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Nutrients profiling for investigating variation and its effect on heterosis and combining ability of cucumber (*Cucumis sativus*)

YASHPAL SINGH BISHT[1], D K SINGH[1], N K SINGH[1], SHASHANK SHEKHAR SINGH[2], RAJENDRA BHATT[1], MUKESH KUMAR[1] and ARVIND CHAUHAN[1]

G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, 263 145, India

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ABSTRACT

An experiment was conducted at Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, during 2021 and 2022 to determine the nutritional quality, variation and its effect on cucumber (*Cucumis sativus* L.). Heterosis for nutritional quality in 30 F_1 of cucumber obtained by L×T method involving 10 gynoecious and 3 monoecious cucumber, was studied and significant difference was found in all the characters. Based on *per se* performance, PPCUC-6 (gynoecious) followed by PPCUC-3 (gynoecious) are best performing parents and PPCUC-7 × PCUC-8 (monoecious) is best performing hybrid for most of characters. The cross combination PPCUC-10 × PCUC-28 (monoecious) based on mid parent, PPCUC-10 × PCUC-28 (monoecious) and PPCUC-12 × PCUC-28 (monoecious) based on better parent and PPCUC-12 × PCUC-28 (monoecious) based on standard parent are found best hybrids for maximum traits. PPCUC-3 (gynoecious) and PCUC-28 (monoecious) were best general combiner for most of characters, which can be used as a parents in improvement of nutritional quality. PPCUC-12 × PCUC-28 (monoecious) was best specific combiner for most of characters. Information of gene actions obtained from the study indicates the predominance of dominant gene action which is highly desirable to develop hybrids in cucumber with better nutritional quality.

Keywords: Cucumber, Combining ability, Gynoecious, Heterosis, Nutritional, Quality

Cucurbits are an important and large group of summer vegetables cultivated extensively in tropical and subtropical countries. Cucumber (*Cucumis sativus* L.) belong to family Cucurbitaceae, have chromosome number 2n = 2X = 14. The Cucurbitaceae consist of 120 genera and 960 species known till date (Bhowmick and Jha 2015). One of the oldest cultivated vegetable is cucumber, dating back thousands of years and possibly originating in India (Tatlioglu 1993). It is a rich source of many nutrients and bioactive components and has been used in many therapeutic medicines, and beauty applications since ancient times (Dixit and Kar 2010). Also, cucumber is very low in calories and rich in moisture content (water). Cucumber is also a vegetable that is rich in many polyphenolics and phytochemicals that have many biological activities such as antioxidants, anti-carcinogenic, anti-inflammatory, anti-hyaluronidase, anti-elastase, diuretic, and analgesic activities (Nema *et al.* 2011, Mukherjee *et al.* 2013). Consuming cucumbers is also advised for treating Alzheimer's disease, hypertension and preventing a number of skin issues, such as swelling under the eyes and sunburn. It is also thought that cucumber consumption will have an increased cooling, healing, soothing, emollient and anti-itching effect on irritated skin. A 100 gm edible portion of fresh cucumber contains 72 IU of vitamin A, 0.03 mg of vitamin B_1, 0.02 mg of vitamin B_2, 0.3 mg of niacin, 3.2 mg of vitamin C, 12 mg of calcium, 0.3 mg of iron, 15 mg of magnesium, and 24 mg of phosphorus (Uthpala *et al.* 2020). There are various benefit of consuming cucumber. Therefore, an experiment was performed to determine the nutritional (quality) properties in cucumber (gynoecious and monoecious) and its hybrids.

