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Study of Four Cucumber Germplasm Genotypes, Grown in Qatar and the Indian Agro-climatic Zone, Based on Its Phenotypic Traits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study included four genotypes of cucumber (IC257296, IC420405, GYNE-5, PUSA SANYOG) which were evaluated based on phenotypic traits when grown under two different soil zones of Doha (Qatar) and Meerut (India). Statistical analysis to estimate various genetic parameters like phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain and principal component analysis (PCA) of genotypes was done in order to assess the magnitude of variability for various agro-metrical characters. In Indian soil zone, highest yield was observed in GYNE-5, while, in Qatar soil zone, highest yield was observed in PUSA SANYOG. The phenotypic coefficient of variation (PCV) was

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higher than its corresponding genotypic counterpart (GCV) for all characters studied. High broad-sense heritability was associated with all the traits in both zones except fruit length. Days to edible maturity, fruit length and fruit width showed low genetic gain in qatar zone; hence, heterosis breeding would be recommended. Principal component analysis involved vine length and days to edible maturity as the most discriminating trait that accounted for greater variability in cucumber in qatar zone, and it should be considered in cucumber improvement programs. Correlation analysis represent that yield was positively correlated with fruit length and fruit width, while, fruit per plant showed positive significant correlation with vine length. Present findings suggest that PUSA SANYOG may be cultivated in other areas with similar climatic conditions. This study will help to improve the protected agriculture model of Qatar and revenue generation for the farmers.

Keywords: Cucumber; phenotypic; traits; genotype and yield; qatar soil; Indian soil.

1. INTRODUCTION

The native place for cultivation of cucumber is Himalaya to China (Yunnan, Guizhou, Guangxi) and North Thailand where it is known to be cultivated since last 3000 years. It is an annual plant that grows primarily in the seasonally dry tropical biome [1]. Annual world production of cucumber (*Cucumis sativus* L.) is estimated to 91,258,272 Metric tonnes [2]. China is the largest producing country of cucumber. In India and Qatar, it is one of most preferred green vegetable used as “salad”. Cucumber is the second most widely cultivated member of the family Cucurbitaceae in the world after watermelon [2]. It is grown primarily for processing (pickling) or for fresh market (slicing). The cucumber fruit is known to have cooling effect which prevents constipation and indigestion, also keeps jaundice under control [3]. Cucumber is a low calorie (15 calories/100 g only) vegetable, contains 95% water, ideal hydrating and cooling food, excellent source of some unique anti-oxidants, rich in potassium and vitamin K [4]; also rich in vitamin 'B' and 'C' as well as minerals such as calcium, phosphorus, iron and potassium. Besides these, it contains about 2.5% carbohydrate (13 Kcal energy), 0.4% protein, 0.1% fat and 0.4% fibre [5]. It has antioxidants which help to discard substances from the body known as free radicals, however, if accumulated more in the body, they can lead to cell damage and various types of disease [6,4].

Cucumber requires a warm climate, with optimum day and night temperature in the range 20-30 ℃, however, parthenogenetic varieties can be grown round the year in Naturally Ventilated Polyhouse (NVP).It is grown throughout the year in southern states of India, however, in plains of Northern India, it is grown during summer and rainy seasons in open fields. Modern farmers are growing cucumber in winter also under protected cultivation. In Qatar, cucumber is widely grown in greenhouses resulting in 82.7% of the total production of 2952 metric tonnes FAO, 2021). In 2007, more than 13,000 tons of cucumber was consumed, while the local production was only >8,500 tonnes and thus resulting in deficit of 35% [7]. The deficit of cucumber is high in summer and early autumn months, while, consumption rate is 70-90% during winter and spring months [8]. India has emerged as one of the largest exporter of cucumber (gherkins) in the world (1,23,846 Metric Tonnes with a value of USD 114 million during April-October,2020-21- Ministry of Commerce and Industry23rd January, 2022). Cucumber production has the capacity to enhance agricultural production, economic empowerment of the farmers and add to nutritive value of the food consumed. In spite of being native of India and one of the major grown crops in Qatar, yield is very low due to various abiotic and biotic stresses and lack of appropriate agricultural practices [9]. Cucumber is very under-marked agriculture crop in terms of its economic potential and therefore, has hardly been explored for breeding programme. Cucumber production can be potentially increased by introducing it to more cultivable area, using high yielding genotypes and protected agriculture approach [10]. The objectives of cucumber improvement is to produce high yielding genotypes which have phenotypic traits such as early fruiting, uniform size, cylindrical fruit, soft seeds at edible maturity, free from bitterness, green color with smooth surface and resistant to various (biotic and abiotic) stresses. The ultimate goal of any plant breeding programme is to evolve improved genotypes which are better than the existing ones.

