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Evaluation of gynoecious cucumber (*Cucumis sativus*) hybrids for early-summer greenhouse production in western Indian arid plains

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ABSTRACT

A great stride is witnessed in area expansion under protected cultivation, particularly in arid-western parts of India, where cucumber (*Cucumis sativus* L.) is a predominant greenhouse crop. The early-summer crop of cucumber is highly remunerative owing to high prevailing market price. In current study, efforts were made to select suitable greenhouse cucumber hybrids for early season harvest under western Indian arid plains. Growth, yield and commercial quality traits of seven commercial gynoecious and parthenocarpic (seedless) cucumber hybrids were studied under greenhouse condition during 2015-16. Among the hybrids evaluated for early summer greenhouse production, Terminator was more precocious for fruit harvest (36 days after transplanting) followed by Rica and Dinamik. The per plant fruit yield was highest in Ekron (5.3 kg) followed by Terminator (4.2 kg). The vine length, leaf size and leaf dry weight were also found to be highest in Ekron, followed by Terminator. The fruit appearance, taste and texture, and overall consumer's acceptability were also determined, which were found better in Rica, Terminator and Dinamik. Despite exhibiting highest production related traits, Ekron measured least score for sensory parameters, especially the fruit appearance due to presence of rudimentary spines on skin, and also the taste. Fruit pericarp thickness and dry matter content were significantly higher in Ekron but the values were at par with that recorded for Terminator and a few other hybrids. The character association analysis reveals that per plant fruit yield had significant positive correlation with vine length, leaf size, foliar (stem+leaf) dry mass and mean fruit weight. Based on targeted characters for earliness, fruit yield and commercial quality of evaluated hybrids, it is concluded that Terminator followed by Rica were highly suitable for early summer production under protected condition in western arid plains of India.

Key words: Arid, Cucumber, Early, Greenhouse, Yield

In western arid plains of India, greenhouse cultivation has attained a great pace in recent years owing to its promise in providing protection to the crops from damages caused due to prevalence of weather aberrations which challenged the open field cultivation in arid region. In addition, it provides favourable micro-climate to the plants for optimal growth and production that enables to extend growing season in either directions of normal growing period. Furthermore, even under normal growing season,vegetables grown under greenhouse are superior in yield and quality as compared to those grown under open field conditions (Sharma *et al*., 2005). However, special emphasis is to be laid for commercial exploitation of greenhouse for off-season cultivation of selected vegetables such as parthenocarpic cucumber (*Cucumis sativus* L.), as this despite providing good yield and quality, is more remunerative (Yadav *et al*. 2014).

Cucumber is a predominant greenhouse crop which can be grown throughout the year, especially during off-season under protected condition that fetches higher price in very short span (Panghal *et al*. 2016). There is a constant demand throughout the year for cucumber, especially the smooth skinned seedless fruit because of its popular use in salad dish, sandwich, pizza and other preparations (Bisht *et al*., 2011). In fact, gynoecious and parthencarpic cucumber hybrids have revolutionized greenhouse industry throughout the world. However, the popularity of each hybrid has its own specificity depending on adaptability to particular growing conditions such as stability regarding pistillate flowering (More 2002), and local market demands for specialized fruits. The precocity or earliness for fruit bearing and harvest is the desired characters for early summer production that fetches high price. Additionally, the cultivar may have high yield potential and good commercial quality that relates to consumers preference.

Since a huge investment is involved in greenhouse production system, farmers cannot afford wrong selection of cultivars, especially of very costly gynoecious and

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parthenocarpic cucumber hybrids. Therefore, before going for commercial cultivation of any gynoecious hybrid, it is imperative to assess the production potential based on growth, earliness, yield and quality for a particular location. Moreover, the commercial quality that relies on physical fruit appearance such as colour, form and size, texture and shelf life (Bertin and Genard 2018) which determines consumers' acceptability of the hybrids in the local market. Therefore, a promising cultivar would be such that have a good compromise between fresh yield and commercial quality traits to satisfy the demands of local market with providing good returns to the farmers. Singh *et al*. (2012) have proposed that the cultivar selection to be based on certain parameters which include earliness, plant vigour, fruit yield and quality, besides consumers' preference for fruits in local market. Hence, cultivars selection for specific agro-ecosystem is a pre-requisite, especially for the prevailing non-automated greenhouse of western arid plains such as naturally ventilated polyhouse or shade net house of which inside environment is greatly influenced by the ambient ones.