MATERIALS AND METHODS

The experiment was conducted at the Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (29.50° latitude and 79.30° longitude at an altitude of 1129 feet (344 m) from the mean sea level), Uttarakhand, during the rainy (*kharif*) season of 2021 and the summer season of 2022 under naturally ventilated protected conditions. Ten gynoecious cucumber (female) namely Pant Parthenocarpic Cucumber-2, Pant Parthenocarpic Cucumber-3, PPCUC-4, PPCUC-5, PPCUC-6, PPCUC-7, PPCUC-9, PPCUC-10, PPCUC-11,

[1]G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand; [2]Krishi Vigyan Kendra, Nawada, Bihar. *Corresponding author email: Yashpal.ktw@gmail.com

PPCUC-12 and 3 monoecious cucumber (male) namely PCUC-8, PCUC-28 and PCUC-51 were crossed by line × tester method design by Kempthorne (1957) to develop 30 F_1 hybrids. The experiment was performed in Randomized Block Design (RBD) with 3 replications in both seasons. The crop was trained on thread by umbrella system and to raise the healthy crop, all cultural practises specified in the package of practises for cucumber crops have been used.

The quality characters, viz. dry matter (%), ascorbic acid (mg/100 g FW), total phenol (mg/g on FW), protein (mg/100 g on FW), phosphorus (mg/100 g DW), potassium (mg/100 g DW), sodium (mg/100 g DW), calcium (mg/100 g DW), iron (mg/100 g DW) and zinc (mg/100 g DW) were studied in 30 hybrids along with parents and check (Pointsett). The ascorbic acid estimation was done by method of Ranganna (1979), protein by Bradford (1976), total phenol by Malick and Singh (1980), phosphorus by Olsen *et al.* (1954), potassium by Pickett and Koirtyohann (1969), Sodium and calcium by Okalebo *et al.* (2002), iron and zinc by Lindsay and Norvell (1978) with minor modifications. The analysis of variance was performed manually in an MS Excel-2013 spreadsheet using the data recorded on the 30 crosses and their 13 parents in accordance with Panse and Sukhatme (1967). Further, line × tester analysis was done through OPSTAT software (Sheoran *et al.* 1998). The degree of heterosis was calculated for the line × tester analysis in relation to the mid-parent, better parent and standard parent. Thus, they were determined as a percentage increase or decrease of F_1's over the mid-parent (MP), better parent (BP) and standard parent (SP) given by Turner (1953) and Hayes *et al.* (1956). The formula provided by Fonseca and Patterson (1968) for estimating heterosis. Additionally, the additive and dominant parts of variance were calculated using the formulas provided by Singh and Chaudhary (1997) and Dabholkar (1992).

RESULTS AND DISCUSSION

Mean performance: Many health benefits of consuming the fresh cucumber has been mentioned by many scientist (Uthpala *et al.* 2020). Desirable significant variation was found for all nutritional characters under study (Table 1) and mean value range between, for all traits, viz. dry matter (%) (parents = 2.75–4.21 and hybrids = 2.91–4.25), ascorbic acid (mg/100 g) (parents = 5.29–6.40 and hybrids = 4.58–6.54), protein (mg/g FW) (parents = 0.26–0.72 and hybrids = 0.20–0.78), total phenol (mg/100 g) (parents = 0.97–1.84 and hybrids = 0.92–1.65), phosphorus (mg/g DW) (parents = 1.25–7.25 and hybrids = 1.02–7.24), potassium (mg/g DW) (parents = 7.29–30.31 and hybrids = 5.42–34.98), sodium (mg/g DW) (parents = 0.57–15.96 and hybrids = 1.19–13.65), calcium (mg/g DW) (parents = 5.23–17.19 and hybrids = 1.36–17.26), iron (mg/100 g DW) (parents = 4.68–12.35 and hybrids = 4.21–13.24), zinc (mg/100 g DW) (parents = 0.19–4.84 and hybrids = 2.81–8.18) (Table 1). PPCUC-6 (gynoecious) is found best performing parents for dry matter, ascorbic acid, phosphorus, potassium, sodium and zinc followed by PPCUC-3 (gynoecious) for dry matter, protein, potassium, calcium and iron. PPCUC-7 × PCUC-8 (monoecious) is best performing hybrid for dry matter, calcium, iron and zinc. Similar range of results for nutrients composition in pumpkin was studied by Nagar *et al.* (2018). According to Allard's (1960) theory, choosing parents based on average performance does not provide desirable outcomes. Therefore, we have to identified heterosis, combining and gene action for all the traits under study in order to choose the best performing parents.