Characterization of different high yielding genotypes of cucumber is of much importance for present and future genetic development program of the crop. Till date, very few public sector varieties are accepted by farmers for commercial cultivation. So, in order to isolate desirable genotypes with higher yield and better quality, there is an urgent need to assess the existing variability under specific environment [11].

Various agro-metrical traits confirm polygenic inheritance and are greatly influenced by minute fluctuation of environmental components. Genetic improvement of any crop is largely dependent on the magnitude of several genetic parameters like phenotypic and genotypic variances [12], phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain; on which the breeding methods are formulated for its further improvement. Analysis on genetic variability reveals its presence and is of utmost importance as it provides the basis for effective selection. The extent of variability is measured by genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) which provides information about the relative amount of variation in different characters. Hence, to obtain a comprehensive idea, it is necessary to undertake an assessment of quantitative traits. Heritability estimates in conjunction with the predicted genetic gain is more reliable [13].

Since, morphological representation is the chief step in explanation and understanding of genetic means in cucumber [14], present study is designed as an attempt to characterize cucumber germplasm at morphological basis in different agro-climatic zones and soil conditions of India and Qatar to analyze the genetic pattern of morphological character of cucumber. The main objective is to identify the high yielding variety of Cucumber in Qatar agro-climatic zone and to quantify yield potential of cucumber germplasm for future utilization.

2. MATERIALS AND METHODS

Cucumber grows well in warm climate, a well drained soil, sandy loam to sandy clay loam with optimum day and night temperature in the range of 20 to 30℃, soil temperature, fertility and moisture content must be adequate. It does not need special care and is widely cultivated throughout the world including India and Qatar.

2.1 Experimental Site and Field Operations

The experiments were carried out in the Agricultural Research Farm of Shobhit Institute of Engineering & Technology, Meerut, India and is characterized by monsoon influenced humid subtropical climate with hot summers and cooler winters. Summers are extremely hot and duration is from April-June. The monsoon season starts from late June and ends in middle of September. During monsoon, humidity remains high with cloud cover and low temperature (www.meerut.nic.in, 2022). Winter season is dry and mild from November to the middle of March. In Qatar, experiments were done in Al Thumama, Doha which is characterized by an arid and semi-arid climate. Rainfall is highly unpredictable in space and time with annual precipitation generally less than 50 mm. Temperatures are generally high, reaching 50°C at times in summer—the main problem is prolonged hot periods (over 35°C) through the summer, when the relative humidity is also often high. Duration of the experiment was from June to September 2022. Four cucumber genotypes (IC257296, IC420405, GYNE-5, PUSA SANYOG) obtained from the NBPGR, New Delhi, India were used for the study. They were evaluated in a randomized complete block design (RCBD) with three replicates. The field was prepared and divided into blocks. The crop was seeded directly after the soil was well prepared. Fertilizers, Irrigation and Pest management were done on proper time and using standard agronomical practices. Half dose of fertilizers was applied at the time of sowing and half after 28 days. Randomly five plants from each row were selected for data. Growth traits were measured 8 weeks after planting and yield traits measured immediately after harvest. These traits included germination %age, days to 50% flowering, days to fruit initiation, days to edible maturity, Vine Length, fruits per plant, fruits per kilogram, fruit length, fruit width and total fruit yield per hectare.

2.2 Statistical Analysis

The experimental data was compiled by taking the mean value of the 4 genotypes of cucumber for all 10 traits from all the three replications. Then, it was subjected to the following statistical analyses: Analysis of variance (ANOVA) for the design of experiment [15], Coefficient of variation, heritability and genetic advance [16], Genetic advance in per cent of mean [13], Principal component analysis and Correlation coefficient [17] by using Scilab [18] to show the highest discriminating trait and level of relationship, respectively, among the cucumber genotypes.

