-1 (-17.63%) and VRCU-2304 × Pusa Uday (-13.87%). Heterosis over the economic parent (Pusa sanyog), the values ranged from -9.94 to 17.99 per cent. The top best crosses with high and significant positive heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (17.99%), VRCU-2371 × Pusa

Uday (16.59%), VRCU-2304 × Kalyanpur Green (16.04%), VRCU-2365 × Pant Kheera-1 (13.82%), VRCU-2365 × Pusa Uday (13.24%), VRCU-2371 × Pant Kheera-1 (13.11%) and VRCU-2371 × Kalyanpur Green (12.30%). The findings showed that many crosses had significant negative heterosis over better parents, indicating the potential for early finishing genotype selection, while some crosses showed positive heterosis over the standard check, indicating the possibility of longer harvesting times. The magnitude of inbreeding depression ranged from 0.742% to 15.557%. The top best crosses showing maximum positive inbreeding depression were VRCU-2318 × Pant Kheera-1 (15.557%) followed by VRCU-2304 × Kalyanpur Green (12.579%), VRCU-2365 × Pusa Uday (11.148%), VRCU-2371 × Pant Kheera-1 (11.501%), VRCU-2365 × Pant Kheera-1 (10.934%), VRCU-2371 × Pusa Uday (8.072%) and VRCU-2366 × Kalyanpur Green (8.679 %). Kumar *et al.* (2010), Singathiya *et al.* (2025), findings were validated results of the current study who also reported heterosis and inbreeding depression for days to last fruit harvest.

Number of fruits per plant

Heterosis over the better parent, the range varied from -19.72 to 18.30 per cent. The top best crosses showing significant positive heterosis were VRCU-2317 × Pusa Uday (18.30%), VRCU-2365 × Pusa Uday (7.13%), VRCU-2383 × Pant Kheera-1 (6.80%), VRCU-2318 × Pant Kheera-1 (4.13%), VRCU-2365 × Kalyanpur Green (2.60%), VRCU-2304 × Kalyanpur Green (2.27%) and VRCU-2366 × Pusa Uday (1.22%). Heterosis over the standard check (Pusa sanyog), the values ranged from -4.82 to 23.47 per cent. The top best crosses with high and significant positive heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (23.47%), VRCU-2371 × Pusa Uday (19.20%), VRCU-2304 × Kalyanpur Green (18.93%), VRCU-2317 × Pusa Uday (18.32%), VRCU-2365 × Pusa Uday (14.09%), VRCU-2365 × Kalyanpur Green (13.81%) and VRCU-2366 × Pusa Uday (13.26%).

The magnitude of inbreeding depression ranged from 1.733% to 22.581%, with a mean value of 8.657%. The top best crosses with lowest inbreeding depression were VRCU-2366 × Pant Kheera-1 (1.733%) followed by VRCU-2383 × Pant Kheera-1 (2.162%), VRCU-2317 × Kalyanpur Green (2.273%), VRCU-2361 × Pusa Uday (2.743%), VRCU-2361 × Kalyanpur Green (3.056%), VRCU-2304 × Kalyanpur Green (3.708%) and VRCU-2360 × Kalyanpur Green (3.961%).These results are in agreement with the findings of Bairagi *et al.* (2002), Kumbhar *et al.* (2005).

Fruit length (cm)

In case of better parent heterosis, the range varied from -13.59 to 30.63 per cent. The top best crosses with significant positive heterosis were VRCU-2383 × Pant Kheera-1 (30.63%), VRCU-2383 × Kalyanpur Green (23.19%), VRCU-2371 × Pusa Uday (21.44%), VRCU-2304 × Kalyanpur Green (19.90%), VRCU-2360 × Pant Kheera-1 (19.19%), VRCU-2318 × Pant Kheera-1 (18.74%) and VRCU-2317 × Kalyanpur Green (18.11%). Heterosis over the economic parent (Pusa sanyog), the values ranged from -13.69 to 25.84 per cent. The top best crosses with high and significant positive heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (25.84%), VRCU-2371 × Pusa Uday (22.05%), VRCU-2304 × Kalyanpur Green (19.76%), VRCU-2317 × Kalyanpur Green (15.71%), VRCU-2371 × Pant Kheera-1 (13.01%), VRCU-2310 × Pusa Uday (12.33%) and VRCU-2383 × Pant Kheera-1 (12.30%).

The magnitude of inbreeding depression ranged from 2.160% to 20.871%. The top best crosses showing the lowest inbreeding depression were VRCU-2304 × Kalyanpur Green (2.160%) followed by VRCU-2366 × Pusa Uday (2.432%), VRCU-2318 × Pusa Uday (2.716%), VRCU-2317 × Pant Kheera-1 (3.202%), VRCU-2361 × Pusa Uday (3.286%), VRCU-2371 × Kalyanpur Green (4.700%) and VRCU-2361 × Kalyanpur Green (4.729%). These results are consistent with the findings of Singh *et al.* (2015).

Fruit diameter (cm)

Heterosis over the better parent, the range varied from -12.47 to 30.22 per cent. The top best crosses with significant positive heterosis were VRCU-2383 × Pant Kheera-1 (30.22%), VRCU-2383 × Kalyanpur Green (24.46%), VRCU-2361 × Pant Kheera-1 (22.59%), VRCU-2371 × Pusa Uday (17.34%), VRCU-2304 × Kalyanpur Green (15.84%), VRCU-2318 × Pant Kheera-1 (14.95%) and VRCU-2360 × Pant Kheera-1 (15.06%). Heterosis over the economic parent (Pusa sanyog), the values ranged from -7.46 to 21.39 per cent. The top best crosses with high and significant positive heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (21.39%), VRCU-2371 × Pusa Uday (18.82%), VRCU-2304 × Kalyanpur Green (17.41%), VRCU-2383 × Kalyanpur Green (9.70%), VRCU-2383 × Pant Kheera-1 (7.55%), VRCU-2317 × Pant Kheera-1 (6.97%) and VRCU-2383 × Pusa Uday (6.30%). The magnitude of inbreeding depression ranged from 1.728% to 27.824%. The top best crosses with the lowest inbreeding depression were VRCU-2360 × Pant Kheera-1 (1.728%) followed by VRCU-2360 × Pusa

Uday (2.233%), VRCU-2317 × Pant Kheera-1 (2.791%), VRCU-2310 × Pusa Uday (2.871%), VRCU-2318 × Pusa Uday (2.632%), VRCU-2366 × Kalyanpur Green (3.830%) and VRCU-2310 × Pant Kheera-1 (3.837%). Similar results were reported by Dhumal *et al.* (2019).

Average fruit weight (g)

Heterosis over the better parent heterosis, the range varied from -4.01 to 35.96 per cent. The top best crosses with significant positive heterosis were VRCU-2318 × Pant Kheera-1 (35.96%), VRCU-2304 × Kalyanpur Green (35.44%), VRCU-2366 × Pant Kheera-1 (34.52%), VRCU-2371 × Pant Kheera-1 (33.83%), VRCU-2371 × Kalyanpur Green (32.04%), VRCU-2360 × Kalyanpur Green (32.28%) and VRCU-2383 × Pant Kheera-1 (28.89%). Heterosis over the economic parent (Pusa sanyog), the values ranged from -15.92 to 11.72 per cent. The top best crosses based on positive standard heterosis were VRCU-2318 × Pant Kheera-1 (11.72%), VRCU-2371 × Pusa Uday (10.27%), VRCU-2371 × Pant Kheera-1 (9.19%), VRCU-2304 × Kalyanpur Green (9.87%), VRCU-2366 × Pant Kheera-1 (7.73%), VRCU-2371 × Kalyanpur Green (7.73%) and VRCU-2383 × Pusa Uday (6.28%).

The magnitude of inbreeding depression ranged from 0.691% to 6.048%. The top best crosses showing the lowest inbreeding depression were VRCU-2304 × Pusa Uday (0.691%) followed by VRCU-2317 × Kalyanpur Green (0.700%), VRCU-2304 × Pant Kheera-1 (0.778%), VRCU-2318 × Kalyanpur Green (0.790%), VRCU-2317 × Pant Kheera-1 (0.800%), VRCU-2361 × Kalyanpur Green (0.872%) and VRCU-2365 × Pant Kheera-1 (0.914%). Pati *et al.* (2015) reported similar findings on heterosis and inbreeding depression.

