Journal of Postharvest Technology
2021, **09**(2): 71-80
www.jpht.in

RESEARCH ARTICLE

Characterization of gynoecious cucumber hybrids in relation to morphological descriptors and organoleptic quality

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Received: 10.03.2021 Accepted: 19.04.2021

ABSTRACT

The research was performed to study qualitative traits including sensory quality of slicing cucumber parents, their hybrids and standard check. The present study was carried out with 27 genotypes of cucumber at vegetable research farm and FS&PHT lab of BAC Sabour, Bhagalpur, Bihar. Significant variations among the genotypes were observed for characters viz., fruit shape, fruit spine color, skin hardness, leaf pubescence density, fruit skin texture and fruit skin color at tender harvestable maturity. However, limited source of variation were identified for stem pubescence, placental cavity, fruit skin mottling and flesh color. To determine the best results of quality, fruits were subjected for sensory analysis of bitterness using a 9-point hedonic scale. Study of qualitative traits and sensory analysis in gynoecious cucumber hybrids suggest that it is a promising method to maintain quality parameters of cucumber for economic returns.

Keywords: Bitterness, downy mildew, gynoecious hybrids, hedonic scale, sensory quality

Citation: Kumari, A., Kumar, R., Tripathi, V., and Bhardwaj, A. 2021. Characterization of gynoecious cucumber hybrids in relation to morphological descriptors and organoleptic quality. *Journal of Postharvest Technology*, **9**(2): 71-80.

INTRODUCTION

Cucumbers (*Cucumis sativus* L.) are rich in vitamins B, C, K along with minerals like copper, phosphorus, potassium and magnesium (Kumari et al., 2018). There is a worldwide tendency towards higher consumption of cucumber because of a growing concern for a more balanced diet, with a lower proportion of carbohydrates, fats and oils and a higher proportion of dietary fiber, vitamins and minerals hence demand for greater external and internal quality of cucumber is increasing. Cucumber originally originated in India, where the wild and cultivated forms are extremely varied. Cultivated cucumber and its wild relatives, including *Cucumis sativus* var. *hardwickii*, expressed wide differences in traits such as fruit size, fruit skin (ridges, colors, speckling), growth habit (vine length and branching), spines (size, density and color), sex expression, and flesh bitterness (Sebastian et al., 2010). Morphological traits are the first impression received by users and the most significant component of acceptance and ultimately of the purchase decision. Fruit size and form are the key determinants of yield and quality at the commercial harvest stage, as well as the fundamental criteria for domestication, market classes, and breeding (Qi et al., 2013; Weng et al., 2015; Wei et al., 2016; Pan et al., 2017). Fruit size and form are dynamic characteristics determined by a variety of attributes, including

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ISSN: 2348-4330

genotype and environmental factors such as light, temperature, cultivation and management. Bitterness in cucumbers is one of the most significant qualitative characteristics that determine its commercial values. Different factors lead to the enhancement of bitterness, such as genetic, environmental and physiological factors (Pitchaimuthu et al., 2012). Cucurbit cultivars with low cucurbitacin content in the fruit have been preferred by the consumer (Klosinska et al., 2001). Evaluation of qualitative traits of gynoecious based cucumber hybrids at tender harvestable maturity involves various parameters to be studied such as leaf pubescence density, stem pubescence, placental cavity, stem-end fruit shape, blossom end fruit shape, fruit skin texture, fruit skin color at tender harvestable maturity, skin hardness of fruit, fruit skin mottling, fruit spine color, fruit shape, flesh color, incidence of downy mildew. Parthenocarpic cucumbers have different fruit features, such as skin colour, appearance, and thickness (Reid, 2015). Cucumber production is limited by pre- and post-harvest diseases. Disease-related economic losses are estimated to range from 30% to 100% each year (Amand and Wehner, 1991). *Pseudoperonospora cubensis* causes cucumber downy mildew, a foliar disease that is considered an economically important disease worldwide for cucumbers. Downy mildew thrives in cool temperatures (60 to 66 degrees Fahrenheit) and relative humidity (approaching 100%) on the leaf surface (Sherf and MacNab, 1986). In this research, we investigated at the prevalence of downy mildew in gynoecious cucumber hybrids. The spine and skin colours of cucumber, *Cucumis sativus* L., are two essential fruit quality traits for variety improvement (Li et al., 2013). In this research, we looked at spine and tender fruit skin colors in gynoecious cucumber hybrids. Morphological characterization would help in elimination of inferior genotypes (Garnepudi et al., 2020). Thus, selecting genotypes based on morphological characteristics such as fruit form and skin colour improved the efficiency of genotype selection for cucumber quality.