3. RESULTS AND DISCUSSION

3.1 Morphological Variability

All the genotypes exhibited variable phenotypic traits when sown in different agro-climatic zones. Among phenotypic traits, %age germination depicted variability among the genotypes (Table 1). In Indian soil, maximum germination was recorded for genotype IC420405 while minimum in genotype PUSA SANYOG, whereas, in Qatar soil, PUSA SANYOG recorded highest, while, IC257296 recorded lowest. Similarly, the genotypes showed variation in days to half flowering i.e. 50% flowering. Greatest number of days to 50% flowering was recorded for genotypes PUSA SANYOG and GYNE-5 in India and Qatar, respectively, whereas minimum number of days was recorded for genotypes IC257296 and PUSA SANYOG in India and Qatar, respectively. From the (Table 1) it is evident that the genotype PUSA SANYOG took maximum number of days for fruit initiation and genotype IC420405 took least. These results are in accordance with the finding of Ahmed et al. [19] and Hamid et al. [20]. These variations in traits such as seed germination, 50% flowering days, days to fruit initiation could be possibly due to genetic makeup of the cultivars, which responded differently to the environmental conditions.

The genotypes displayed significant variation (Table 1) for days to edible maturity. Greater number of days was recorded for genotype PUSA SANYOG in India & Qatar, respectively while lowest number of days was recorded for genotype 257296 in India, and genotypes GYNE-5 & 420405 in qatar. Our results were supported with findings of Resende [21] and Ahmed et al. [19] who concluded that major variability is present in days to edible maturity due to the genetic differences in genotypes of cucumber. Vine length presented in Table 1 varied greatly among all cucumber genotypes. Genotype GYNE-5 and PUSA SANYOG recorded maximum vine length in both zones and genotype 420405 showed minimum vine length. Our findings are similar with Abusalena and Dutta, (1990) and Hossain et al. (2010) who also studied vine length and found great variation in it. This variability shows that a great genetic diversity is present among cucumber genotypes.

The maximum number of fruits per plant was present in genotype GYNE-5 in India and PUSA SANYOG in Qatar zone, while the minimum number of fruits per plant was present in genotype 420405 in both zones as shown in Table 1. Hossain et al. (2010) also reported that variation in number of fruit per plant among the accessions may be due to the different environmental conditions or the genetic variation.

Fruit per kilogram reveal significant variation between the genotypes as shown in Table 1. Genotype 420405 showed the maximum number of fruit per kg in both Indian and Qatar zone, whereas, genotype GYNE-5 showed minimum number of fruits per kg. Our results are accordance with Hamid et al. (2002) who concluded that genotypic variation among cucumber genotypes is present when considering fruit per kg trait. In this study, fruit length showed great variation among all the genotypes. Genotype 257296 and PUSA SANYOG recorded the highest fruit length in India and Qatar, respectively. While the genotype 420405 recorded the lowest length of fruit as shown in Table 1. These results are agreed to that obtained by Sharma et al. [11], Prasad and Singh [22], Hormuzdi and More, [23] and Hossain et al. (2010) who also found significant differences in fruit length in their study. The fruit width data shown in Table 1 revealed that different cucumber genotypes exhibit significant differences. Greater fruit width was shown by genotype PUSA SANYOG in both climatic zones. On the other hand, cucumber genotype 420405 showed lowest fruit width. Variation in fruit width was also reported by Saha et al. [24] and Hossain et al. (2010) in their study.

3.2 Genetic Variability

All the studied agro-metrical characters showed significant differences ($P<0.05$) among genotypes (Table 2), indicating that the cucumber genotypes were genetically divergent. Thus, there is a huge scope for selection of promising lines with different agro-metrical traits from the present gene pool. Afangideh and Uyoh [25] reported the existence of genetic variation among cucumber genotypes and the similar results were reported for other crops from the same family regarding the number of branches per plant, vine length per plant, number of pods per plant, and seed yield per plant [26-28].