Fruit yield (kg/ha)

Heterosis over the better parent heterosis, the range varied from -11.69 to 41.56 per cent. The top best crosses with significant positive heterosis were VRCU-2318 × Pant Kheera-1 (41.56%), VRCU-2304 × Kalyanpur Green (38.60%), VRCU-2371 × Pusa Uday (36.35%), VRCU-2360 × Kalyanpur Green (32.97%), VRCU-2365 × Pusa Uday (31.86%), VRCU-2366 × Pusa Uday (30.88%) and VRCU-2365 × Kalyanpur Green (29.94%). Heterosis over the economic parent (Pusa sanyog), the values ranged from -16.62 to 33.65 per cent. The top best crosses with high and significant positive heterosis over the standard check were VRCU-2318 × Pant Kheera-1 (33.65%), VRCU-2371 × Pusa Uday (27.25%), VRCU-2304 × Kalyanpur Green (26.70%), VRCU-2371 × Pant Kheera-1 (18.80%), VRCU-2360 × Kalyanpur Green (17.03%), VRCU-2366 × Pusa Uday (13.76%) and VRCU-2365 × Kalyanpur Green (12.94%).

The magnitude of inbreeding depression ranged from 2.959% to 27.261. The top best crosses showing the lowest inbreeding depression were VRCU-2317 × Kalyanpur Green (2.959%) followed by VRCU-2361 × Pusa Uday (3.853%), VRCU-2361 × Kalyanpur Green (3.899%), VRCU-2366 × Pant Kheera-1 (4.380%), VRCU-2304 × Kalyanpur Green (6.332%), VRCU-2366 × Pusa Uday (6.271%) and VRCU-2304 × Pusa Uday (6.556%). Dhall *et al.* (2025), Bisht *et al.* (2025) reported that significant negative inbreeding depression was recorded frequently for yield and yield contributing traits indicating that the F_2 was superior to the F_1.

Total soluble solid (^{0}Brix)

Heterosis over the better parent heterosis, the values varied from -15.10 to 44.00 per cent. The top best crosses were VRCU-2317 × Pant Kheera-1 (44.00%), VRCU-2371 × Pusa Uday (33.18%), VRCU-2317 × Pusa Uday (31.75%), VRCU-2360 × Pant Kheera-1 (31.10%), VRCU-2304 × Kalyanpur Green (31.23%), VRCU-2361 × Pusa Uday (32.16%) and VRCU-2383 × Pant Kheera-1 (29.90%). Heterosis over the economic parent (Pusa sanyog), the range extended from -9.47 to 44.35 per cent. The top performing crosses were VRCU-2318 × Pant Kheera-1 (44.35%), VRCU-2371 × Pusa Uday (41.55%), VRCU-2317 × Pant Kheera-1 (39.13%), VRCU-2304 × Kalyanpur Green (38.84%), VRCU-2361 × Pusa Uday (34.20%), VRCU-2366 × Pant Kheera-1 (30.92%) and VRCU-2317 × Pusa Uday (28.70%).

The magnitude of inbreeding depression ranged from 0.231% to 24.699%. The top best crosses with the lowest inbreeding depression were VRCU-2383 × Pant Kheera-1 (0.231%) followed by VRCU-2365 × Pant Kheera-1 (1.616%), VRCU-2304 × Pusa Uday (1.762%), VRCU-2365 × Pusa Uday (2.072%), VRCU-2383 × Kalyanpur Green (2.133%), VRCU-2310 × Pusa Uday (2.387%) and VRCU-2310 × Kalyanpur Green (2.518%). Kumar *et al.* (2024) reported similar findings for these characters as given in the present study.

Fruit flesh thickness (mm)

Heterosis better parent heterosis, the estimates varied from -25.95 to 40.87 per cent. The best best crosses were VRCU-2310 × Pusa Uday (40.87%), VRCU-2383 × Pusa Uday (40.87%), VRCU-2360 × Pusa Uday (34.05%), VRCU-2310 × Pant Kheera-1 (31.42%), VRCU-2383 × Kalyanpur Green (26.49%), VRCU-2310 × Kalyanpur Green (26.45%) and VRCU-2383 × Pant Kheera-1 (22.59%). In case of standard

check heterosis (Pusa sanyog), the values ranged from -0.39 to 70.93 per cent. The top best crosses were VRCU-2371 × Pusa Uday (70.93%), VRCU-2304 × Kalyanpur Green (64.10%), VRCU-2304 × Pant Kheera-1 (31.87%), VRCU-2310 × Pant Kheera-1 (30.86%), VRCU-2310 × Pusa Uday (21.06%), VRCU-2383 × Pusa Uday (21.06%) and VRCU-2383 × Kalyanpur Green (21.09%).

The magnitude of inbreeding depression ranged from 1.259% to 19.014%. The top best crosses showing the lowest inbreeding depression were VRCU-2310 × Pusa Uday (1.259%) followed by VRCU-2304 × Pusa Uday (1.766%), VRCU-2371 × Pant Kheera-1 (2.068%), VRCU-2360 × Pant Kheera-1 (2.486%), VRCU-2361 × Kalyanpur Green (2.555%), VRCU-2317 × Kalyanpur Green (3.564%) and VRCU-2318 × Pusa Uday (4.380%). Similar findings were also reported by Simi *et al.* (2017) in cucumber crop.

Ascorbic acid (mg/100gm FW)

Heterosis over the better parent, the estimates varied from -13.24 to 32.22 per cent. The top best crosses were VRCU-2383 × Pant Kheera-1 (32.22%), VRCU-2304 × Kalyanpur Green (27.50%), VRCU-2318 × Pant Kheera-1 (25.30%), VRCU-2366 × Pant Kheera-1 (25.68%), VRCU-2365 × Pant Kheera-1 (25.07%), VRCU-2366 × Pusa Uday (23.44%) and VRCU-2360 × Pusa Uday (23.50%). Heterosis over the standard check (Pusa sanyog), the range extended from -6.27 to 22.76 per cent. The top best crosses were VRCU-2318 × Pant Kheera-1 (22.76%), VRCU-2304 × Kalyanpur Green (19.35%), VRCU-2383 × Pant Kheera-1 (15.95%), VRCU-2360 × Pusa Uday (13.32%), VRCU-2366 × Pusa Uday (13.26%), VRCU-2365 × Pusa Uday (13.26%) and VRCU-2366 × Pant Kheera-1 (10.22%).

The magnitude of inbreeding depression ranged from 0.943% to 29.143%. The top best crosses showing the lowest inbreeding depression were VRCU-2366 × Pusa Uday (0.943%) followed by VRCU-2365 × Pusa Uday (0.980%), VRCU-2383 × Kalyanpur Green (1.613%), VRCU-2318 × Kalyanpur Green (1.681%), VRCU-2360 × Pusa Uday (1.695%), VRCU-2318 × Pant Kheera-1 (1.709%) and VRCU-2366 × Kalyanpur Green (1.923%). Similar findings were also reported from made done by Kumar *et al.*, (2025).

Shelf life of the fresh fruits (Days)

Heterosis over the better parent, the estimates ranged from -14.77 to 29.94 per cent. The top best crosses were VRCU-2304 × Kalyanpur Green (29.94%), VRCU-2361 × Pusa Uday (21.89%), VRCU-2317 × Pant Kheera-1 (20.60%), VRCU-2371 × Pusa Uday (19.65%), VRCU-2383 × Kalyanpur Green (18.17%), VRCU-2361 × Kalyanpur Green (17.72%) and VRCU-2318 × Pant Kheera-1 (16.70%). In case of standard heterosis (Pusa sanyog), the range extended from -0.12 to 51.64 per cent. The top best crosses were VRCU-2318 × Pant Kheera-1 (51.64%), VRCU-2371 × Pusa Uday (41.50%), VRCU-2304 × Kalyanpur Green (40.00%), VRCU-2317 × Pant Kheera-1 (29.94%), VRCU-2361 × Pusa Uday (28.52%), VRCU-2383 × Kalyanpur Green (21.27%) and VRCU-2361 × Kalyanpur Green (20.81%).

The magnitude of inbreeding depression ranged from -6.889% to 23.651%. The top best crosses with the lowest inbreeding depression (including the negative value) were VRCU-2318 × Kalyanpur Green (-6.889%) followed by VRCU-2304 × Pusa Uday (0.108%), VRCU-2360 × Pant Kheera-1 (1.493%), VRCU-2366 × Pant Kheera-1 (2.532%), VRCU-2365 × Kalyanpur Green (3.069%), VRCU-2360 × Pusa Uday (3.797%) and VRCU-2310 × Pusa Uday (3.906%). Such type findings of heterosis were also reported by Preethi *et al.* (2019).

Conclusions

The study found significant heterosis and inbreeding depression for yield and related variables in cucumber, highlighting the role of non-additive gene action in their inheritance. VRCU-2318 Pant Kheera-1 was the most promising hybrid, with higher fruit yield per hectare compared to the better parent (41.56%) and standard check Pusa Sanyog (33.65%). VRCU-2304 × Kalyanpur Green, VRCU-2371 × Pusa Uday, VRCU-2360 × Kalyanpur Green and VRCU-2366 × Pusa Uday were superior hybrids with high heterotic effects for fruit yield and yield-attributing characteristics like fruit length, diameter and weight. Crosses including VRCU-2317 × Kalyanpur Green, VRCU-2361 × Pusa Uday and VRCU-2304 × Kalyanpur Green showed less inbreeding depression, indicating better performance stability in future generations. As a result, these hybrids can be used for commercial hybrid development and in future breeding programs focused at improving cucumber quality and yield.