Heterosis and its effect: Heterosis is one of the important tool for exploitation of genetic diversity (Kumar *et al.* 2017). The quality characters, viz. dry matter, ascorbic acid, total phenol, protein, phosphorus, potassium, sodium, calcium, iron and zinc are important to determine the nutritional constituents of cucumber based on different variety and hybrids. In present study, the data revealed that heterosis over mid parent, better parent and over check value ranged from -14.38 to 30.85%, -24.72 to 29.77% and -7.62 to 34.92%, respectively. Out of 30 crosses, 13 hybrids exhibits positive significant relative heterosis, 11 hybrids showed significant heterobeltiosis and 24 hybrids showed significant standard heterosis for dry matter content. The present findings are in correspondence with the finding of Kaur *et al.* (2016), Das *et al.* (2019) and Abo-Arab *et al.* (2020). For ascorbic acid, 24 hybrids exhibit significant relative heterosis (-27.87 to 18.14%), 25 hybrids showed significant heterobeltiosis (-23.24 to 16.54%) and 24 hybrids showed significant standard heterosis (25.00 to 5.77%). The present findings are in correspondence to finding of Kaur *et al.* (2016), Das *et al.* (2019). Heterosis for protein showed, 24 hybrids exhibit significant relative heterosis (-63.07 to 63.95%), 25 hybrids showed significant heterobeltiosis (-69.13 to 22.41%) and 24 hybrids showed significant standard heterosis (-68.60 to 23.74%). Heterosis for total phenol content showed 27 hybrids exhibits significant relative heterosis (-41.69 to 14.55%), all hybrids showed significant heterobeltiosis (-47.57 to -7.12 %) and standard heterosis (-47.23 to 5.16%). Twenty-nine hybrids exhibit significant relative heterosis (-70.37 to 269.53%), 28 hybrids showed significant heterobeltiosis (-79.94 to 223.67%) and 20 hybrids showed significant standard heterosis (-75.50 to 73.26%) for phosphorus content. For potassium, 28 hybrids exhibit significant relative heterosis (-70.79 to 234.18%), 27 hybrids showed significant heterobeltiosis (-73.51 to 234.18%) and 24 hybrids showed significant standard heterosis (61.94 to 145.47%). For sodium content, 29 hybrids exhibit significant relative heterosis (-89.71 to 341.51%), all hybrids showed significant heterobeltiosis (-92.34 to 144.68%) and 29 hybrids showed significant standard heterosis (-82.77 to 97.68%). For calcium content, 27 hybrids exhibit significant relative heterosis (-84.03 to 134.90%), 28 hybrids showed significant heterobeltiosis (-84.03 to 134.90%) and 27 hybrids showed significant standard heterosis (-67.96 to 147.87%). For iron content, 28 hybrids exhibit significant relative heterosis (-39.39 to 86.89%), 26 hybrids showed significant heterobeltiosis (-49.85 to 39.54%) and 26 hybrids showed significant standard heterosis (42.24 to 81.59%).

Table 1 Analysis of variance and mean performance of top 5 parents and hybrids for nutritional contents