MATERIAL AND METHODS

Experimental materials

The experiment was conducted at the vegetable research farm and department of FSPHT lab of BAC, BAU Sabour, Bhagalpur, Bihar. This study was taken up by crossing five diverse parental lines of cucumber genotypes, two of them were gynoecious, one parthenocarpic line, while the other two were monoecious. The five parental lines, along with their 20 F_1 progenies were grown in a field experiment at vegetable farm of BAU Sabour for evaluating their performance for quantitative as well as qualitative traits.

Assessment of morphological traits and sensory (organoleptic) quality

This study was undertaken to test qualitative traits and sensory analysis in gynoecious based cucumber hybrids. Data from all population were recorded on an individual plant basis at commercial harvest stage for the qualitative traits (Table 2). The occurrence of downy mildew disease was recorded under natural conditions. To determine the best results on bitterness, fruits were subjected for sensory analysis using a 9-point hedonic scale. Sensory evaluation was characterized in the form of bitterness and taste of fruit using 10 semi trained panelists. The research was performed to study sensory quality of slicing cucumber parents, their hybrids and standard checks. A total of 10 persons, 7 males, 3 females, aged 30–50 years, participated in the study. The panelists were provided a questionnaire to test bitterness of cucumber. The evaluation was carried out on a '9-point hedonic scale' (1-Dislike extremely, 2-Dislike very much, 3-Dislike moderately, 4-Dislike Slightly, 5-Neither like nor dislike, 6-Like slightly, 7-Like moderately, 8-Like very much, 9-Like extremely). Cucumbers were kept in darkness at room temperature with a relative humidity of 85 percent until two hours before testing. Samples were prepared one hour before assessment and tested within a day. The 1 cm thick slices were cut from the central as well as end portion of the cucumber and placed on coded and randomized plates. Samples were tasted at a self-determined pace by panelists and fresh water and salted peanuts were offered for palate cleaning. The mean data was then subjected for DMRT analysis.

RESULTS AND DISCUSSION

Leaf and stem pubescence

The leaf pubescence density on harvestable maturity was sparsely dense on more than fifty per cent of the genotypes except genotypes BRGCU-10, Punjab Naveen, BRCU-1, BRGCU-4 × Pb. Naveen, BRGCU-10 × BRCU-1, Pb. Naveen × BRGCU-4, Pb. Naveen × BRGCU-10, Pb. Naveen × BRCU-1, BRCU-1 × Pb. Naveen, Don, Malini, where it was intermediate. All the genotypes understudy had hairs on stem (stem pubescence). No significant variations were observed for stem pubescence. The *Cucurbitaceae* family contains a wide range of pubescence morphologies (Inamdar and Gangadhara, 1975). Pubescence serves a variety of roles in plants. They lower heat load, improve freeze resistance, encourage seed dispersal and water absorption, protect against UV-B rays, and repel insects (Adebooye et al., 2012).