Table 1 : Heterosis and inbreeding depression for number of primary branches and days to first male flowers

S. No.	Crosses	Number of primary branches				Days to first male flowers			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	35.09**	27.61**	10.21*	9.057	-21.75**	-32.12**	-14.14**	-28.988
2	(VRCU-2304 × Pant Kheera 1)	23.95**	20.17**	-1.71 NS	1.129	-11.96**	-22.67**	-4.99 NS	-21.577
3	(VRCU-2304 × Kalyanpur Green)	48.57**	44.10**	10.67*	5.513	-24.52**	-34.90**	-16.51**	-41.299
4	(VRCU-2310 × Pusa Uday)	43.64**	16.32**	0.46 NS	13.931	-14.54**	-25.17**	-5.35 NS	-24.939
5	(VRCU-2310 × Pant Kheera 1)	19.54**	-1.13 NS	-19.13**	12.178	-9.54*	-19.79**	-1.45 NS	-23.778
6	(VRCU-2310 × Kalyanpur Green)	30.07**	13.25 NS	-18.25**	11.186	-10.95*	-22.48**	-0.59 NS	-12.952
7	(VRCU-2317 × Pusa Uday)	77.06**	27.61**	10.21*	7.925	-21.01**	-29.68**	-11.05*	-30.634
8	(VRCU-2317 × Pant Kheera 1)	44.74**	6.10 NS	-13.22**	2.236	-14.93**	-23.28**	-5.73 NS	-16.493
9	(VRCU-2317 × Kalyanpur Green)	42.77**	9.09 NS	-21.26**	7.746	-13.71**	-23.64**	-2.07 NS	-13.140
10	(VRCU-2318 × Pusa Uday)	-10.00 NS	-11.88*	-23.89**	9.289	-8.39 NS	-22.12**	-1.49 NS	-6.416
11	(VRCU-2318 × Pant Kheera 1)	43.95**	43.10**	18.44**	3.513	-23.73**	-34.37**	-19.36**	-34.180
12	(VRCU-2318 × Kalyanpur Green)	-0.98 NS	-7.31 NS	-23.29**	7.051	-4.85 NS	-19.56**	3.16 NS	-9.986
13	(VRCU-2360 × Pusa Uday)	1.66 NS	-8.35 NS	-20.84**	6.829	-11.87**	-21.82**	-1.11 NS	-9.957
14	(VRCU-2360 × Pant Kheera 1)	9.87 NS	1.53 NS	-16.96**	8.848	-7.51 NS	-16.89**	2.11 NS	-13.752
15	(VRCU-2360 × Kalyanpur Green)	1.47 NS	-0.51 NS	-28.19**	3.282	-5.78 NS	-16.92**	6.55 NS	-8.422
16	(VRCU-2361 × Pusa Uday)	-0.95 NS	-13.32*	-25.14**	3.519	-10.48*	-20.38**	0.71 NS	-27.452
17	(VRCU-2361 × Pant Kheera 1)	12.93 NS	1.19 NS	-17.24**	10.889	-4.69 NS	-14.14**	5.50 NS	-14.566
18	(VRCU-2361 × Kalyanpur Green)	26.52**	20.04**	-13.35**	0.160	-8.26*	-18.89**	4.01 NS	-20.230
19	(VRCU-2365 × Pusa Uday)	13.76*	7.28 NS	-7.35 NS	5.389	-7.90 NS	-17.93**	3.82 NS	-14.482
20	(VRCU-2365 × Pant Kheera 1)	12.08 NS	8.47 NS	-11.28*	3.438	-5.71 NS	-14.89**	4.57 NS	-16.344
21	(VRCU-2365 × Kalyanpur Green)	6.71 NS	3.68 NS	-20.66**	9.441	-10.31*	-20.55**	1.89 NS	-21.858
22	(VRCU-2366 × Pusa Uday)	13.43*	-0.59 NS	-14.14**	1.292	-3.47 NS	-15.29**	7.15 NS	-15.150
23	(VRCU-2366 × Pant Kheera 1)	21.31**	8.87 NS	-10.95*	0.779	0.96 NS	-10.28**	10.23*	-10.330
24	(VRCU-2366 × Kalyanpur Green)	25.90**	19.65**	-13.63**	0.963	-4.66 NS	-16.83**	6.66 NS	-9.319
25	(VRCU-2371 × Pusa Uday)	35.19**	28.79**	11.23*	9.726	-23.14**	-33.26**	-15.58**	-52.717
26	(VRCU-2371 × Pant Kheera 1)	9.19 NS	6.78 NS	-12.66*	5.079	1.69 NS	-10.59**	9.85*	-10.084
27	(VRCU-2371 × Kalyanpur Green)	29.99**	25.00**	-2.26 NS	2.411	1.53 NS	-12.34**	12.41**	-11.167
28	(VRCU-2383 × Pusa Uday)	27.97**	9.68 NS	-5.27 NS	10.102	-2.74 NS	-11.11**	12.44**	-11.072
29	(VRCU-2383 × Pant Kheera 1)	42.22**	24.75**	2.03 NS	0.543	1.74 NS	-5.77 NS	15.77**	-7.333
30	(VRCU-2383 × Kalyanpur Green)	35.45**	25.61**	-9.33 NS	1.376	-2.37 NS	-11.32**	13.72**	-12.317
Range		-10.00 to 77.06	-13.32 to 44.10	-28.19 to 18.44		-23.73 to 1.74	-34.90 to -5.77	-19.36 to 15.77	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 2 : Heterosis and inbreeding depression for days to first female flowers and node number to first male flower.

S. No.	Crosses	Days to first Female flowers				Node number to first male flower			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	-17.45**	-28.71**	-17.97**	-26.679	16.69*	11.72 NS	-3.28 NS	-29.938
2	(VRCU-2304 × Pant Kheera 1)	-10.09*	-20.81**	-13.00**	-22.437	-21.83**	-33.88**	-24.28**	-27.559
3	(VRCU-2304 × Kalyanpur Green)	-20.78**	-31.58**	-21.31**	-33.512	-14.97*	-16.91*	-31.04**	-50.649
4	(VRCU-2310 × Pusa Uday)	-17.61**	-24.75**	-13.41**	-22.511	14.42*	4.89 NS	8.96 NS	-30.959
5	(VRCU-2310 × Pant Kheera 1)	-12.77**	-18.61**	-10.58*	-24.699	-18.54**	-22.33**	-11.04*	-15.772
6	(VRCU-2310 × Kalyanpur Green)	-15.30**	-22.61**	-11.00*	-16.945	13.10*	1.72 NS	5.67 NS	-19.774
7	(VRCU-2317 × Pusa Uday)	-19.98**	-29.45**	-18.82**	-33.221	-10.28 NS	-21.00**	-10.15 NS	-33.554
8	(VRCU-2317 × Pant Kheera 1)	-12.25**	-21.05**	-13.26**	-13.564	-9.76*	-10.08*	2.99 NS	-19.420
9	(VRCU-2317 × Kalyanpur Green)	-11.43**	-21.89**	-10.17*	-9.712	-2.98 NS	-16.10**	-4.58 NS	-25.938
10	(VRCU-2318 × Pusa Uday)	-6.63 NS	-20.91**	-9.00*	-3.205	45.70**	28.62**	11.34*	-16.621
11	(VRCU-2318 × Pant Kheera 1)	-20.62**	-31.46**	-24.70**	-29.565	-32.31**	-46.57**	-38.81**	-58.537
12	(VRCU-2318 × Kalyanpur Green)	-4.40 NS	-19.01**	-6.85 NS	-10.783	51.33**	36.09**	12.94*	-23.016
13	(VRCU-2360 × Pusa Uday)	-13.58**	-22.62**	-10.97*	-8.013	33.03**	18.65**	31.04**	-19.362
14	(VRCU-2360 × Pant Kheera 1)	-8.89*	-16.71**	-8.50*	-13.271	-0.40 NS	-2.17 NS	12.04*	-24.000
15	(VRCU-2360 × Kalyanpur Green)	-7.61 NS	-17.25**	-4.84 NS	-10.688	34.67**	17.93**	30.25**	-25.688
16	(VRCU-2361 × Pusa Uday)	-10.93**	-19.98**	-7.93 NS	-23.173	-4.37 NS	-7.79 NS	-14.03*	-26.389