Trait *df*	Mean Sum of Square			Range		Mean ± SE	Top parents	Top combinations
	Replication	Treatment	Error					
	2	43	89	Parents	Hybrids			
Dry matter (%)	2	43	89	2.75-4.21	2.91-4.25	0.08	PPCUC-6, PPCUC-3, PCUC-28, PPCUC-12, PPCUC-4	PPCUC-9 × PCUC-28, PPCUC-7 × PCUC-28, PPCUC-7 × PCUC-51, PPCUC-7 × PCUC-8, PPCUC-9 × PCUC-8
Ascorbic Acid (mg/100 g)	0.03	0.38**	0.02	5.29-6.40	4.58-6.54	0.08	PPCUC-2, PPCUC-5, PPCUC-6, PCUC-8, PPCUC-12	PPCUC-12 × PCUC-28, PPCUC-10 × PCUC-28, PPCUC-9 × PCUC-28, PPCUC-6 × PCUC-51, PPCUC-12 × PCUC-8
Protein (mg/g FW)	0.004	0.99**	0.02	0.26-0.72	0.20-0.78	0.008	PPCUC-4, PPCUC-3, PCUC-8, PCUC-28, PCUC-51	PPCUC-10 × PCUC-51, PPCUC-3 × PCUC-28, PPCUC-2 × PCUC-28, PPCUC-10 × PCUC-28, PPCUC-2 × PCUC-51
Total phenol (mg/100 g)	0.0002	0.06**	0.00	0.97-1.84	0.92-1.65	0.01	PCUC-28, PCUC-8, PCUC-51, PPCUC-7, PPCUC-2	PPCUC-12 × PCUC-8, PPCUC-12 × PCUC-51, PPCUC-7 × PCUC-28, PPCUC-12 × PCUC-28, PPCUC-10 × PCUC-8
Phosphorus (mg/g DW)	0.003	0.17**	0.001	1.25-7.25	1.02-7.24	0.06	PPCUC-6, PPCUC-9, PCUC-8, PPCUC-12, PPCUC-7	PPCUC-9 × PCUC-51, PPCUC-12 × PCUC-28, PPCUC-6 × PCUC-28, PPCUC-4 × PCUC-8, PPCUC-9 × PCUC-28
Potassium (mg/g DW)	0.02	8.64**	0.01	7.29-30.31	5.42-34.98	0.29	PPCUC-2, PPCUC-5, PPCUC-6, PPCUC-3, PCUC-51	PPCUC-4 × PCUC-28, PPCUC-6 × PCUC-51, PPCUC-3 × PCUC-8, PPCUC-3 × PCUC-28, PPCUC-9 × PCUC-51
Sodium (mg/g DW)	0.33	150.98**	0.25	0.57-15.96	1.19-13.65	0.12	PPCUC-2, PPCUC-5, PPCUC-6, PPCUC-12, PCUC-51	PPCUC-12 × PCUC-51, PPCUC-3 × PCUC-8, PPCUC-3 × PCUC-51, PPCUC-11 × PCUC-28, PPCUC-11 × PCUC-51
Calcium (mg/g DW)	0.24	40.56**	0.05	5.23-17.19	1.36-17.26	0.15	PPCUC-3, PPCUC-2, PPCUC-5, PPCUC-11, PPCUC-10	PPCUC-7 × PCUC-8, PPCUC-10 × PCUC-51, PPCUC-4 × PCUC-8, PPCUC-7 × PCUC-28, PPCUC-7 × PCUC-51
Iron (mg/100 g DW)	0.02	42.01**	0.07	4.68-12.35	4.21-13.24	0.1	PPCUC-9, PPCUC-3, PPCUC-5, PPCUC-10, PCUC-51	PPCUC-10 × PCUC-28, PPCUC-7 × PCUC-8, PPCUC-5 × PCUC-28, PPCUC-2 × PCUC-51, PPCUC-12 × PCUC-51
Zinc (mg/100 g DW)	0.005	12.95**	0.03	0.19-4.84	2.81-8.18	0.06	PPCUC-6, PPCUC-4, PPCUC-7, PPCUC-5, PPCUC-12	PPCUC-10 × PCUC-28, PPCUC-6 × PCUC-28, PPCUC-7 × PCUC-8, PPCUC-4 × PCUC-8, PPCUC-10 × PCUC-51

Heterosis over mid parent, better parent and over check value ranged from -21.23 to 238.82%, -32.37 to 140.28% and 6.11 to 208.50%, respectively. Out of 30 crosses, 29 hybrids exhibit significant relative heterosis, 29 hybrids showed significant heterobeltiosis and all hybrids showed significant standard heterosis for zinc content (Table 2).