Table 1: Characteristics of 27 genotypes of cucumber on 14 qualitative traits

Genotype	Leaf Pubescence Density	Stem Pubescence	Placental Cavity	Stem-end Fruit Shape	Blossom end Fruit Shape	Fruit skin texture	Fruit skin color at tender harvestable maturity
BRGCU-4	Sparse	Present	Absent	Rounded	Rounded	Netted	Light Green
BRPCU-8	Sparse	Present	Absent	Rounded	Pointed	Plain	Dark Green
BRGCU-10	Intermediate	Present	Absent	Pointed	Rounded	Netted	Light Green
Punjab Naveen	Intermediate	Present	Absent	Rounded	Rounded	Netted	Light Green
BRCU-1	Intermediate	Present	Absent	Rounded	Pointed	Netted	Light Green
BRGCU-4 × BRPCU-8	Sparse	Present	Absent	Rounded	Rounded	Netted	Light Green
BRGCU-4 × BRGCU-10	Sparse	Present	Absent	Rounded	Rounded	Netted	Light Green
BRGCU-4 × Pb. Naveen	Intermediate	Present	Absent	Rounded	Rounded	Netted	Light Green
BRGCU-4 × BRCU-1	Sparse	Present	Absent	Rounded	Rounded	Netted	Light Green
BRPCU-8 × BRGCU-4	Sparse	Present	Absent	Rounded	Rounded	Plain	Dark Green
BRPCU-8 × BRGCU-10	Sparse	Present	Absent	Pointed	Rounded	Plain	Dark Green
BRPCU-8 × Pb. Naveen	Sparse	Present	Absent	Rounded	Rounded	Plain	Dark Green
BRPCU-8 × BRCU-1	Sparse	Present	Present	Rounded	Rounded	Netted	Light Green
BRGCU-10 × BRGCU-4	Sparse	Present	Absent	Pointed	Rounded	Netted	Light Green
BRGCU-10 × BRPCU-8	Sparse	Present	Absent	Rounded	Rounded	Plain	Dark Green
BRGCU-10 × Pb. Naveen	Sparse	Present	Absent	Rounded	Rounded	Netted	Light Green
BRGCU-10 × BRCU-1	Intermediate	Present	Absent	Rounded	Pointed	Netted	Light Green
Pb. Naveen × BRGCU-4	Intermediate	Present	Absent	Rounded	Pointed	Netted	Dark Green

Pb. Naveen × BRPCU-8	Sparse	Present	Absent	Rounded	Rounded	Netted	Dark Green
Pb. Naveen × BRGCU-10	Intermediate	Present	Absent	Rounded	Rounded	Netted	Dark Green
Pb. Naveen × BRCU-1	Intermediate	Present	Absent	Rounded	Pointed	Netted	Light Green
BRCU-1 × BRGCU-4	Sparse	Present	Present	Rounded	Rounded	Netted	Light Green
BRCU-1 × BRPCU-8	Sparse	Present	Absent	Rounded	Pointed	Plain	Green
BRCU-1 × BRGCU-10	Sparse	Present	Absent	Rounded	Pointed	Netted	Green
BRCU-1 × Pb. Naveen	Intermediate	Present	Present	Rounded	Rounded	Netted	Light Green
Don	Intermediate	Present	Absent	Rounded	Rounded	Netted	Light Green
Malini	Intermediate	Present	Absent	Pointed	Rounded	Netted	Light Green

Table 1: Continued

Genotype	Skin hardness of fruit	Fruit skin mottling	Fruit spine color	Fruit shape	Flesh color	Sex Form	Incidence of disease (Downy Mildew)
BRGCU-4	Intermediate	Present	White	OE	White	Gynoecious	Present
BRPCU-8	Soft	Absent	Absent	BET	White	Parthenocarpic Gynoecious	Present
BRGCU-10	Intermediate	Present	White	GR	White	Gynoecious	Present
Punjab Naveen	Hard	Present	Black	OE	White	Monoecious	Present
BRCU-1	Hard	Present	Black	BET	White	Monoecious	Present
BRGCU-4 × BRPCU-8	Intermediate	Present	White	EE	Green	Gynoecious	Present
BRGCU-4 × BRGCU-10	Intermediate	Present	White	GR	White	Gynoecious	Present
BRGCU-4 × Pb. Naveen	Hard	Present	Black	OE	White	Gynoecious	Present
BRGCU-4 × BRCU-1	Intermediate	Present	Black	OE	White	Gynoecious	Present
BRPCU-8 × BRGCU-4	Soft	Absent	White	EE	White	Gynoecious	Present
BRPCU-8 × BRGCU-10	Soft	Absent	Absent	GR	White	Gynoecious	Present
BRPCU-8 × Pb. Naveen	Soft	Absent	Absent	EE	Green	Gynoecious	Present
BRPCU-8 × BRCU-1	Intermediate	Present	Absent	OE	Green	Gynoecious	Present
BRGCU-10 × BRGCU-4	Intermediate	Present	White	GR	White	Gynoecious	Present
BRGCU-10 × BRPCU-8	Soft	Absent	Absent	OE	White	Gynoecious	Present
BRGCU-10 × Pb. Naveen	Intermediate	Present	White	GR	White	Gynoecious	Present
BRGCU-10 × BRCU-1	Intermediate	Present	Black	BET	White	Gynoecious	Present
Pb. Naveen × BRGCU-4	Intermediate	Present	Absent	OE	White	Gynoecious	Present
Pb. Naveen × BRPCU-8	Hard	Present	Absent	OE	White	Gynoecious	Present