Wide range of variability among genotypes might be due to diverse sources of the materials, as well as environmental influence affecting the phenotypes. The coefficient of variation (%CV) compares the relative amount of variability between crop plant traits [11]. The value of coefficient of variation (CV%) ranges from 7.8 to 0.27 in Indian zone, while, 19.53 to 0.55 in Qatar zone (Table 3). In Indian zone, the highest being recorded by number of fruits per plant followed by fruits per kilogram and fruit width. Similarly, in Qatar zone, highest being recorded by germination percentage followed by number of fruits per plant and fruit per kilogram. These results imply that the germination percentage, fruits per plant, fruits per kilogram and fruit width, in that order, had higher amounts of exploitable genetic variability among the studied cucumber attributes. It implies that there is greater potential for favorable advance in selecting these attributes compared to others [29]. Further, the lowest CV% was recorded for vine length and days to edible maturity for both zones, which exhibits low exploitable genetic variability and, thus, has less potential for favorable advance in selecting when compared to other traits.

The estimation of genotypic and phenotypic variance (PV and GV), genotypic (GCV) and phenotypic (PCV) coefficient of variation, broad sense heritability (h^2_{bs}) and genetic advance mean (GAM%) of genotypes is given in Table 3. A wide range of variation was observed with regard to different traits. The maximum genotypic and phenotypic variations were obtained for total leaves per plant and plant height at 50% flowering; while moderate variation was observed for days to branching, seeds per inflorescence and total flower per plant. This indicated that the environment did not significantly ($P<0.05$) influence these characters. There was a very close difference between PV and GV for traits, except fruit length (Indian zone) and germination percentage, vine length and fruits per plant (qatar zone). The character with almost equal value of PV and GV can be considered stable, based on Yadav et al. [30]. The magnitude of genotypic variances (GV) was higher than their corresponding environmental variances (EV) in both agro-climatic zones, which indicates that the genotypic component of variation was the major contributor to total variation in the studied traits.

In general, the phenotypic coefficient of variation (PCV%) was higher than its genotypic counterpart (GCV%) for all the characters studied (Table 3). This resemblance in almost all the characters suggests that the environment had little effect on those characters' expression. These values provide a measure for comparing genetic variability in various metrical characters. In Indian zone, the highest PCV % and GCV % was obtained for the fruit per plant followed by vine length, fruit width, germination percentage and yield (tons/h), while, the least value was recorded for fruit length followed by days to 50% flowering. For the Qatar zone, the highest PCV was recorded in yield (Tons/h) followed by germination percentage and fruits per plant, while, days to edible maturity had the lowest values. High PCV and GCV indicate the existence of a greater scope of selection for the trait being considered, which depends on the amount of variability present [31]. Thus, a greater potential is expected in selecting for the fruits per plant, vine length and total fruit yield ha-1 among the studied cucumber genotypes. On the other hand, there is a narrow scope of selection for days to 50% female flowering and fruit length because of low variability. Strikingly, in Qatar agro-climatic zone, a greater difference between PCV and GCV estimates for germination percentage and fruit per plant indicates a greater degree of environmental control for these traits. The environmental coefficient of variation (ECV %) is also high in germination percentage (19.28) and fruits per plant (8.5) in Qatar zone.

3.3 Heritability Estimates

Burton [32] suggested that the genetic coefficient of variation together with heritability estimates gave a better picture of the extent of heritable variation. Broad sense heritability (h^2_{bs}) and genetic advance mean (GAM %) estimates were interpreted as low, medium and high as per the classification of Johnson et al. [13]. It gives an insight into the array of genetic control for phenotypic expression and phenotypic reliability in predicting its breeding value and higher index indicates less environment influence in observed variation [29].

In Indian zone, broad sense heritability ranged from 99.96% for vine length to 62.00% for fruit length, whereas in Qatar zone, the value ranged from 99.92% for vine length to 66% for fruit width. Further, in Qatar zone, germination percentage exhibits the lowest value of heritability and fruit length being the moderate. This indicates presence of considerable genetic variation and thus, these traits may be given special emphasis during cucumber improvement programs. In this analysis, although high h^2_{bs} estimates were recorded for most of the traits in both agro-climatic zones, they were associated with low genetic advance (Table 3) indicating non-additive gene action and environmental influence, especially in days to edible maturity, fruit length and fruit width (in Qatar zone).