17	(VRCU-2361 × Pant Kheera 1)	-3.06 NS	-11.09**	-2.32 NS	-11.299	-9.48 NS	-17.90**	-5.97 NS	-30.794
18	(VRCU-2361 × Kalyanpur Green)	-6.78 NS	-16.23**	-3.66 NS	-18.188	31.00**	23.80**	15.42**	-27.907
19	(VRCU-2365 × Pusa Uday)	-9.59*	-18.19**	-5.87 NS	-12.808	63.01**	61.61**	39.90**	-6.824
20	(VRCU-2365 × Pant Kheera 1)	-6.28 NS	-13.40**	-4.86 NS	-14.301	6.78 NS	-6.95 NS	6.57 NS	-20.448
21	(VRCU-2365 × Kalyanpur Green)	-12.84**	-21.11**	-9.27*	-23.459	30.25**	28.65**	9.45 NS	-16.349
22	(VRCU-2366 × Pusa Uday)	-4.35 NS	-15.15**	-2.37 NS	-16.132	-5.86 NS	-10.80 NS	-13.73*	-25.606
23	(VRCU-2366 × Pant Kheera 1)	-0.29 NS	-9.73*	-0.82 NS	-9.224	9.37 NS	0.87 NS	15.52**	-12.403
24	(VRCU-2366 × Kalyanpur Green)	-6.05 NS	-16.64**	-4.14 NS	-7.977	41.20**	31.17**	26.87**	-29.176
25	(VRCU-2371 × Pusa Uday)	-21.22**	-32.24**	-22.03**	-48.689	-16.57*	-24.48**	-34.63**	-47.489
26	(VRCU-2371 × Pant Kheera 1)	1.66 NS	-10.83**	-2.04 NS	-10.661	18.75**	-4.26 NS	9.65 NS	-16.894
27	(VRCU-2371 × Kalyanpur Green)	3.47 NS	-10.99**	2.37 NS	-10.714	34.63**	24.22**	3.08 NS	-37.681
28	(VRCU-2383 × Pusa Uday)	0.00 NS	-8.65*	5.11 NS	-7.847	21.03**	20.00**	5.67 NS	-31.921
29	(VRCU-2383 × Pant Kheera 1)	3.70 NS	-3.24 NS	6.31 NS	-8.858	-15.42**	-25.20**	-14.33**	-31.707
30	(VRCU-2383 × Kalyanpur Green)	-0.89 NS	-9.44*	4.15 NS	-8.572	7.50 NS	4.41 NS	-8.06 NS	-32.786
Range		-21.22 to 3.70	-32.24 to -3.24	-24.70 to 6.31			-32.31 to 63.01	-46.57 to 61.61	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 3 : Heterosis and inbreeding depression for node number to first Female flower and days to first fruit set.

S. No.	Crosses	Node number to first Female flower				Days to first fruit set			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	-13.84*	-19.07**	-19.27**	-18.927	-11.61*	-18.10**	-9.41 NS	-25.024
2	(VRCU-2304 × Pant Kheera 1)	-5.58 NS	-5.94 NS	12.46 NS	-14.011	-13.74**	-20.60**	-10.90*	-22.963
3	(VRCU-2304 × Kalyanpur Green)	-20.15**	-21.59**	-13.50*	-38.462	-18.56**	-23.62**	-17.70**	-31.972
4	(VRCU-2310 × Pusa Uday)	-2.93 NS	-3.04 NS	31.20**	3.059	-10.02*	-15.22**	-6.23 NS	-17.391
5	(VRCU-2310 × Pant Kheera 1)	5.37 NS	-0.76 NS	34.29**	-25.517	-11.63*	-17.31**	-7.20 NS	-12.857
6	(VRCU-2310 × Kalyanpur Green)	-1.55 NS	-6.01 NS	27.19**	-27.184	-12.88**	-16.90**	-10.46*	-25.978
7	(VRCU-2317 × Pusa Uday)	7.76 NS	6.41 NS	43.67**	-17.634	-18.71**	-23.43**	-15.31**	-26.346
8	(VRCU-2317 × Pant Kheera 1)	14.88*	9.62 NS	44.28**	-12.205	-10.69*	-16.44**	-6.23 NS	-22.763
9	(VRCU-2317 × Kalyanpur Green)	11.44*	7.82 NS	41.92**	-6.319	-9.82*	-14.00**	-7.33 NS	-13.518
10	(VRCU-2318 × Pusa Uday)	11.38 NS	0.00 NS	35.02**	-6.865	-5.29 NS	-15.11**	-6.11 NS	-7.624
11	(VRCU-2318 × Pant Kheera 1)	-35.12**	-38.42**	-26.36**	-44.958	-22.04**	-30.56**	-22.08**	-27.870
12	(VRCU-2318 × Kalyanpur Green)	24.66**	16.74**	43.67**	-12.688	0.52 NS	-8.85 NS	-1.78 NS	-6.905
13	(VRCU-2360 × Pusa Uday)	-0.07 NS	-3.28 NS	39.55**	-16.593	-7.54 NS	-12.15**	-2.83 NS	-2.797
14	(VRCU-2360 × Pant Kheera 1)	1.87 NS	-6.85 NS	34.40**	-23.218	-11.16*	-16.16**	-5.91 NS	-15.896
15	(VRCU-2360 × Kalyanpur Green)	12.63*	4.35 NS	50.57**	-18.686	-3.96 NS	-7.61 NS	-0.44 NS	-8.034
16	(VRCU-2361 × Pusa Uday)	7.11 NS	6.86 NS	44.28**	-21.413	-6.17 NS	-9.63*	-0.04 NS	-15.631
17	(VRCU-2361 × Pant Kheera 1)	32.60**	25.29**	68.38**	-2.202	-3.42 NS	-7.63 NS	3.66 NS	-13.409
18	(VRCU-2361 × Kalyanpur Green)	25.76**	20.46**	61.89**	-8.016	-2.31 NS	-4.72 NS	2.67 NS	-17.601
19	(VRCU-2365 × Pusa Uday)	29.80**	29.70**	75.39**	-1.761	-6.23 NS	-8.51 NS	1.19 NS	-7.751
20	(VRCU-2365 × Pant Kheera 1)	10.99 NS	4.57 NS	41.40**	-11.790	-7.31 NS	-10.20*	0.77 NS	-12.803
21	(VRCU-2365 × Kalyanpur Green)	11.72*	6.70 NS	44.28**	-13.919	-6.51 NS	-7.61 NS	-0.44 NS	-18.090
22	(VRCU-2366 × Pusa Uday)	-11.02*	-15.75**	-17.29**	-27.184	-3.57 NS	-7.45 NS	2.36 NS	-13.205
23	(VRCU-2366 × Pant Kheera 1)	20.09**	7.57 NS	62.51**	-1.141	-1.71 NS	-6.32 NS	5.13 NS	-14.865
24	(VRCU-2366 × Kalyanpur Green)	23.52**	12.07*	69.31**	-7.299	-0.94 NS	-3.72 NS	3.74 NS	-5.792
25	(VRCU-2371 × Pusa Uday)	-33.25**	-38.60**	-17.10*	-32.090	-19.24**	-27.18**	-19.46**	-49.144
26	(VRCU-2371 × Pant Kheera 1)	21.66**	18.52**	41.71**	-14.814	4.11 NS	-6.73 NS	4.66 NS	-2.700
27	(VRCU-2371 × Kalyanpur Green)	36.67**	31.30**	61.59**	-21.801	4.85 NS	-4.35 NS	3.07 NS	-18.712
28	(VRCU-2383 × Pusa Uday)	-12.98*	-1.14 NS	33.47**	-33.796	-2.75 NS	-5.31 NS	4.73 NS	-19.156
29	(VRCU-2383 × Pant Kheera 1)	8.15 NS	6.14 NS	31.82**	-25.059	3.29 NS	-0.14 NS	12.06*	-13.268
30	(VRCU-2383 × Kalyanpur Green)	2.96 NS	2.49 NS	27.29**	-21.845	4.84 NS	3.39 NS	11.41*	-8.327
Range		-35.12 to 36.67	-38.60 to 31.30	-26.36 to 75.39			-22.04 to 4.85	-30.56 to 3.39	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 4 : Heterosis and inbreeding depression for days to marketable maturity and days to last fruit harvest.