Combining ability: By analysing combining ability, it is possible to assess the genetic potential of parents and hybrids. GCA represent the mean performance of a line in a set of crosses that is governed by additive gene action, which can be fixed. While, specific combining ability (SCA) is representation of these parental lines in specific crosses that is governed non-additive gene action (dominance or epistasis or both) and which is non-fixable. Best general combiner is PPCUC-3 (ascorbic acid, total phenol, phosphorus, potassium, sodium, calcium, iron and zinc) and PCUC-28 (ascorbic acid, protein, total phenol, phosphorus, potassium, sodium and calcium) followed by PPCUC-10 (ascorbic acid, protein, total phenol, potassium and calcium) (Table 3). The low GCA (positive or negative) suggest that mean of parents not vary largely from mean of crosses. Whereas, the high GCA (positive or negative) depicted that parental mean is superior or inferior to general mean of crosses. This indicate the presence of gene flow

Table 2 Range of heterosis of nutritional characters for heterosis (over better, mid and standard parents)

Trait	Range of heterosis (%)			Number of heterosis cross over		
	Mid	Better	Standard	Mid	Better	Standard
Dry matter (%)	-14.38 to 30.85	-24.72 to 29.77	-7.62 to 34.92	13	11	24
Ascorbic acid (mg/100 g)	-27.87 to 18.14	-23.24 to 16.54	-25.00 to 5.77	6	2	1
Protein (mg/g FW)	-63.07 to 63.95	-69.13 to 22.41	-68.60 to 23.74	12	9	9
Total phenol (mg/100 g)	-41.69 to 14.55	-47.57 to -7.12	-47.23 to 5.16	10	0	0
Phosphorus (mg/g DW)	-70.37 to 269.53	-79.94 to 223.67	-75.50 to 73.26	13	11	4
Potassium (mg/g DW)	-70.79 to 234.18	-73.51 to 234.18	-61.94 to 145.47	15	10	17
Sodium (mg/g DW)	-89.71 to 341.51	-92.34 to 144.68	-82.77 to 97.68	12	7	11
Calcium (mg/g DW)	-84.03 to 134.90	-87.99 to 134.16	-67.96 to 147.87	11	7	12
Iron (mg/100 g DW)	-39.39 to 86.89	-49.85 to 39.54	-42.24 to 81.59	11	6	10
Zinc (mg/100 g DW)	-21.23 to 238.82	-32.37 to 140.28	6.11 to 208.50	25	23	30

from parents to off spring (Fasahat *et al.* 2016).

PPCUC-12 × PCUC-28 (protein, total phenol, potassium, phosphorus, sodium, iron and zinc) was best specific combiner followed by PPCUC-4 × PCUC-51 (ascorbic acid, total phenol, potassium, sodium, calcium and iron), PPCUC-5 × PCUC-51 (ascorbic acid, protein, total phenol, phosphorus, sodium and calcium) and PPCUC-9 × PCUC-8 (ascorbic acid, potassium, sodium, calcium, iron and zinc). The cross involves good × good, good × poor and poor × poor general combiner parents. Good × good may be described as additive gene action, poor × poor may be dominance gene effect and SCA effect derived from good × poor may be caused by additive gene effect (Fasahat *et al.* 2016).