3.4 PCA Analysis

Principal component analysis is an important multivariate technique used to examine associations between characters and measure genotype genetic diversity [33]. The result of PCA for 10 traits of cucumber genotypes evaluated in Indian and Qatar agro-climatic zones is presented in Table 4. The first two components accounted for 99.67% and 99.47% of the cumulative variation in the genotypes in both zones, respectively. In the Indian zone, the first component (PC1) described 99.31% of the total variation and was positively and highly associated with germination percentage and vine length, whereas, negatively associated with fruit per plant and yield (Tons/h), and therefore, could be called as a vegetative component. The second component axis (PC2) explained 0.36% of the total variability and was positively associated with germination percentage, whereas, for vine length and yield (Tons/h), it was found to be highly negative. The results for the Qatar zone followed a similar trend. The PC1 accounted for 98.73% of the total variation and was also positively and highly associated with days to edible maturity and vine length. The PC2 explained 0.72% of the total variation and was positively related to days to edible maturity whereas vine length was negative. The genetic diversity studies about cucumber quantitative traits based on the multivariate analysis using PCA involved vine length, germination percentage and yield (tons/h) as the most discriminating traits explaining greater variability in cucumber in both the zones.

3.5 Correlation Analysis

In both climatic zones of India & Qatar, Vine length was found to be positively correlated with total number of fruit per plant and fruit width, whereas, it showed non-significant correlation with other traits (Table 5 and Table 6). These results are also in accordance with the study of Hossain et al. (2010) and Abusalena and Dutta (1988) who also concluded that vine length have positive significantly correlated with fruit width and total number of fruit per plant because of the increase in the number of nodes for fruit initiation. Significant variability was present in fruit per plant among all genotypes. Total number of fruit per plant showed positive significant relationship with vine length and fruit width (Table 3 and Table 4). Hossain et al., (2010) and Abusalena and Dutta, (1988) who also reported that a significant positive correlation was present between total number of fruit per plant, vine length and fruit width.

A strong positive correlation was present between fruits width and fruit length in both zones (Table 3 and Table 4). These results are supported by the study of Eifediyi et al. [34] who also found positive significant relationship among fruit width and fruit length. Fruit length is also positively correlated with yield tons/ha. Result of the correlation analysis represents that yield was positively correlated with vine length (Table 3 and Table 4). Ballesta-Jimenez [35] suggested that soil quality assessment is a new tool for evaluation and monitoring the production systems in terms of different agro-climatic zones. The soil quality and agro-climatic conditions of Meerut (India) and Doha (Qatar) markedly differ which suggest that the differences in varietal yield during our studies may be because of both soil quality as well as agro-climatic conditions. Lawal [36] concluded very high positive correlation between cucumber genotypes in relation to fruit length and fruit yield. Further, Eifediyi et al. [34] found no significant positive correlation between fruit width and fruit yield. Fruit width also positively correlated with total number of fruit per plant. Hossain et al. (2010) who found no relationship between fruit width and total number of fruit per plant. These variations are due to the differences in environmental conditions, the genetic diversity of genotypes, or the presence of available nutrients.

Sallam et al. [37] have reported that the use of poultry manure and minerals as fertilizers can enhance the productivity of cucumber under greenhouse conditions. Our study suggest that the changes induced due to agro-climatic conditions may be encountered using green manure and minerals rich fertilizers. Cucumber is rich in minerals, vitamins and anti-oxidants, hence the supplementation of minerals rich fertilizers will logically improve the quality and yield of cucumber. Lalnunkimi et al. [38] while evaluating eight genotypes of cucumber under Prayagraj agro-climatic conditions found that Sunny-85 was highly cost effective. It suggests that the varietal trials under different agro-climatic conditions yield highly useful information that may enhance the cost benefit ratio of farmers and may improve better financial gains for the farmers. Prathyusha [39] and Singh and Shaju et al. [40] while studying the varietal evaluation of different varieties of cucumber in Prayagraj found that different varieties respond differently under similar agro-climatic zones. It, is

Table 1. Variation in quantitative characteristics among cucumber genotypes when grown in qatar and India climatic zones