S. No.	Crosses	Days to marketable maturity				Days to last fruit harvest			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	5.84 NS	5.76 NS	-4.78 NS	1.607	-10.86*	-13.87**	-3.62 NS	2.108
2	(VRCU-2304 × Pant Kheera 1)	6.12 NS	3.84 NS	-2.46 NS	0.682	-13.42**	-13.71**	-2.80 NS	1.052
3	(VRCU-2304 × Kalyanpur Green)	-4.91 NS	-6.13 NS	-13.38**	-11.999	4.50 NS	3.70 NS	16.04**	12.579
4	(VRCU-2310 × Pusa Uday)	-2.30 NS	-4.81 NS	-9.66**	-1.898	-6.75 NS	-8.00 NS	-4.01 NS	7.474
5	(VRCU-2310 × Pant Kheera 1)	9.39**	8.83**	3.28 NS	7.621	-13.44**	-17.70**	-7.29 NS	1.072
6	(VRCU-2310 × Kalyanpur Green)	8.47*	6.98*	1.52 NS	-3.571	-0.09 NS	-4.00 NS	5.78 NS	3.838
7	(VRCU-2317 × Pusa Uday)	0.03 NS	-5.68 NS	-4.14 NS	-5.880	-7.37 NS	-13.68**	-9.94 NS	1.322
8	(VRCU-2317 × Pant Kheera 1)	-0.20 NS	-3.98 NS	-2.41 NS	0.051	-8.49 NS	-17.63**	-7.22 NS	1.151
9	(VRCU-2317 × Kalyanpur Green)	4.45 NS	-0.35 NS	1.28 NS	2.041	3.44 NS	-5.98 NS	3.60 NS	3.338
10	(VRCU-2318 × Pusa Uday)	13.12**	11.25**	0.16 NS	-1.778	-7.96 NS	-12.75**	1.61 NS	3.027
11	(VRCU-2318 × Pant Kheera 1)	-7.71*	-11.09**	-16.48**	-24.218	3.00 NS	1.31 NS	17.99**	15.557
12	(VRCU-2318 × Kalyanpur Green)	4.59 NS	1.63 NS	-6.21 NS	7.520	-6.18 NS	-8.70 NS	6.32 NS	4.251
13	(VRCU-2360 × Pusa Uday)	5.13 NS	-4.41 NS	5.15 NS	8.746	7.87 NS	6.77 NS	11.40*	3.706
14	(VRCU-2360 × Pant Kheera 1)	-9.88**	-16.46**	-8.11*	-16.360	-5.61 NS	-9.98*	1.41 NS	0.966
15	(VRCU-2360 × Kalyanpur Green)	-7.37*	-14.83**	-6.32*	-0.036	-4.11 NS	-7.58 NS	1.84 NS	6.382
16	(VRCU-2361 × Pusa Uday)	-4.61 NS	-11.34**	-7.07*	-3.783	-0.75 NS	-1.46 NS	2.82 NS	2.473
17	(VRCU-2361 × Pant Kheera 1)	-2.95 NS	-7.98**	-3.55 NS	3.004	-6.73 NS	-10.78*	0.50 NS	1.883
18	(VRCU-2361 × Kalyanpur Green)	1.63 NS	-4.44 NS	0.16 NS	0.896	2.50 NS	-0.91 NS	9.18 NS	5.747
19	(VRCU-2365 × Pusa Uday)	6.96*	-0.17 NS	3.70 NS	0.000	10.52*	8.53 NS	13.24*	11.148
20	(VRCU-2365 × Pant Kheera 1)	5.03 NS	0.00 NS	3.88 NS	-1.139	6.75 NS	1.04 NS	13.82*	10.934
21	(VRCU-2365 × Kalyanpur Green)	-9.76**	-14.80**	-11.49**	-19.297	-3.35 NS	-7.56 NS	1.86 NS	4.724
22	(VRCU-2366 × Pusa Uday)	-9.60**	-14.85**	-13.26**	-8.017	-2.22 NS	-4.41 NS	4.42 NS	0.742
23	(VRCU-2366 × Pant Kheera 1)	-7.11*	-10.73**	-9.06**	2.190	-13.34**	-14.65**	-3.86 NS	1.580
24	(VRCU-2366 × Kalyanpur Green)	-6.37 NS	-10.78**	-9.11**	-1.281	-0.15 NS	-0.58 NS	9.55 NS	8.679
25	(VRCU-2371 × Pusa Uday)	-4.68 NS	-5.25 NS	-14.70**	-16.364	7.13 NS	2.87 NS	16.59**	8.072
26	(VRCU-2371 × Pant Kheera 1)	6.93*	4.09 NS	-2.22 NS	9.632	0.11 NS	-0.20 NS	13.11*	11.501
27	(VRCU-2371 × Kalyanpur Green)	3.43 NS	1.56 NS	-6.28*	-5.571	0.48 NS	-0.92 NS	12.30*	7.368
28	(VRCU-2383 × Pusa Uday)	-0.36 NS	-3.07 NS	-7.71*	-3.597	-4.63 NS	-6.97 NS	2.08 NS	4.742
29	(VRCU-2383 × Pant Kheera 1)	-0.85 NS	-1.52 NS	-6.23 NS	-2.317	-12.97**	-14.10**	-3.24 NS	3.857
30	(VRCU-2383 × Kalyanpur Green)	1.95 NS	0.38 NS	-4.42 NS	-1.791	-16.67**	-16.84**	-8.37 NS	4.558
Range		-9.88 to 13.12	-16.46 to 11.25	-16.48 to 5.15			-16.67 to 10.52	-17.70 to 8.53	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 5 : Heterosis and inbreeding depression for number of fruits per plant and fruit length (cm)

S. No.	Crosses	Number of fruits per plant				Fruit length (cm)			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	-1.10 NS	-9.01 NS	5.82 NS	5.906	-13.22*	-13.59**	-13.69**	6.132
2	(VRCU-2304 × Pant Kheera 1)	-7.93 NS	-8.29 NS	6.66 NS	11.889	6.06 NS	-1.38 NS	-1.49 NS	17.641
3	(VRCU-2304 × Kalyanpur Green)	4.68**	2.27**	18.93**	3.708	27.82**	19.90**	19.76**	2.160
4	(VRCU-2310 × Pusa Uday)	10.26**	9.20**	6.68**	6.146	16.67**	13.42*	12.33*	11.800
5	(VRCU-2310 × Pant Kheera 1)	0.62 NS	-7.91 NS	6.25 NS	17.244	15.33**	10.62 NS	3.46 NS	10.942
6	(VRCU-2310 × Kalyanpur Green)	8.16 NS	0.79 NS	11.81 NS	8.548	15.52**	11.80*	4.57 NS	5.793
7	(VRCU-2317 × Pusa Uday)	19.69**	18.30**	18.32**	6.212	-1.25 NS	-1.79 NS	-2.73 NS	17.101
8	(VRCU-2317 × Pant Kheera 1)	2.48 NS	-4.34 NS	10.38 NS	7.441	9.58 NS	2.82 NS	0.73 NS	3.202
9	(VRCU-2317 × Kalyanpur Green)	2.25 NS	-2.78 NS	7.84 NS	2.273	24.77**	18.11**	15.71**	7.210
10	(VRCU-2318 × Pusa Uday)	1.61 NS	-7.34 NS	9.87 NS	8.981	-0.14 NS	-3.40 NS	2.37 NS	2.716
11	(VRCU-2318 × Pant Kheera 1)	5.55**	4.13**	23.47**	22.581	31.18**	18.74**	25.84**	18.189
12	(VRCU-2318 × Kalyanpur Green)	-17.05**	-19.72**	-4.82 NS	8.500	-4.43 NS	-12.76**	-7.55 NS	17.616
13	(VRCU-2360 × Pusa Uday)	-2.79 NS	-9.92 NS	3.12 NS	5.882	5.29 NS	-1.69 NS	-2.63 NS	4.947
14	(VRCU-2360 × Pant Kheera 1)	-11.27 NS	-11.61 NS	1.98 NS	7.812	19.21**	19.19**	2.40 NS	5.481
15	(VRCU-2360 × Kalyanpur Green)	0.25 NS	-1.30 NS	12.99 NS	3.961	12.85*	11.82*	-2.15 NS	12.125
16	(VRCU-2361 × Pusa Uday)	-3.07 NS	-6.51 NS	-1.70 NS	2.743	10.21 NS	-3.89 NS	-4.82 NS	3.286
17	(VRCU-2361 × Pant Kheera 1)	4.75 NS	0.11 NS	15.50*	11.513	19.84**	11.33 NS	-4.39 NS	20.871
18	(VRCU-2361 × Kalyanpur Green)	2.09 NS	-0.57 NS	10.29 NS	3.056	25.04**	15.17*	0.78 NS	4.729

19	(VRCU-2365 × Pusa Uday)	11.75**	7.13**	14.09**	14.554	10.41 NS	7.17 NS	6.14 NS	5.845
20	(VRCU-2365 × Pant Kheera 1)	-14.06*	-17.37**	-4.66 NS	14.911	8.67 NS	4.38 NS	-2.68 NS	6.939
21	(VRCU-2365 × Kalyanpur Green)	4.69**	2.60**	13.81**	15.513	3.53 NS	0.36 NS	-6.44 NS	7.856
22	(VRCU-2366 × Pusa Uday)	8.08**	1.22**	13.26**	4.816	3.16 NS	1.10 NS	0.13 NS	2.432
23	(VRCU-2366 × Pant Kheera 1)	-6.68 NS	-8.09 NS	6.05 NS	1.733	14.34*	8.81 NS	3.46 NS	6.529
24	(VRCU-2366 × Kalyanpur Green)	-7.80 NS	-8.20 NS	2.72 NS	8.587	12.74*	8.25 NS	2.93 NS	11.000
25	(VRCU-2371 × Pusa Uday)	10.57 NS	1.09 NS	19.20**	14.035	22.33**	21.44**	22.05**	6.021
26	(VRCU-2371 × Pant Kheera 1)	-3.71 NS	-4.75 NS	12.32 NS	6.382	21.27**	12.45*	13.01*	19.859
27	(VRCU-2371 × Kalyanpur Green)	-11.10 NS	-13.74*	1.72 NS	14.157	8.92 NS	1.88 NS	2.38 NS	4.700
28	(VRCU-2383 × Pusa Uday)	4.15 NS	-4.02 NS	11.21 NS	12.292	15.94**	8.29 NS	7.25 NS	5.648
29	(VRCU-2383 × Pant Kheera 1)	6.61**	6.80**	7.99**	2.162	30.69**	30.63**	12.30*	5.605
30	(VRCU-2383 × Kalyanpur Green)	-9.92 NS	-11.85 NS	2.14 NS	6.177	24.28**	23.19**	7.80 NS	7.230
Range		-17.05 to 19.69	-19.72 to 18.30	-4.82 to 23.47			-13.22 to 31.18	-13.59 to 30.63	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 6 : Heterosis and inbreeding depression for fruit Diameter (cm) and average fruit weight (gm).