The present study was undertaken to identify a suitable cucumber hybrid for early summer season production, based on different vegetative and reproductive growth along with commercial quality attributes, during late winter-early summer season under greenhouse condition of western arid plains of India.

MATERIALS AND METHODS

The experiment was conducted during 2015-16 in 500 m^2 greenhouse covered with UV stabilized polyethylene film (200µ) at Central Research Farm, ICAR-Central Arid Zone Research Institute, Jodhpur (26° 15' N latitude and 72°59' E longitude; 231 MSL). Seven commercial gynoecious and parthenocarpic cucumber hybrids, viz. Kian and Infinity (Nunhems), Rica, Terminator, 52-32 and Dinamik (YukselTohum,), and Ekron (EnzaZaden), were evaluated in the greenhouse condition during December to March, 2015-16. The experiment was arranged in Randomized Complete Block Design with three replications. Each experimental unit consisted of ten plants. The daily mean temperature and relative humidity inside greenhouse ranged from 16–30ºC and 50–85%, respectively during cropping season. The greenhouse soil had pH 7.8, organic carbon 0.22%, total N 0.03%, available P 16.3 kg/ha and available K 221.5 kg/ha. The soil contained 85% sand, 8.1% silt and 5.5% clay, and was classified as coarse loamy, mixed, hyperthermic camborthids according to US soil taxonomy.

Twenty-eight days old seedlings, raised in 50 celled (size 2") pro-trays in cocopeat: vermiculite (3:1) media inside the greenhouse, were transplanted on 27 December, 2015 at 45 cm spacing in paired rows of 50cm on 90cm wide raised beds. Plants were trained to single stem vertically with plastic thread over trellis by regular pinching of side shoots. Drip lines (16 mm) having in-line drippers of 2.1 LPH discharge rate spaced at 30 cm intervals placed 10 cm from plants. At the time of land preparation, 25 t/ha compost was mixed by tilling in the top (15 cm) soil. One day before transplanting, NPK @ 60:60:80 kg/ha and 1.0 t/ha neem cake were mixed in top soil of beds. During crop cycle, additional fertilizers of 60 kg/ha N and 80 kg/ha K along with 12 kg/ha Ca and 4 kg/ha Mg were given through fertigation in whole cropping period. Commercial grade micronutrients were applied through drip at weekly interval. Similar plant protection measures to control pests and diseases were followed in all the treatments.

Plant growth and yield parameters were measured on five randomly selected competitive plants from each hybrid in each replication. At final harvest, the aerial plant parts were separated into leaf and stem, and their dry weight (DW) was determined after oven-drying at 65 °C until constant weight was obtained. Dry weights of leaf and stem together is designated as aerial dry mass. Leaf size (length and width) was measured just before final plant harvest as per methods suggested by Rouphael *et al*. (2010). Physical fruit parameters such as fruit length, fruit girth, fruit pericarp thickness and average fruit weight were measured during peak harvest. The quality analyses of total soluble solids and titratable acidity were performed on the selected sample fruits. Fruit dry matter content was also determined. Commercial fruit quality was determined subjectively by assessing the sensory parameters, viz. fruit appearance, taste, texture and overall consumer's acceptability by employing 9-point Hedonic scale, adjudged by a 10-members panel (Chaudhari *et al*. 2016).

The mean data of each replication were subjected to analysis of variance in a randomized block design with three replications according to Gomez and Gomez (1984). Simple correlations for various characters were worked out and tested for significance.