Pb. Naveen × BRGCU-10	Hard	Present	White	OE	White	Monoecious	Present
Pb. Naveen × BRCU-1	Hard	Present	Black	BET	White	Monoecious	Present
BRCU-1 × BRGCU-4	Intermediate	Present	Absent	OE	White	Gynoecious	Present
BRCU-1 × BRPCU-8	Soft	Absent	Black	BET	White	Gynoecious	Present
BRCU-1 × BRGCU-10	Hard	Present	Black	OE	White	Gynoecious	Present
BRCU-1 × Pb. Naveen	Hard	Present	Black	BET	White	Monoecious	Present
Don	Intermediate	Present	White	OE	White	Monoecious	Present
Malini	Intermediate	Present	White	OE	White	Monoecious	Present

OE: Oblong ellipsoid, BET: Blossom end tapered, EE: Elliptical elongate, GR: Globular round

Stem end, blossom end fruit shape and fruit skin texture

The stem end fruit shape was pointed at harvestable maturity in the genotype BRGCU-10, BRPCU-8 × BRGCU-10, BRGCU-10 × BRGCU-4, Malini, whereas it was rounded in the rest of the genotypes. The blossom end fruit shape was observed to be pointed at harvestable maturity in the seven genotype BRPCU-8, BRCU-1, BRGCU-10 × BRCU-1, Pb. Naveen × BRGCU-4, Pb. Naveen × BRCU-1, BRCU-1 × BRPCU-8 and BRCU-1 × BRGCU-10, while in rest of the twenty genotypes it was found rounded. (Qi et al., 2013; Weng et al., 2015; Wei et al., 2016; Pan et al., 2017) also found comparable results while performing experiments on cucumber fruit size and shape. Fruit skin texture was found plain in the genotypes BRPCU-8, BRPCU-8 × BRGCU-4, BRPCU-8 × BRGCU-10, BRPCU-8 × Pb. Naveen, BRGCU-10 × BRPCU-8 and BRCU-1 × BRPCU-8, whereas it was netted in rest of the genotypes. Shimomura et al. (2012) and Sakata et al. (2011) also found similar results while working on fruit texture in beit alpha, European greenhouse and Japanese cucumbers.

Fruit skin color

Light green fruit skin color at tender harvestable maturity was seen in all the parents understudy except parthenocarpic parent BRPCU-8 where dark green colour was observed. It has been often observed to have dark green fruit skin color in hybrids with one of the parent BRPCU-8 such as BRPCU-8 × BRGCU-4, BRPCU-8 × BRGCU-10, BRPCU-8 × Pb. Naveen, BRGCU-10 × BRPCU-8, Pb. Naveen × BRPCU-8, Pb. Naveen × BRGCU-4 and Pb. Naveen × BRGCU-10, whereas green fruit skin color was observed in BRCU-1 × BRPCU-8 and BRCU-1 × BRGCU-10. Rest of the hybrids understudy produced light green color. Shetty and Whener (1998) reported that the primary variations between the cucumber genotypes are the physical appearance of the fruit, such as rind color and form. Among the parents' fruit skin color was characterized as light green color in gynoecious and monoecious genotypes but dark green color in case of parthenocarpic fruits. Parents having light green color, their combinations produced light green color hybrids but few crosses produced green color hybrids. Combinations having dark green color as one of the parents yielded dark green fruits. This shows dominant behavior of dark green rind color over light green color. (Airina, 2013, Garnepudi, 2020) also found comparable results in cucumber.