S. No.	Crosses	Fruit Diameter (cm)				Average fruit weight (gm)			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	-5.86 NS	-7.01 NS	1.24 NS	21.130	-0.33 NS	-4.01 NS	-15.92**	0.691
2	(VRCU-2304 × Pant Kheera 1)	10.96 NS	-2.44 NS	6.22 NS	24.122	13.02 NS	11.34 NS	-9.68 NS	0.778
3	(VRCU-2304 × Kalyanpur Green)	19.19**	15.84**	17.41*	16.102	35.70**	35.44**	9.87 NS	2.722
4	(VRCU-2310 × Pusa Uday)	1.58 NS	-2.11 NS	3.98 NS	2.871	22.77**	16.52*	2.06 NS	2.741
5	(VRCU-2310 × Pant Kheera 1)	14.47 NS	5.22 NS	3.65 NS	3.837	22.12**	22.09**	-3.90 NS	2.873
6	(VRCU-2310 × Kalyanpur Green)	-0.84 NS	-6.06 NS	-7.46 NS	18.817	16.04*	14.50*	-7.47 NS	1.492
7	(VRCU-2317 × Pusa Uday)	-0.91 NS	-1.95 NS	4.15 NS	22.674	11.46 NS	6.62 NS	-6.61 NS	3.290
8	(VRCU-2317 × Pant Kheera 1)	14.67 NS	2.87 NS	6.97 NS	2.791	16.55*	15.63*	-7.52 NS	0.800
9	(VRCU-2317 × Kalyanpur Green)	9.02 NS	0.72 NS	4.73 NS	8.551	11.49 NS	10.92 NS	-10.37 NS	0.700
10	(VRCU-2318 × Pusa Uday)	-6.35 NS	-10.18 NS	3.90 NS	2.632	17.75**	14.10*	-0.05 NS	1.847
11	(VRCU-2318 × Pant Kheera 1)	22.46**	14.95**	21.39**	19.057	38.88**	35.96**	11.72*	6.048
12	(VRCU-2318 × Kalyanpur Green)	-0.65 NS	-12.47*	1.24 NS	5.405	10.88 NS	9.96 NS	-9.65 NS	0.790
13	(VRCU-2360 × Pusa Uday)	3.47 NS	-5.62 NS	0.25 NS	2.233	12.98 NS	7.66 NS	-5.69 NS	1.409
14	(VRCU-2360 × Pant Kheera 1)	18.42*	15.06 NS	0.75 NS	1.728	17.16*	16.68*	-7.40 NS	0.960
15	(VRCU-2360 × Kalyanpur Green)	12.41 NS	12.04 NS	-1.24 NS	10.832	33.48**	32.28**	6.89 NS	3.283
16	(VRCU-2361 × Pusa Uday)	10.55 NS	-1.87 NS	4.23 NS	16.946	14.99*	10.02 NS	-3.62 NS	1.143
17	(VRCU-2361 × Pant Kheera 1)	22.78**	22.59**	1.24 NS	4.669	14.71*	13.77 NS	-8.95 NS	1.562
18	(VRCU-2361 × Kalyanpur Green)	15.47 NS	11.67 NS	-1.58 NS	9.848	18.47**	17.90*	-4.73 NS	0.872
19	(VRCU-2365 × Pusa Uday)	3.21 NS	-4.53 NS	1.41 NS	10.784	18.06**	13.45*	-0.62 NS	2.894
20	(VRCU-2365 × Pant Kheera 1)	15.11 NS	10.19 NS	-0.50 NS	13.750	23.02**	21.46**	-1.90 NS	0.914
21	(VRCU-2365 × Kalyanpur Green)	16.45*	15.06 NS	3.90 NS	22.488	26.63**	26.59**	2.30 NS	4.241
22	(VRCU-2366 × Pusa Uday)	-1.30 NS	-2.58 NS	3.48 NS	21.635	23.66**	18.35**	3.67 NS	1.530
23	(VRCU-2366 × Pant Kheera 1)	8.38 NS	-2.56 NS	0.83 NS	11.605	35.68**	34.52**	7.73 NS	2.694
24	(VRCU-2366 × Kalyanpur Green)	8.52 NS	0.48 NS	3.98 NS	3.830	24.49**	23.93**	0.14 NS	2.422
25	(VRCU-2371 × Pusa Uday)	19.56**	17.34**	18.82**	27.824	30.35**	25.88**	10.27 NS	4.930
26	(VRCU-2371 × Pant Kheera 1)	5.02 NS	-8.31 NS	1.49 NS	10.049	36.23**	33.83**	9.19 NS	1.884
27	(VRCU-2371 × Kalyanpur Green)	4.75 NS	-5.92 NS	4.15 NS	16.707	32.67**	32.04**	7.73 NS	1.197
28	(VRCU-2383 × Pusa Uday)	12.90 NS	0.08 NS	6.30 NS	16.159	27.84**	21.32**	6.28 NS	1.358
29	(VRCU-2383 × Pant Kheera 1)	30.61**	30.22**	7.55 NS	15.118	28.93**	28.89**	1.46 NS	4.849
30	(VRCU-2383 × Kalyanpur Green)	28.88**	24.46**	9.70 NS	25.397	29.92**	28.20**	3.60 NS	1.247
Range		-6.35 to 30.61	-12.47 to 30.22	-7.46 to 21.39			-0.33 to 38.88	-4.01 to 35.96	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 7 : Heterosis and inbreeding depression for fruit yield (kg/ha) and total Soluble Solid (°Brix)