Gene action: For a successful crop improvement, estimation of additive and non-additive which are component

Table 3 List of best general and specific combiner for quality traits in cucumber

Trait	Best general combiner	Best specific combiner
Dry matter (%)	PPCUC-7 (0.59), PPCUC-9 (0.47)	PPCUC-10 × PCUC-8 (0.31), PPCUC-11 × PCUC-8 (0.21), PPCUC-3 × PCUC-28 (0.20), PPCUC-2 × PCUC-51 (0.19), PPCUC-10 × PCUC-51 (0.18)
Ascorbic acid (mg/100 g FW)	PPCUC-3 (0.41), PPCUC-10 (0.58), PCUC-28 (0.23)	PPCUC-6 × PCUC-28 (0.96), PPCUC-9 × PCUC-8 (0.77), PPCUC-12 × PCUC-51 (0.64), PPCUC-11 × PCUC-28 (0.45), PPCUC-7 × PCUC-51 (0.30)
Total phenol (mg/g FW)	PPCUC-5 (0.12), PCUC-28 (0.08), PPCUC-7 (0.03), PPCUC-2 (0.02), PPCUC-6 (0.02)	PPCUC-6 × PCUC-8 (0.24), PPCUC-9 × PCUC-51 (0.25), PPCUC-12 × PCUC-28 (0.17), PPCUC-7 × PCUC-51 (0.08), PPCUC-2 × PCUC-28 (0.05)
Protein (mg/g FW)	PPCUC-4 (0.14), PPCUC-10 (0.14), PPCUC-2 (0.10), PPCUC-6 (0.07), PPCUC-3 (0.05)	PPCUC-5 × PCUC-51 (0.26), PPCUC-9 × PCUC-51 (0.22), PPCUC-6 × PCUC-28 (0.17), PPCUC-2 × PCUC-8 (0.17), PPCUC-3 × PCUC-8 (0.12)
Phosphorus (mg/g DW)	PPCUC-4 (1.33), PPCUC-7 (2.30), PPCUC-3 (0.97), PCUC-28 (0.50)	PPCUC-4 × PCUC-28 (2.13), PPCUC-6 × PCUC-51 (2.32), PPCUC-11 × PCUC-51 (1.71), PPCUC-10 × PCUC-51 (1.51), PPCUC-12 × PCUC-8 (1.03)
Potassium (mg/g DW)	PPCUC-10 (6.65), PPCUC-12 (5.98), PPCUC-11 (2.44), PCUC-28 (1.22), PPCUC-3 (0.84)	PPCUC-3 × PCUC-28 (15.35), PPCUC-4 × PCUC-51 (12.14), PPCUC-9 × PCUC-8 (8.81), PPCUC-12 × PCUC-28 (3.75), PPCUC-5 × PCUC-8 (3.67)
Sodium (mg/g DW)	PPCUC-12 (2.77), PPCUC-28 (2.83), PPCUC-4 (1.55), PPCUC-9 (0.71), PPCUC-3 (0.29)	PPCUC-2 × PCUC-28 (3.34), PPCUC-4 × PCUC-51 (4.29), PPCUC-6 × PCUC-51 (3.26), PPCUC-9 × PCUC-28 (3.15), PPCUC-12 × PCUC-28 (1.87)
Calcium (mg/g DW)	PPCUC-11 (3.01), PPCUC-12 (3.31), PPCUC-10 (2.21), PPCUC-3 (1.19), PCUC-28 (1.13)	PPCUC-3 × PCUC-28 (7.16), PPCUC-4 × PCUC-51 (5.01), PPCUC-12 × PCUC-51 (2.75), PPCUC-6 × PCUC-51 (2.45), PPCUC-10 × PCUC-8 (2.34)
Iron (mg/100 g DW)	PPCUC-5 (0.92), PPCUC-9 (2.30), PPCUC-6 (0.60), PPCUC-3 (0.61), PPCUC-4 (0.72)	PPCUC-3 × PCUC-28 (3.10), PPCUC-5 × PCUC-8 (4.59), PPCUC-5 × PCUC-8 (4.59), PPCUC-5 × PCUC-8 (4.59), PPCUC-5 × PCUC-8 (4.59)
Zinc (mg/100 g DW)	PPCUC-3 (0.62), PPCUC-9 (1.62), PPCUC-6 (0.31), PCUC-8 (0.15), PPCUC-5 (0.12)	PPCUC-3 × PCUC-51 (1.60), PPCUC-9 × PCUC-8 (2.24), PPCUC-5 × PCUC-8 (0.73), PPCUC-4 × PCUC-28 (0.72), PPCUC-7 × PCUC-28 (0.71)