Skin hardness

On the basis of skin hardness, parthenocarpic parent (BRPCU-8) fruits were found to be soft, whereas the fruits of gynoecious parents BRGCU-4 and BRGCU-10 were seen with intermediate skin hardness and further it was observed that monoecious parents viz., Punjab Naveen and BRCU-1 were having hard skin. Among hybrids, BRPCU-8 × BRGCU-4, BRPCU-8 × BRGCU-

10, BRPCU-8 × Pb. Naveen, BRGCU-10 × BRPCU-8 and BRCU-1 × BRPCU-8 were found to be soft on the basis of skin hardness. Hybrids BRGCU-4 × BRPCU-8, BRGCU-4 × BRGCU-10, BRGCU-4 × BRCU-1, BRPCU-8 × BRCU-1, 10 × BRGCU-4, BRGCU-10 × Pb. Naveen, BRGCU-10 × BRCU-1, Pb. Naveen × BRGCU-4, BRCU-1 × BRGCU-4, standard check Don and Malini were found to have intermediate skin hardness, while hybrids BRGCU-4 × Pb. Naveen, Pb. Naveen × BRPCU-8, Pb. Naveen × BRGCU-10, Pb. Naveen × BRCU-1, BRCU-1 × BRGCU-10 and BRCU-1 × Punjab Naveen were found to be hard. On the basis of skin hardness, parthenocarpic fruit was found to be soft, gynoecious parents intermediate skin whereas monoecious parents with hard skin. From this investigation it was observed that soft skin character was dominant over intermediate skin and hard skin. Following trend was observed in case of dominant nature of skin as soft skin ≥ intermediate skin ≥ hard skin. Garnepudi et al. (2020) also found comparable results while working with morphological characterization of cucumber.

Fruit skin mottling

Fruit skin mottling was present on most of the genotypes understudy except BRPCU-8, BRPCU-8 × BRGCU-4, BRPCU-8 × BRGCU-10, BRPCU-8 × Pb. Naveen, BRGCU-10 × BRPCU-8 and BRCU-1 × BRPCU-8, where fruit skin mottling was found to be absent. Fruit skin mottling was present on most of the genotypes understudy such as gynoecious as well as monoecious parents and their hybrids but it was absent in parthenocarpic based hybrids.

Fruit spine color

Fruit spine was absent in parthenocarpic parents fruit BRPCU-8 but gynoecious parents BRGCU-4 and BRGCU-10 were seen with white fruit spine color whereas it was observed to be black spine in monoecious parents Punjab Naveen and BRCU-1. Among hybrids, BRPCU-8 × BRGCU-10, BRPCU-8 × Pb. Naveen, BRPCU-8 × BRCU-1, Pb. Naveen × BRPCU-8, BRGCU-10 × BRPCU-8 and BRCU-1 × BRPCU-8 had no spines on fruit at tender harvestable maturity. Hybrids BRGCU-4 × BRPCU-8, BRGCU-4 × BRGCU-10, BRPCU-8 × BRGCU-4, BRGCU-10 × BRGCU-4, BRGCU-10 × Pb. Naveen, Pb. Naveen × BRGCU-10, standard check Don and Malini were found to have white fruit spine color, while hybrids BRGCU-4 × Pb. Naveen, BRGCU-4 × BRCU-1, Pb. Naveen × BRCU-1, BRCU-1 × BRGCU-10 and BRCU-1 × Punjab Naveen had black fruit spine color. Fruit spine was absent in parthenocarpic fruit as well as parthenocarpic based hybrids. Gynoecious parents were seen with white fruit spine color whereas it was observed to be black spine in monoecious parents. All the hybrids involving one of the parents as gynoecious possessed white spine whereas majority of the hybrids having monoecious parents produced black spine color on their fruits. This shows that black spine color is dominant over white spine color. Similar results were suggested by (Airina, 2013, Bhardwaj, 2017) while working on parthenocarpic, gynoecious and monoecious cucumber.