Traits Genotype	GP	DoF	FI	EM	VL	FPP	FPK	FL	FW	YT
In Indian agro-climatic zone										
IC257296	64.00	37.17	43.83	57.17	168.32	7.00	5.33	18.58	4.58	7.33
IC420405	66.83	39.50	43.33	58.83	141.98	6.33	5.30	18.20	4.72	8.70
GYNE-5	62.53	38.50	46.17	64.33	195.77	8.67	5.17	17.78	5.64	9.12
Pusa-Sanyog	49.97	40.67	47.50	67.50	150.92	6.33	4.67	17.57	6.04	7.13
In Qatar agro-climatic zone										
IC257296	27.50	37.83	44.50	65.00	138.60	5.67	4.33	18.69	5.52	3.41
IC420405	48.00	43.00	43.83	61.50	131.60	5.33	5.67	17.26	5.26	4.91
GYNE-5	42.00	43.67	45.17	61.67	170.13	7.33	3.33	18.74	5.78	4.22
Pusa-Sanyog	61.33	35.67	50.67	66.50	201.28	9.67	3.67	20.90	6.33	7.63

Table 2. Analysis of variance for yield and its contributing traits in cucumber

Source of variation	Df	Germ %age	Days to 50% flowering	Days to fruit initiation	Days to edible maturity	Vine length (cm)	Fruit per plant	Fruit per kilogram	Fruit length (cm)	Fruit width (cm)	Yield (tons/ha)
Indian Zone											
Replication	2	0.2008	0.3958	0.3958	0.3333	0.0647	0.0833	0.1908	0.0752	0.0402	0.0602
Treatment	3	167.0022	6.6319	11.5764	69.0764	1683.568	3.6389	0.2856	0.6044	1.5068	2.9124
Error	6	0.8497	0.1736	0.2014	0.0556	0.2085	0.3056	0.0231	0.1025	0.0136	0.0124
Qatar Zone											
Replication	2	58.5208	0.1458	0.7708	0.3333	2.1471	0.25	2.19	0.3721	0.1805	0.1037
Treatment	3	590.6875	45.9097	29.4097	18.5	3070.8	11.7778	3.1944	6.7555	0.63	10.0888
Error	6	76.2708	0.1181	0.0764	0.1667	0.7924	0.3611	0.1111	0.5758	0.0922	0.0838

Table 3. Mean square and genetic parameters for some quantitative traits in cucumber genotypes in both agro-climatic zones

Trait	Mean	PV	GV	EV	CV%	PCV %	GCV %	ECV %	h2 (%)	GAM (%)
Indian Agro-Climatic Zone										
GP	60.833	56.2339	55.3842	0.8497	1.515	12.327	12.2335	1.51527	98.489	25.0099
DoF	38.958	2.3264	2.1528	0.1736	1.069	3.9151	3.7662	1.06948	92.537	7.4632
FI	45.208	3.9931	3.7917	0.2014	0.992	4.4201	4.3072	0.99268	94.956	8.6462
EM	61.958	23.0625	23.0069	0.0556	0.380	7.7509	7.7416	0.38057	99.759	15.9284
VL	164.24	561.328	561.119	0.2085	0.278	14.425	14.4223	0.27801	99.962	29.7045
FPP	7.0833	1.4167	1.1111	0.3056	7.804	16.8034	14.8813	7.80442	78.431	27.149
FPK	5.1167	0.1106	0.0875	0.0231	2.970	6.4984	5.7812	2.97040	79.145	10.5949
FL	18.035	0.2698	0.1673	0.1025	1.775	2.8801	2.2678	1.77519	62.005	3.6787
FW	5.2433	0.5113	0.4977	0.0136	2.224	13.6376	13.4552	2.22415	97.342	27.347
YT	8.0708	0.9791	0.9667	0.0124	1.379	12.2601	12.182	1.37973	98.730	24.9352
Qatar agro-climatic zone										
GP	44.708	247.743	171.472	76.271	19.53	35.206	29.289	19.534	69.214	50.196
DoF	40.042	15.382	15.264	0.118	0.858	9.795	9.757	0.858	99.233	20.022
FI	46.042	9.854	9.778	0.076	0.600	6.818	6.792	0.600	99.225	13.936
EM	63.667	6.278	6.111	0.167	0.641	3.935	3.883	0.641	97.345	7.892
VL	160.40	1024.12	1023.33	0.792	0.555	19.951	19.943	0.555	99.923	41.067
FPP	7.000	4.167	3.806	0.361	8.585	29.161	27.868	8.585	91.333	54.865
FPK	4.250	1.139	1.028	0.111	7.843	25.110	23.854	7.843	90.244	46.681
FL	18.897	2.636	2.060	0.576	4.016	8.591	7.595	4.016	78.153	13.832
FW	5.724	0.272	0.179	0.092	5.305	9.102	7.397	5.305	66.044	12.383
YT	5.041	3.419	3.335	0.084	5.743	36.680	36.228	5.743	97.550	73.710