of genetic variance is essential. The estimates of σ^2SCA for all the nutrients were higher in magnitude as compared to σ^2GCA (average) under study (Supplementary Table 1) suggesting that non-additive gene effects may be involved in the regulation of these characters. Thus, heterosis breeding may be more effectively used to genetically improve nutritional characters. Earlier, researcher kumar *et al.* (2017) had made known the significance of variance ratio (σ^2g/σ^2s) for gene action studies in cucumber for earliness traits. The closer this ratio is to 1, the higher the predictability based on GCA alone. In the present study, we found variance ratios less than 1 for all traits examined, except for dry matter and sodium content. Again it confirmed the role of non-additive gene action governing nutritional traits. Therefore, study on gene action has highlighted the significance of non-additive gene action in the expression of various traits that are being studied. Heterosis breeding could therefore be used to improve the nutritional quality of cucumbers.

Nutrients quality is important parameter to eradicate the malnutrition. Hence, the quality parameter in cucumber was studied to know the extent of nutrient content in cucumber (gynoecious, monoecious and their cross combination). PPCUC-6 (gynoecious) followed by PPCUC-3 (gynoecious) are best performing parents and PPCUC-7 × PCUC-8 (monoecious) is best performing hybrid on mean basis for most of characters under study. The cross combination PPCUC-10 × PCUC-28 (monoecious) based on mid parent heterosis, PPCUC-10 × PCUC-28 (monoecious) and PPCUC-12 × PCUC-28 (monoecious) based on better parent and PPCUC-12 × PCUC-28 (monoecious) based on standard parent is found best for maximum traits. Based on general combining ability, PPCUC-3 (ascorbic acid, total phenol, phosphorus, potassium, sodium, calcium, iron and zinc) and PCUC-28 (ascorbic acid, protein, total phenol, phosphorus, potassium, sodium and calcium) were best parents. PPCUC-12 × PCUC-28 was best specific combiner followed by PPCUC-4 × PCUC-51 and PPCUC-5 × PCUC-51. The estimates of σ^2SCA were higher in magnitude as compared to σ^2GCA for all characters except dry matter and sodium content, thereby indicating predominant role of dominance gene action governing these traits. Thus, hybrid breeding could better be exploited for genetic improvement of these traits.

REFERENCES

Abo-Arab D E, Ebido A I, Aly M A, Wahb-Allah M A and Bayoumy A M. 2020. General performance, heterosis and potence ratio for some important characters using complete diallel cross among five inbred lines of cucumber (*Cucumis sativus* L.) under greenhouse conditions. *International Journal of Advance Agricultural Research* **25**(4): 364–78.

Allard R W. 1960. *Principles of Plant Breeding,* pp. 485. John Willey and Sons. Inc. New York.

Bhowmick B K and Jha S. 2015. Dynamics of sex expression and chromosome diversity in Cucurbitaceae: a story in the making. *Journal of Genetics* **94**(4): 793–808.

Bradford M M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry* **72**(1-2): 248–54.

Dabholkar A R. 1992. *Elements of Biometrical Genetics,* pp. 187–214. Concept Publishing Company, New Delhi.

Das S P, Mandal A R, Maurya P K, Bhattacharjee T, Banerjee S, Mandal A K and Chattopadhyay A. 2019. Genetic control of economic traits and evidence of economic heterosis in crosses involving monoecious cucumber genotypes. *International Journal of Vegetable Science* **26**(2): 1–22.

Dixit Y and Kar A. 2010. Protective role of three vegetable peels in alloxan induced diabetes mellitus in male mice. *Plant Foods for Human Nutrition* **65**: 284–89.

Fasahat P, Rajabi A, Rad J M and Derera J. 2016. Principles and utilization of combining ability in plant breeding. *Biometrics and Biostatistics International Journal* **4**(1): 1–24.