RESULTS AND DISCUSSION

There was a significant variation for different plant growth parameters among the greenhouse cucumber hybrids (Table 1). The plant growth attributes such as vine length and foliar (leaf and stem) dry mass were highest in Ekron, while lowest in Kian and Infinity. Previous workers have also reported a significant variation in shoot growth including vine length (Singh *et al*. 2015, Chaudhari *et al*. 2016). The highest number of nodes/vine was measured in Dinamik, though it was at par with Rica, Terminator and 52-32. In some instances, vine length has been found to be associated with nodes per vine and/ or internodal length (Chaudhari *et al*., 2016). We also noted a positive correlation between node number per vine and final vine length (Table 3). The node number per vine was in accordance to vine length in all cucumber hybrids, except Ekron, which produced largest vine but having relatively low number of nodes per vine. This variation may rely on the genetic makeup of the cultivars and growing environment. The leaf dry weight and leaf size (horizontal and vertical leaf width) were also positively related and these were recorded highest in Ekron, though it was statistically on par with Terminator. In contrary, lowest

Table 1 Growth characteristics of gynoecious cucumber hybrids in greenhouse

Hybrid	Vine length (m)	No. of node/vine	Horizontal leaf width (cm)	Vertical leaf width (cm)	Stem dry weight (g/plant)	Leaf dry weight (g/plant)
52-32	3.40	50.42	24.64	19.43	23.4	69.9
Dinamik	3.46	55.67	23.30	18.93	25.8	62.9
Terminator	3.76	52.50	26.06	20.25	25.6	70.0
Rica	3.55	53.42	25.74	20.14	23.6	69.4
Infinity	2.46	42.42	22.89	18.90	19.7	53.8
Kian	1.90	38.67	21.05	19.06	16.9	42.8
Ekron	4.23	48.25	27.46	20.77	28.6	89.1
CD (P=0.05)	0.76	5.6	2.14	NS	2.65	10.4

Table 2 Yield and yield attributes of gynoecious cucumber hybrids in greenhouse

Hybrid	Days to first harvest	Fruit length (cm)	Fruit girth (cm)	Mean fruit weight (g)	Number of fruits/plant	Yield (kg/plant)
52-32	39.1	21.5	3.76	199.6	22.5	3.81
Dinamik	37.5	22.1	3.94	218.3	23.1	3.91
Terminator	36.1	21.6	4.08	246.3	22.1	4.17
Rica	37.3	20.9	3.99	229.5	22.9	3.94
Infinity	40.7	21.0	4.76	217.2	22.3	3.46
Kian	38.9	17.4	4.43	203.2	16.0	3.03
Ekron	40.1	21.6	4.78	282.9	24.6	5.53
CD (P=0.05)	2.76	2.83	0.73	33.5	5.87	0.71

Table 3 Correlation between different growth and yield parameters and yield of cucumber

Parameter	Vine length (m)	No. of node/ vine	Horizontal leaf width (cm)	Vertical leaf width (cm)	Stem dry weight (g/plant)	Leaf dry weight (g/plant)	Days to first harvest	Fruit length (cm)	Fruit girth (cm)	Mean fruit weight (g)	Number of fruits/ plant	Yield (kg/ plant)
Vine length (m)	1	0.78*	0.93**	0.77*	0.97**	0.95**	-0.30	0.79*	-0.21	0.71	0.84*	0.87*
No. of nodes/vine		1	0.58	0.33	0.76*	0.58	-0.64	0.79*	-0.66	0.23	0.69	0.41
Horizontal leaf width (cm)			1	0.91**	0.86*	0.95**	-0.19	0.66	-0.03	0.80*	0.77*	0.88**
Vertical leaf width (cm)				1	0.68	0.83*	-0.20	0.31	0.11	0.84*	0.47	0.82*
Stem dry weight (g/plant)					1	0.92**	-0.26	0.81*	-0.15	0.73	0.83*	0.88**
Leaf dry weight (g/plant)						1	-0.05	0.70	-0.01	0.78*	0.82*	0.94**
Days to first harvest							1	-0.16	0.69	0.00	0.01	0.06
Fruit length (cm)								1	-0.25	0.39	0.94**	0.58
Fruit girth (cm)									1	0.46	-0.05	0.24
Mean fruit weight (g)										1	0.56	0.91**
Number of fruits/ plant											1	0.73
Yield (kg/plant)												1

Table 4 Fruit quality characteristics of gynoecious cucumber hybrids in greenhouse