GP: germination percentage; DoF: days of 50% flowering; FI: days to fruit initiation; EM: days to edible maturity; VL: vine length (cm); FPP: fruits per plant; FPK: fruits per kilogram; FL: fruit length (cm); FW: fruit width (cm); YT: total yield per hectare

Table 4. Eigen vectors and total percentage variation for the principal component axes of cucumber genotypes evaluated in both agro-climatic zones

	Indian zone		Qatar Zone	
Traits	**PC_1**	**PC_2**	**PC_1**	**PC_2**
GP	1.4007	0.4459	0.339	-0.6687
DoF	-0.157	0.1425	0.09905	0.2747
FI	0.2825	0.08367	0.4999	0.1971
EM	1.4834	0.1418	1.8244	0.4425
VL	8.6678	-0.2556	8.7075	-0.1224
FPP	-2.4572	-0.1638	-2.3929	-0.08023
FPK	-2.5916	-0.121	-2.5692	0.004537
FL	-1.6639	-0.02509	-1.5031	0.0582
FW	-2.5831	-0.1483	-2.4727	-0.01286
YT	-2.3816	-0.1002	-2.5321	-0.09277
% of Variance	99.3194	0.3572	98.7372	0.7322
Cumulative (%)	99.3194	99.6766	98.7372	99.4694

GP: germination percentage; DoF: days of 50% flowering; FI: days to fruit initiation; EM: days to edible maturity; VL: vine length (cm); FPP: fruits per plant; FPK: fruits per kilogram; FL: fruit length (cm); FW: fruit width (cm); YT: total yield per hectare

Table 5. Correlation analysis of cucumber genotypes in Indian agro-climatic zone

	VL	**FL**	**FW**	**TNF/P**	**Y ton/ha**
VL	1				
FL	.269	1			
FW	.452 *	.611**	1		
TNF/P	.995**	.350	.514*	1	
Y ton/ha	.264	.521**	439	.267	1

*Note: **=Correlation is significant at the 0.01 level, *=Correlation is significant at the 0.05 level, ns=Non significant, VL= Vine length, FL=Fruit Length, FW=Fruit Width, TNF/P=Total number of fruits per plant, Y ton/ha=Yield tons per hectare*

Table 6. Correlation analysis of cucumber genotypes in Qatar agro-climatic zone

	VL	FL	FW	TNF/P	Y ton/ha
VL	1				
FL	.223	1			
FW	.398*	.597**	1		
TNF/P	974**	.353	.524*	1	
Y ton/ha	.274	.512 **	.435	.312	1

*Note: **=Correlation is significant at the 0.01 level, *=Correlation is significant at the 0.05 level, ns=Non significant, VL= Vine length, FL=Fruit Length, FW=Fruit Width, TNF/P=Total number of fruits per plant, Y ton/ha=Yield tons per hectare* thus, safely concluded the prior trial studies of different varieties under different soil conditions and different agro-climatic zones should be conducted using different manures and mineral fertilizers to get the best yields of high quality [41-46].

4. CONCLUSIONS

In summary, comparing phenotypic pattern of different cucumber genotypes in both different agro-climatic zones, maximum germination has been observed in the genotype GYNE-5 and PUSA SANYOG. These genotypes have also shown early days to maturity and maximum fruit length, thus, can be chosen for business production in Qatar. On the other hand, in PUSA SANYOG highest yield was observed in Qatar climatic zone. Based on these results, these genotypes are found suitable and these genotypes should be grown in other areas of India and Qatar and must be characterized at using molecular markers such as SSR, RFLP etc. to investigate environmental influence on yield. The trait which expressed high heritability and low genetic gain (days to edible maturity, fruit length and fruit width) showed non additive gene interaction, hence heterosis breeding would be recommended for that trait. The mean contributions of germination percentage, days to edible maturity and vine length were high in the principal axes. This observation suggests that these traits are major traits explaining most of the variations in cucumber and further contributing to total yield in the cucumber genotypes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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