S. No.	Crosses	Fruit yield (kg/ha)				Total Soluble Solid (°Brix)			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	-1.09 NS	-5.66 NS	-13.76 NS	6.556	10.83**	6.58*	12.75**	1.762
2	(VRCU-2304 × Pant Kheera 1)	4.02 NS	2.09 NS	-6.68 NS	12.572	17.42**	12.33**	18.84**	9.024
3	(VRCU-2304 × Kalyanpur Green)	42.09**	38.60**	26.70**	6.332	31.41**	31.23**	38.84**	24.434
4	(VRCU-2310 × Pusa Uday)	35.20**	27.09**	5.45 NS	8.722	13.17**	11.77**	9.18**	2.387
5	(VRCU-2310 × Pant Kheera 1)	23.01*	12.54 NS	-0.95 NS	19.621	-2.52 NS	-3.20 NS	-6.47*	3.405
6	(VRCU-2310 × Kalyanpur Green)	25.38**	15.36 NS	0.27 NS	9.916	26.18**	20.05**	26.67**	2.518
7	(VRCU-2317 × Pusa Uday)	33.45**	29.06**	7.08 NS	9.304	36.83**	31.75**	28.70**	4.054
8	(VRCU-2317 × Pant Kheera 1)	19.67*	12.54 NS	-0.95 NS	8.179	48.76**	44.00**	39.13**	5.833
9	(VRCU-2317 × Kalyanpur Green)	13.84 NS	7.68 NS	-6.40 NS	2.959	16.27**	7.97**	13.91**	18.320
10	(VRCU-2318 × Pusa Uday)	19.97*	12.70 NS	6.40 NS	10.663	-1.92 NS	-13.90**	11.30**	4.948
11	(VRCU-2318 × Pant Kheera 1)	46.53**	41.56**	33.65**	27.261	27.80**	11.66**	44.35**	24.699
12	(VRCU-2318 × Kalyanpur Green)	-8.04 NS	-11.69 NS	-16.62*	9.221	-6.50**	-15.10**	9.76**	5.013
13	(VRCU-2360 × Pusa Uday)	10.28 NS	7.12 NS	-5.72 NS	7.211	21.43**	19.09**	16.33**	11.221
14	(VRCU-2360 × Pant Kheera 1)	4.02 NS	4.02 NS	-8.45 NS	8.696	32.96**	31.10**	26.67**	11.442
15	(VRCU-2360 × Kalyanpur Green)	33.80**	32.97**	17.03*	7.111	27.03**	20.05**	26.67**	8.009
16	(VRCU-2361 × Pusa Uday)	11.66 NS	10.84 NS	-8.04 NS	3.853	34.72**	32.16**	34.20**	6.477
17	(VRCU-2361 × Pant Kheera 1)	20.06*	15.79 NS	1.91 NS	12.895	28.43**	25.31**	27.25**	6.151
18	(VRCU-2361 × Kalyanpur Green)	20.84*	17.24*	1.91 NS	3.899	5.27*	3.30 NS	8.99**	13.561
19	(VRCU-2365 × Pusa Uday)	32.19**	31.86**	9.95 NS	17.030	14.20**	13.86**	11.88**	2.072
20	(VRCU-2365 × Pant Kheera 1)	5.72 NS	2.94 NS	-9.40 NS	15.691	10.36**	9.44**	7.54**	1.616
21	(VRCU-2365 × Kalyanpur Green)	32.64**	29.94**	12.94 NS	19.086	4.41 NS	0.82 NS	6.38*	5.991
22	(VRCU-2366 × Pusa Uday)	33.92**	30.88**	13.76 NS	6.271	19.88**	18.10**	15.36**	9.799
23	(VRCU-2366 × Pant Kheera 1)	26.64**	25.85**	10.76 NS	4.380	36.80**	35.50**	30.92**	5.531
24	(VRCU-2366 × Kalyanpur Green)	14.73 NS	14.73 NS	-0.27 NS	10.800	28.51**	21.98**	28.70**	5.180
25	(VRCU-2371 × Pusa Uday)	44.36**	36.35**	27.25**	18.274	38.80**	33.18**	41.55**	4.303
26	(VRCU-2371 × Pant Kheera 1)	31.03**	27.30**	18.80*	8.147	17.43**	12.09**	19.13**	3.163
27	(VRCU-2371 × Kalyanpur Green)	17.91*	13.87 NS	6.27 NS	15.191	-14.51**	-14.82**	-9.47**	3.526
28	(VRCU-2383 × Pusa Uday)	33.97**	29.94**	14.71 NS	13.478	31.21**	26.41**	23.48**	2.582
29	(VRCU-2383 × Pant Kheera 1)	20.56*	20.37*	6.27 NS	6.897	34.12**	29.90**	25.51**	0.231
30	(VRCU-2383 × Kalyanpur Green)	16.95*	16.05 NS	2.45 NS	7.351	24.59**	15.75**	22.13**	2.133
Range		-8.04 to 46.53	-11.69 to 41.56	-16.62 to 33.65			-14.51 to 48.76	-15.10 to 44.00	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 8 : Heterosis and inbreeding depression for fruit flesh thickness (mm) and ascorbic acid (mg/100 gm FW).

S. No.	Crosses	Fruit Flesh thickness (mm)				Ascorbic acid (mg/100 gm FW)			
		MP (%)	BP (%)	SC (%)	IBD	MP (%)	BP (%)	SC (%)	IBD
1	(VRCU-2304 × Pusa Uday)	7.83 NS	-12.68**	21.09**	1.766	20.46**	19.27**	11.65**	9.677
2	(VRCU-2304 × Pant Kheera 1)	10.70 NS	-4.91 NS	31.87**	8.824	20.99**	17.17**	9.68**	8.148
3	(VRCU-2304 × Kalyanpur Green)	40.01**	18.33**	64.10**	6.757	30.55**	27.50**	19.35**	7.738
4	(VRCU-2310 × Pusa Uday)	41.68**	40.87**	21.06**	1.259	11.39**	8.85**	-0.12 NS	11.290
5	(VRCU-2310 × Pant Kheera 1)	41.82**	31.42**	30.86**	6.338	16.16**	16.08**	1.79 NS	8.955
6	(VRCU-2310 × Kalyanpur Green)	33.99**	26.45**	21.06**	6.569	11.08**	10.04**	-1.79 NS	2.419
7	(VRCU-2317 × Pusa Uday)	20.41**	14.25*	9.37 NS	6.227	11.94**	6.84**	-1.97 NS	8.036
8	(VRCU-2317 × Pant Kheera 1)	20.00**	17.69**	17.19*	8.113	18.78**	15.87**	1.61 NS	1.667
9	(VRCU-2317 × Kalyanpur Green)	16.29*	16.29*	11.33 NS	3.564	10.80**	7.16**	-4.36*	2.632
10	(VRCU-2318 × Pusa Uday)	-4.04 NS	-25.30**	15.27*	4.380	3.53 NS	0.24 NS	-1.79 NS	3.390
11	(VRCU-2318 × Pant Kheera 1)	-9.99 NS	-25.95**	14.26*	10.657	32.24**	25.30**	22.76**	1.709
12	(VRCU-2318 × Kalyanpur Green)	-7.07 NS	-24.70**	16.18*	12.745	17.10**	11.89**	9.62**	1.681
13	(VRCU-2360 × Pusa Uday)	36.38**	34.05**	15.20*	6.803	33.59**	23.50**	13.32**	1.695
14	(VRCU-2360 × Pant Kheera 1)	19.81**	9.84 NS	9.37 NS	2.486	13.20**	6.88**	-6.27**	8.036
15	(VRCU-2360 × Kalyanpur Green)	21.33**	13.26 NS	8.43 NS	4.389	17.23**	9.77**	-2.03 NS	5.405
16	(VRCU-2361 × Pusa Uday)	12.99 NS	0.89 NS	10.32 NS	8.526	4.55*	-5.38**	7.17**	3.540
17	(VRCU-2361 × Pant Kheera 1)	8.44 NS	3.60 NS	13.28*	7.577	1.13 NS	-10.28**	1.61 NS	6.897

18	(VRCU-2361 × Kalyanpur Green)	11.46 NS	4.53 NS	14.29*	2.555	-2.95 NS	-13.24**	-1.73 NS	2.564
19	(VRCU-2365 × Pusa Uday)	16.57*	15.91*	-0.39 NS	5.380	34.80**	23.44**	13.26**	0.980
20	(VRCU-2365 × Pant Kheera 1)	11.13 NS	2.97 NS	2.54 NS	7.843	33.77**	25.07**	9.68**	2.857
21	(VRCU-2365 × Kalyanpur Green)	16.74*	10.17 NS	5.47 NS	8.969	30.28**	20.82**	7.83**	3.704
22	(VRCU-2366 × Pusa Uday)	36.77**	20.45**	3.52 NS	15.190	34.85**	23.44**	13.26**	0.943
23	(VRCU-2366 × Pant Kheera 1)	27.80**	5.88 NS	5.44 NS	10.895	34.48**	25.68**	10.22**	6.481
24	(VRCU-2366 × Kalyanpur Green)	26.04**	6.09 NS	1.56 NS	10.354	32.71**	23.03**	9.80**	1.923
25	(VRCU-2371 × Pusa Uday)	50.24**	20.71**	70.93**	4.380	4.81*	2.69 NS	-1.79 NS	29.143
26	(VRCU-2371 × Pant Kheera 1)	-0.36 NS	-15.15**	20.15**	2.068	4.01 NS	-0.31 NS	-4.66*	4.065
27	(VRCU-2371 × Kalyanpur Green)	-0.40 NS	-16.53**	18.20**	9.397	9.34**	5.68*	1.08 NS	4.959
28	(VRCU-2383 × Pusa Uday)	68.70**	40.87**	21.06**	6.387	17.09**	7.03**	-1.79 NS	4.839
29	(VRCU-2383 × Pant Kheera 1)	55.34**	22.59**	22.07**	19.014	41.68**	32.22**	15.95**	3.200
30	(VRCU-2383 × Kalyanpur Green)	57.96**	26.49**	21.09**	9.006	25.38**	16.06**	3.58 NS	1.613
Range		-9.99 to 68.70	-25.95 to 40.87	-0.39 to 70.93			-2.95 to 41.68	-13.24 to 32.22	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

Table 9 : Heterosis and inbreeding depression for shelf life of the fresh fruits (days).