Fruit shape

On the basis of fruit shape genotypes BRGCU-4, Punjab Naveen, BRGCU-4 × Pb. Naveen, BRGCU-4 × BRCU-1, BRPCU-8 × BRCU-1, BRGCU-10 × BRPCU-8, Pb. Naveen × BRGCU-4, Pb. Naveen × BRPCU-8, Pb. Naveen × BRGCU-10, BRCU-1 × BRGCU-4, BRCU-1 × BRGCU-10, Don and Malini were found to have oblong ellipsoid fruit shape, whereas BRPCU-8, BRCU-1, Pb. Naveen × BRCU-1, BRCU-1 × BRPCU-8 and BRCU-1 × Pb. Naveen were observed with Blossom end tapered fruit shape. Hybrids BRGCU-4 × BRPCU-8, BRPCU-8 × BRGCU-4, BRPCU-8 × Pb. Naveen, BRGCU-10 × BRCU-1 were found to have Elliptical elongate fruit shape, whereas genotypes BRGCU-10 × Pb. Naveen, BRGCU-10 × BRGCU-4, BRPCU-8 × BRGCU-10, BRGCU-4 × BRGCU-10 and BRGCU-10 were seen with globular round fruit shape. Fruit shape was characterized as oblong ellipsoid fruit shape, blossom end tapered fruit shape, elliptical elongate fruit shape, globular round fruit shape. Most of the genotypes under study were observed with oblong ellipsoid fruit shape. Majority of the parents and hybrids understudy produced white flesh color except few parthenocarpic based hybrids which produced Whitish green flesh color. Fruit skin texture was found netted in most of the genotypes whereas it was plain in majority of parthenocarpic based hybrids. The blossom end fruit shape and stem end fruit shape were observed to be rounded at harvestable maturity in majority of the genotypes.

Flesh color and placental cavity

Majority of the parents and hybrids understudy produced white flesh color except BRPCU-8 × BRCU-1, BRPCU-8 × Pb. Naveen and BRGCU-4 × BRPCU-8 which produced greenish tinge at the pericarp end. Placental cavity was found in majority of the genotypes except three genotypes BRPCU-8 × BRCU-1, BRCU-1 × BRGCU-4 and BRCU-1 × Pb. Naveen. Placental cavity is considered to be undesirable traits for cucumber. Garnepudi et al. (2020) also found comparable results while working with morphological characterization of cucumber.

Incidence of downy mildew disease

Downy mildew incidence for different parents and hybrids were noted as presence or absence of disease. All the genotype understudy expressed presence of infection under natural condition. None of the genotypes showed resistance to downy mildew. Among the parents, BRGCU-4, BRPCU-8 and BRGCU-10 exhibited minimum infection which falls under the category of moderate resistance. Among the hybrids BRGCU-10 × BRCU-1, BRGCU-4 × BRCU-1, BRGCU-10 × BRGCU-4, BRPCU-8 × BRCU-1, BRCU-1 × BRPCU-8, BRCU-1 × BRGCU-10 and BRPCU-8 × BRGCU-4 exhibited minimum infection. Palti et al. (1980) and Pessarakli (2016) also worked on downy mildew of cucurbits its epidemiology and control.

Sensory evaluation of bitterness

The bitterness of cucumbers of different genotypes was in the range 1.9 (the most bitter)- 8.4 (less bitter). A difference between monoecious, parthenocarpic and gynoecious cucumbers was observed with the monoecious ones being more bitter. Bitterness was most obvious for monoecious parents, while parthenocarpic cucumber kept best taste (non-bitter) during analysis (Table 2). Among parents BRGCU-10 (7.7) and hybrids BRGCU-10 × BRCU-1 secured highest scores (8.4), hence mostly preferred by the panelists. Though the hybrids cucumbers BRGCU-4x BRPCU-8 and BRPCU-8 × Punjab Naveen displayed better scores (both display 7.6 scores) as per the sensory evaluation. Parents Punjab Naveen (5.8) and Hybrids BRCU-1 × Punjab Naveen achieved minimum scores (1.9) most obvious least preferred by the panelists. Bitterness in most cucurbit species including cucumber fruit is due to the presence of bitter compounds called cucurbitacins (Rehm et al., 1957; Balkema-boomstra et al., 2003). In addition to genetic factors, other factors like environmental conditions also contribute to bitterness (Kano and Goto 2003; Pitchaimuthu et al., 2012). Fluctuation in temperature during growing season is one of the prime factor that contributes bitterness in cucumber (Klosinska et al., 2001). Cucurbit cultivars with low cucurbitacin content in the fruit have been preferred by the consumer. In our study, parents BRGCU-10 and hybrids BRGCU-10 × BRCU-1 were found to contain low cucurbitacin thereby achieved highest scores. Cucurbitacins are thought to be poisons that these plants produce as a defense against insects and herbivores. (Balkema-Boomstra et al., 2003). In the present study, the sensory evaluation test gives an idea of the usefulness of gynoecious based hybrid on overall acceptability of cucumber. Though, the parthenocarpic hybrids cucumbers were showing better results as compared to monoecious hybrids but not better than the gynoecious hybrid ones. Comparable results were reported by Zhang et al. (2012) while working with eighteen genotypes of cucumber and melon collected from south Asian countries; and Airina (2013) when she performed research on parthenocarpic and gynoecious cucumber under polyhouse.