Hybrid	TSS (%)	Titratable acidity (%)	Pericarp thickness (cm)	Fruit dry matter (%)	Sensory parameters			Overall acceptability
					Appearance	Texture	Taste	
52-32	4.2	0.09	1.01	2.02	8.17	8.17	7.53	7.96
Dinamik	4.2	0.10	0.96	2.11	8.43	8.07	7.93	8.14
Terminator	4.3	0.09	1.20	2.67	8.33	8.30	8.07	8.23
Rica	4.4	0.08	1.05	2.45	8.57	8.23	8.1	8.30
Infinity	4.0	0.10	1.14	2.62	7.43	8.03	8.2	7.89
Kian	4.2	0.09	1.34	2.27	7.33	7.73	7.87	7.64
Ekron	4.3	0.10	1.35	3.01	6.23	8.05	7.17	7.15
CD (P=0.05)	NS	0.01	0.23	0.90	1.80	NS	1.38	1.05

leaf size together with lowest vine length was in Kian and Infinity which finally resulted in lowest foliar (leaf and stem) dry mass production. The variation in leaf size among the hybrids was mainly due to variation in horizontal leaf spread, while vertical leaf spread remained same (Table 1). There is a clear indication from correlation analysis that leaf size is closely associated with leaf dry weight (Table 3). The higher leaf surface may possibly help trapping of higher amount of incoming solar radiationthat eventually lead to more active photosynthetic apparatus and net photosynthesis rate, and finally the better shoot growth and fruit yield in cucumber plants (Colla *et al*. 2013).

Fruit precocity is one of the most important characters of cucurbitaceous vegetables grown for early-summer production because early harvest fetches premium price (Kumar *et al*. 2017). Results from this study demonstrate a significant difference in days to first harvest among the cucumber hybrids (Table 2). The days to first fruit harvest ranged from 36.1 to 40.7 with being earliest in Terminator followed by Rica and Dinamik, whereas Ekron, Infinity and Kian were found to be delayed in fruit harvesting. Cucumber fruit yield significantly varied among the hybrids, which ranged from 3.03 kg to 5.53 kg per plant (Table 2). Previous studies have also shown a wide variation in fruit yield among the tested greenhouse cucumber hybrids, and variation in yield was likely due to genotypic make up ofa particular hybrid that expressed in particular environment (Singh *et al*. 2015, Chaudhary *et al*. 2016).

According to Kumar *et al*. (2015), fruit yield is directly influenced by certain yield attributing traits including number of fruits and fruit weight; these may vary depending upon genetic potential of the hybrids and climatic conditions in which they are grown. The highest fruit yield was recorded in Ekron that was possibly ascribed to highest fruit number and mean fruit weight. This finding is corroborated with the earlier studies on polyhouse cucumber (Bisht *et al*. 2011, Chaudhari *et al*. 2016). Correlation study performed on different hybrids reveals that the fruit yield was highly associated with fruit characteristics like fruit weight, besides growth parameters like vine length, leaf size and foliar dry mass were also positively related to yield (Table 3). In a grafting study conducted in greenhouse condition in which Ekron was grafted onto different rootstocks, high fruit yield in best graft combination was related to high number of fruits per plant and high mean fruit weight (Colla *et al*. 2013). Furthermore, Bisht *et al*. (2011) pointed out that cucumber fruit yield/ vine was the most important characters for selection of hybrids. The correlation analysis suggests that among various yield attributing traits, cucumber fruit yield was highly associated with mean fruit weight (Table 3). Panghal *et al*. (2016) reported that maximum fruit number/vine was as a result of profuse female flowering throughout the vegetative growth. However, high fruit number per vine in Ekron was not related to high flower numbers, rather it was probably as a result of high flower to fruit set and average fruit weight. The highest leaf area/ size and shoot dry weight in this hybrid might have helped better availability of assimilates partitioning and other micro elements required for bearing, thus resulting in high fruit number and fruit weight in Ekron (Colla *et al.,* 2013). Owing to its probably high genetic vigour, Ekran produced highest growth, development and physiological activity, and thus resulted highest number and weight of fruits and finally the highest per plant fruit yield. Similar findings were reported by Singh *et al.* (2015) for Priya cucumber hybrid in September sown polyhouse crop in Delhi.