Fonseca A and Patterson F L. 1968. Hybrid vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Science* **8**: 85–88.

Hayes H K, Immer I R and Smith D C. 1956. *Methods of Plant Breeding*, pp. 535. New York, McGraw Hill Company Inc.

Kaur K, Dhall R K and Chawala N. 2016. Heterosis and combining ability for quality attributing traits in cucumber (*Cucumis sativus* L.). *Agriculture Research Journal* **53**(4): 475–79.

Kempthorne O. 1957. *An Introduction to Genetic Statistics,* pp. 458–71. John Wiley and Sons, NewYork.

Kumar S, Kumar R, Kumar D, Gautam N, Singh N, Parkash C, Dhiman M R and Shukla Y R. 2017. Heterotic potential, potence ratio, combining ability and genetic control of yield and its contributing traits in cucumber (*Cucumis sativus* L.). *New Zealand Journal of Crop and Horticultural Science* **45**(3): 175–90.

Lindsay W L and Norvell W A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**: 421–28.

Malick C P and Singh M B. 1980. *Plant Enzymology and Histo-enzymology*, pp. 286. Kalyani Publishers, New Delhi, India.

Mukherjee P K, Nema N K, Maity N and Sarkar B K. 2013. Phytochemical and therapeutic potential of cucumber. *Fitoterapia* **84**: 227–36.

Nagar A, Sureja A K, Kar A, Bhardwaj R, Krishnan S G and Munshi A D. 2018. Profiling of mineral nutrients and variability study in pumpkin (*Cucurbita moschata*) genotypes. *Agricultural Research* **7**(2): 225–31.

Nema N K, Maity N, Sarkar B and Mukherjee P K. 2011. *Cucumis sativus* fruit-potential antioxidant, anti-hyaluronidase, and anti-elastase agent. *Archives of Dermatological Research* **303**: 247–52.

Okalebo J R, Gathua K W and Woomer P L. 2002. *Laboratory Methods of Soil and Plant Analysis: A Working Manual*, 2nd edn, pp. 55–60. Sacred Africa, Nairobi, Kenya.

Olsen S, Cole C, Watanabe F and Dean L. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate, pp. 1–19. USDA Circular No 939, US Government Print Office, Washington, D.C.

Panse V G and Sukhatme P V. 1967. *Statistical Method for Agricultural Workers*, 4th edn, pp. 225–30. ICAR, New Delhi.

Pickett E E and Koirtyohann S R. 1969. Emission flame photometry- A new look at an old method. *Analytical Chemistry* **41**(14): 28A–42A.

Ranganna S. 1979. *Manual of Analysis of Fruits and Vegetables Products*, pp. 105–06. Tata McGraw Hill Book Company, New Delhi.

Sheoran O P, Tonk D S, Kaushik L S, Hasija R C and Pannu R S. 1998. Statistical software package for agricultural research workers. Recent advances in information theory, statistics and computer applications, pp. 139–43. Hooda D S, Hasija R C (Eds). Department of Mathematics Statistics, Chaudhary Charan Singh Haryana Agricultural University, Hisa, Haryana.

Singh R K and Chaudhary B D. 1997. *Biometrical Methods in Quantitative Genetic Analysis*, pp. 342. Kalyani Publishers, Ludhiana, Punjab, India.

Tatlioglu T. 1993. Cucumber: *Cucumis sativus* L. *Genetic Improvement of Vegetable Crops,* pp. 197–234. Pergamon.

Turner J M. 1953. A study of heterosis in upland cotton II combining ability and inbreeding effects. *Agronomy Journal* **43**: 487–90.

Uthpala T G G, Marapana R A U J, Lakmini K P C and Wettimuny D C. 2020. Nutritional bioactive compounds and health benefits of fresh and processed cucumber (*Cucumis Sativus* L.). *Sumerianz Journal of Biotechnology* **3**(9): 75–82.