Table 2: Organoleptic properties of cucumber genotypes for bitterness on the basis of 9 point hedonic scale

Genotypes	Mean
BRGCU-4	6.2^{ghi}
BRPCU-8	7.5^{abcdef}
BRGCU-10	7.7^{abcd}
Punjab Naveen	5.8^{hij}
BRCU-1	6.1^{ghi}
BRGCU-4 × BRPCU-8	7.6^{abcde}
BRGCU-4 × BRGCU-10	5.8^{hijk}
BRGCU-4 × Pb. Naveen	$4.7^{j\,l}$
BRGCU-4 × BRCU-1	$7.2^{abcdefg}$
BRPCU-8 × BRGCU-4	6.4^{efghi}
BRPCU-8 × BRGCU-10	7.9^{abc}
BRPCU-8 × Pb. Naveen	7.6^{abcde}
BRPCU-8 × BRCU-1	7.1^{bcdefg}
BRGCU-10 × BRGCU-4	6.3^{fghi}
BRGCU-10 × BRPCU-8	8.0^{ab}
BRGCU-10 × Pb. Naveen	$6.7^{cdefghi}$
BRGCU-10 × BRCU-1	8.4^{a}
Pb. Naveen × BRGCU-4	5.6^{ijkl}
Pb. Naveen × BRPCU-8	7.5^{abcdef}
Pb. Naveen × BRGCU-10	7.1^{bcdefg}
Pb. Naveen × BRCU-1	2.5^{m}
BRCU-1 × BRGCU-4	6.5^{defghi}
BRCU-1 × BRPCU-8	$7.0^{bcdefgh}$
BRCU-1 × BRGCU-10	$7.2^{abcdefg}$
BRCU-1 × Pb. Naveen	1.9^{m}
DON	3.0^{m}
MALINI	$6.7^{cdefghi}$

The means followed by a common letter are not significantly different at 5% level by DMRT

CONCLUSION

Consumer expectations are affected by physical appearance. Morphological features therefore play an important role in the acceptance as well as commercialization of any cultivar. The concept of study of morphological traits as a way to differentiate cucumber varieties has been recognized for years. This investigation essentially provides the measures for monitoring external as well as internal quality of parthenocarpic, monoecious and gynoecious cucumber cultivars. Fluctuation in temperature during growing season is one of the prime factor that contributes bitterness in cucumber hybrids in present study hence the performance of these hybrids under different environmental conditions and different locations need to be evaluated. The performance of parthenocarpic as well as gynoecious based cucumber hybrids was found to be excellent in quantitative traits therefore the scope of incorporating parthenocarpy in F_1 hybrids should also be explored further in future line of work. In addition, further research should be carried out to illustrate the physiology of bitterness in order to establish bitter free genotypes and effective management practices to prevent bitterness in cucumber. Understanding the morphological characteristics, increases the possibility for better exploiting the genetic diversity for better cultivar development. Desirable traits can be transferred to other cucumber cultivars by adopting a suitable breeding method.

ACKNOWLEDGEMENTS

All kind of support provided by Bihar Agricultural University, Sabour, India is duly acknowledged. This article bears a BAU COMMUNICATION NO. 958/210309.

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