The fruit quality characteristics such as TSS content and titratable acidity have shown variations among the hybrids, though the variation in TSS content among the hybrids was non-significant (Table 4). Among other quality attributes, pericarp thickness and fruit dry matter content have shown significant difference. Fruit pericarp thickness, an associated parameter with shelf life and post-harvest quality of the produce (Ilic *et al*. 2018), was recorded highest in Ekron, though statistically similar with Kian and Terminator. Fruit dry matter content is an important quality trait which is often related to specific fruit weight that is influenced by fruit pericarp thickness (Ilic *et al*. 2018). Except 52-32, fruit dry matter content was statistically similar among all the hybrids with recording highest in Ekron (3.01%) followed by Terminator and Infinity. The commercial fruit quality characteristics assessed subjectively by analysing sensory parameter on 9-point Hedonic Scales. These include fruit appearance (which include skin colour, smoothness and shape), taste

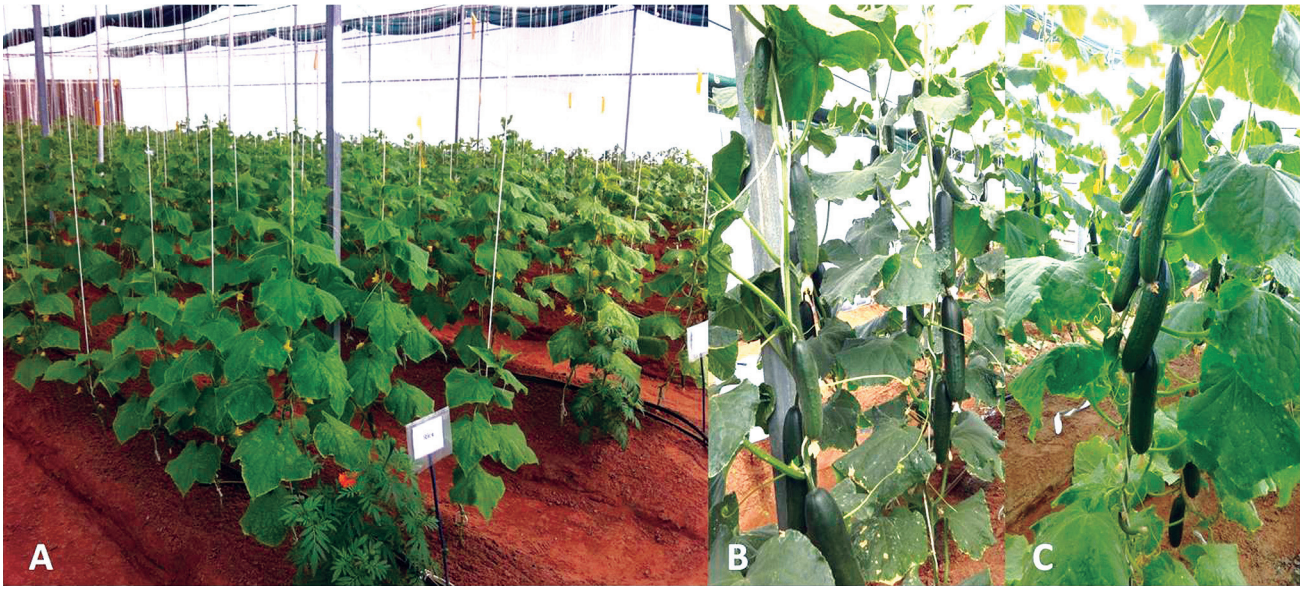

Fig 1 A, Crop general view; B, Ekron plants bearing fruits (spine skinned); C, Terminator plants bearing fruit (smooth skinned).

and overall acceptability and these varied significantly. Another parameters was fruit texture that did not vary among the hybrids. The effectiveness and acceptability of sensory evaluation have been established by the findings of Thompson *et al*. (1982) and Chaudhari *et al*. (2016). They have found close relationship between the results of measurement made by instruments and sensory evaluation by human. Although, the measured fruit quality parameters like titratable acidity, fruit dry matter content and pericarp thickness were highest in Ekron fruits, the least consumers' acceptability was noted in its fruits because of the presence of rudimentary spine on fruit skin, and mild fruit taste (Fig 1).

Despite the superiority of Ekron for production traits as well as few quality traits, the least consumer acceptability of its fruit renders it to be excluded for greenhouse cultivation in this particular area. Ekron fruits are comparable to open field grown monoecious Asiatic type cucumber cultivated in other areas which fetches relatively less price. Among the smooth skinned seedless cucumber, Terminator followed by Rica was considered as suitable hybrids with regard to fruit production traits (i.e. earliness, yield, quality and appearance).

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