S. No.	Crosses	Shelf life of the fresh fruits (days)			
		MP (%)	**BP (%)**	**SC (%)**	**IBD**
1	(VRCU-2304 × Pusa Uday)	0.14 NS	-0.93 NS	6.74 NS	0.108
2	(VRCU-2304 × Pant Kheera 1)	-0.54 NS	-0.54 NS	7.17 NS	4.221
3	(VRCU-2304 × Kalyanpur Green)	33.10**	29.94**	40.00**	16.432
4	(VRCU-2310 × Pusa Uday)	32.39**	12.28 NS	18.38*	3.906
5	(VRCU-2310 × Pant Kheera 1)	32.01**	10.98 NS	19.58*	8.608
6	(VRCU-2310 × Kalyanpur Green)	33.36**	14.38 NS	17.38*	8.966
7	(VRCU-2317 × Pusa Uday)	23.60**	12.28 NS	18.38*	5.762
8	(VRCU-2317 × Pant Kheera 1)	34.05**	20.60**	29.94**	15.929
9	(VRCU-2317 × Kalyanpur Green)	8.78 NS	0.04 NS	2.66 NS	4.842
10	(VRCU-2318 × Pusa Uday)	-5.27 NS	-14.21*	11.48 NS	8.299
11	(VRCU-2318 × Pant Kheera 1)	27.59**	16.70**	51.64**	6.174
12	(VRCU-2318 × Kalyanpur Green)	-4.76 NS	-14.77*	10.75 NS	-6.889
13	(VRCU-2360 × Pusa Uday)	9.22 NS	3.95 NS	9.60 NS	3.797
14	(VRCU-2360 × Pant Kheera 1)	6.87 NS	0.68 NS	8.48 NS	1.493
15	(VRCU-2360 × Kalyanpur Green)	8.04 NS	4.17 NS	6.90 NS	4.108
16	(VRCU-2361 × Pusa Uday)	35.90**	21.89**	28.52**	23.651
17	(VRCU-2361 × Pant Kheera 1)	25.00**	11.05 NS	19.65*	8.696
18	(VRCU-2361 × Kalyanpur Green)	29.68**	17.72*	20.81**	7.751
19	(VRCU-2365 × Pusa Uday)	16.14*	13.34 NS	19.50*	8.320
20	(VRCU-2365 × Pant Kheera 1)	-4.00 NS	-7.30 NS	-0.12 NS	4.514
21	(VRCU-2365 × Kalyanpur Green)	7.61 NS	6.42 NS	9.21 NS	3.069
22	(VRCU-2366 × Pusa Uday)	4.82 NS	4.82 NS	10.52 NS	4.603
23	(VRCU-2366 × Pant Kheera 1)	2.86 NS	1.75 NS	9.63 NS	2.532
24	(VRCU-2366 × Kalyanpur Green)	8.72 NS	7.27 NS	13.10 NS	5.325
25	(VRCU-2371 × Pusa Uday)	26.51**	19.65**	41.50**	8.170
26	(VRCU-2371 × Pant Kheera 1)	-3.05 NS	-7.36 NS	9.56 NS	6.224
27	(VRCU-2371 × Kalyanpur Green)	1.22 NS	-5.47 NS	11.79 NS	8.169
28	(VRCU-2383 × Pusa Uday)	15.78*	9.43 NS	15.38*	11.124
29	(VRCU-2383 × Pant Kheera 1)	8.68 NS	1.68 NS	9.56 NS	9.705
30	(VRCU-2383 × Kalyanpur Green)	23.44**	18.17*	21.27**	9.912
Range		-5.27 to 35.90	-14.77 to 29.94	-0.12 to 51.64	

*,** Significant at 5% and 1% probability levels, respectively; NS = non-significant

References

Al-Jebory, K. D. H., & Almashhadani, M. A. B. (2018). Hybrid vigor of cucumber hybrids developed locally which suitable for open field cultivation. *The Iraqi Journal of Agricultural Science*, **49**(3), 377-387.

Bairagi, S. K., Singh, D. K., & Ram, H. H. (2002). Studies on heterosis for yield attributes in cucumber (*Cucumis sativus* L.). *Vegetable Science*, **29**(1), 75–77.

Bhutia, T. L., Munshi, A. D., Behera, T. K., Sureja, A. K., Lal, S. K., & Seyie, A. (2018). Estimates of heterosis for yield and its contributing traits in cucumber. *Indian J Hortic*, **75**(2), 332-336.

Bisht, Y. S., Singh, D. K., Bhatt, R., Rawat, A. S., Kumar, M., Singh, S. S., & Bisht, C. (2025). Exploitation of heterosis and combining ability in cucumber (Cucumis sativus) for earliness and yield contributing traits. *The Indian Journal of Agricultural Sciences*, **95**(11).

Department of Agriculture and Farmers Welfare, Government of India (2022). Final Estimates of Area and Production of Horticultural Crops, 2022–23. Ministry of Agriculture and Farmers Welfare, Government of India.

Dhall, R. K., Hegde, S. N., Singathiya, P., & Manchanda, P. (2025). Heterotic potential and combining ability for yield and quality attributes in slicing cucumber (*Cucumis sativus* L.). *Scientific Reports*, **15**(1), 43937.

Dhumal, T. L., Jagtap, V. S., Kale, T. S., & Padekar, V. D. (2019). Studies on heterosis, inbreeding depression and heritability in ridge gourd (*Luffa acutangula* L.). *Int. J. Pure App. Biosci*, **7**(2), 503-508.

Hays, H.K., Immer, F.R. and Smith, D.C. (1955). Methods of Plant Breeding. McGraw Hill Book Company Inc., New York, pp. 319-22.

Jat, G. S., Munshi, A. D., Behera, T. K., Choudhary, H., & Dev, B. (2015). Exploitation of heterosis in cucumber for earliness, yield and yield components utilizing gynoecious lines. *Indian Journal of Horticulture*, **72**(4), 494-499.

Kanwar, M. S., Karla, B. N., & Kumar, S. (2003). Evaluation of economic traits in cucumber (*Cucumis sativus* L.). *Himanchal J. Agri. Res*, **29**(2), 43-47.

Kumar, A., Kumar, S., & Pal, A. K. (2008). Genetic variability and characters association for fruit yield and yield traits in cucumber. *Indian journal of horticulture*, **65**(4), 423-428.

Kumar, J., Munshi, A. D., Kumar, R., & Sureja, A. K. (2010). Studies on heterosis in slicing cucumber. *Indian Journal of Horticulture*, **67**(2), 197-201.

Kumar, S., Arya, K., Rajiv, Yadav, R. K., Tripathi, V. K., Singh, D. P., Singh, S. V., & Yadav, V. (2025). Genetic analysis of heterosis and inbreeding depression for fruit quality attributes in cucumber (*Cucumis sativus* L.). *International Journal of Advanced Biochemistry Research*, **9**(11), 307–313.

Kumari, R., Kumar, R., & Mehta, D. K. (2021). Expression of heterosis and residual heterosis for traits of earliness and yield in cross combinations of cucumber (*Cucumis sativus* L.) developed by introgression of indigenous and exotic sources. *Scientia Horticulturae*, **277**, 109781.

Kumbhar, H. C., Dumbre, A. D., & Patil, H. E. (2005). Heterosis and combining ability studies in cucumber (*Cucumis sativus* L.). *Journal of Maharashtra Agricultural Universities*, **30**(3), 272–275.

Mukherjee, P. K., Nema, N. K., Maity, N., & Sarkar, B. K. (2013). Phytochemical and therapeutic potential of cucumber. *Fitoterapia*, **84**, 227-236.

Naik, P. R., Adivappar, N., Srinivasa, V., & Gangaprasad, S. (2019). Testing of hybrid vigour for sex phenology in Cucumber (*Cucumis sativus* L). *Int J Curr Microbiol App Sci*, **8**, 1923-1929.

Pati, K., AD, M., TK, B., & AK, S. (2015). Gynoecious inbred improves yield and earliness in cucumber (Cucumis sativus). *Indian Journal of Agricultural Sciences*, **85**(12), 1609-13.

Preethi, G. P., Anjanappa, M., Pitchaimuthu, M., Devappa, V., Ramachandra, R. K., & Venugopalan, R. (2019). Heterosis study in cucumber (*Cucumis sativus* L.). *International Journal of Pure & Applied Bioscience*, **7**(4), 395–400. https://doi.org/10.18782/2320-7051.5255

Simi, F., Ivy, N. A., Saif, H. B., Akter, S., & Anik, M. F. A. (2017). Heterosis in cucumber (*Cucumis sativus* L.). *Bangladesh Journal of Agricultural Research*, **42**(4), 731-747.

Singathiya, P., Dhall, R. K., Manchanda, P., Kumari, P., Lnu, R., & Praveen, S. (2025). Utilizing parthenocarpic gynoecious beit alpha cucumber inbreds for their heterotic potential under different poly-net house environments. *Scientific Reports*, **15**(1), 11617.

Singh SK, Singh SDV, Srivastava JP (2015). Studies on Heterosis and inbreeding depression in Cucumber (*Cucumis sativus* L.). *Agriways*, **3**(2),107:111.

Singh, R., Singh, A. K., Kumar, S., Singh, B. K., & Singh, S. P. (2012). Heterosis and inbreeding depression for fruit characters in cucumber. *Indian J. Hort*, **69**(2), 200-204.

Singh, S. K., Kishor, G. R., & Srivastava, J. P. (2010). Commercial exploitation of hybrid vigour in cucumber. *Prog. Agric*, **10**, 266-269.

Tiwari, R., & Singh, D. K. (2016). Study of heterosis and combining ability for earliness and vegetative traits in Cucumber (*Cucumis sativus* L.). *Journal of Applied and Natural Science*, **8**(2), 999.