Assessment of Heritability, Genetic Advancement and Yield of Bitter Gourd under Garhwal Region

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Abstract: ***A field experiment was conducted at Horticultural Research Centre, Department of Horticulture, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand. The mean sum of squares due to treatments showed significant differences for all the traits except for number of nodes per vine, fruit length and seed diameter. Coefficients of variability, heritability and genetic advance were computed on 37 traits. In the present investigation, the PCV were higher than the GCV for almost all the traits under studied.The GCV and PCV were moderate to low for almost all the characters except fruit yield per vine. The highest heritability was observed in length of vine, number of nodes per vine, leaf area,days to first fruit harvest, length of fruit, weight of fruit, fruit yield per hectare, carbohydrate content and vitamin A. The estimates of high heritability accompanied with moderate genetic advance over mean were recorded for days taken to opening of first female flower, percent of fruit setting, seed length and percentage of seed germination, so there is an ample scope for direct selection for these traits and also can be improve through mass selection.Hence, provides better opportunities for selecting plant material for these traits inbitter gourd.***

Keywords: Bitter gourd, heritability, genetic advance and GCV

1. Introduction

In vegetables, cucurbits are one of the most diversified families with wide range of variation in crops that supplied edible products and useful fibers to mankind. The cucurbitaceae family consists of about 30 genera and 750 species almost equally divided between the new world and old world tropics. In India alone, 117 genera and 100 species of cucurbits have been reported (Singh & Bhatia, 2009). In the family cucurbitaceae, bitter gourd (*MomordicacharantiaL.*) is one of the most important commercial crops in the point of economic and medicinal value. The bitter gourd (*MoinordicacharantiaL.*) is known as various names *viz.*, bitter gourd, balsam pear, bitter melon, bitter cucumber and African cucumber (Heiser, 1979). It is a large genus comprising nearly 23 species (Jeffrey, 1967) in Africa alone. The bitter gourd is particularly originated to Tropical Asia in the region of East India and South China (Laxuman, 2005). The bitterness of bitter gourd is due to the cucurbitacin-like alkaloid *momordicine* and *triterpene glycosides* (*momordicoside* K and L) (Jeffrey, 1980 and Okabe *et. al.*, 1982). The presence of genetic variability is very lethal for genetic improvement, higher yield, and wider adaptability in thestrains. The selection of traits is very effective when there is availability of genetic variability among the plant populations. For the starting of a successful breeding programme, magnitude of genetic variability is very crucial. The advancement by selection totally depends onthe knowledge of heritability and genetic advance. Genetic advance along with heritability played a vital role in predicting the gain under selection then heritability estimates alone (Johnson *et al.,* 1955). Hence, this research work was undertaken at Garhwal region which comes under subtropical climate to find out the various genetic components for quantitative, qualitative and seed traitsin bitter gourd.

2. Materials and Methods

The field experiment was conducted at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B. Garhwal University, Srinagar, Garhwal, Uttarakhand (India) during 2015 summer season in Randomized Block Design with 20 genotypes. These genotypes were collected from all over India *viz.*, Himachal Pradesh, Madhya Pradesh, Maharastra, Rajesthan, Uttarakhand and Uttar Pradesh. The seedling was transplanted at 4 leaf stage in the experimental plot with the spacing of 1.50 x 0.50 m. The standard horticultural practices and plant protection measures recommended for health crop were adopted for better growth, yield and quality. Five plants were randomly selected from each plot per replication for collecting the data. The observation were recorded *viz.*, length of vine (cm), number of primary branches per vine (cm), days to opening of first male and female flower, number of nodes bearing first male and female flower, number of fruit per vine, fruit length (cm), fruit diameter (cm), fruit weight (g) and fruit yield per vine (kg). Analysis of varianceestimated by Panse and Sukhatme (1961) and genotypic and phenotypic coefficients by Burton & De Vane (1953). The heritability and genetic advance by Burton (1952), Johnson *et. al.* (1955) respectively. The PCV and GCV > 30%- High, 15-30%- Moderate and < 15%- Low, heritability >80%- High, 50-80%- Moderate, >50%- Low by Sharma (1994) and genetic advance in percent of mean (GAM) by >20- high, 10-20- Moderate and<10- Low Johnson *et. al.* (1955).

3. Result and Discussion

Genetic variability plays vital role in crop breeding programmed. In this study, the 20 strains taken from different geographical locations and evaluate for 37 traits and were given scores based on their significance over general mean. The mean sum of squares due to treatments showed significant differences at 1 and 5% level for all the traits except for number of nodes per vine, fruit length and seed diameter (Table1). The mean performance of bitter gourd strains is presented in (Figure1 to 3).

3.1 Seed germination and growth characteristics

Germination of seed and growth is an important parameter of plants.In this study, the various genotypes show different growth and germination of seed given in figure 1.The minimum days to first seed germination was found in PDM, VRBTG-6 and VRBTG-9 respectively, while maximum days for first seed germination were recorded in RAJ-2.The days to 50% seed germination were recorded minimum in PDM, while maximum in RAJ-2. The maximum germination rate was observed in PDM, while minimum in GP-1. Vine length is an important trait that's indirectly influence the yield, as maximum vine length provide the opportunity to produce the highest number of primary branches, number of nodes, number of male and female flower, which eventually increases the yield. The length of vine was recorded maximum in RAJ-2 and minimum in PDM. The diameter of vine was recorded in GP-1 which was found maximum among the genotypes, while minimum in VRBTG-3. The maximum number of primary branches per vine was observed in JP-1, while minimum in VRBTG-2. The strain RAJ-2 had the maximum number of nodes per vine, whereas minimum in PDM. The results of present studies are in line with Mohan (2005), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd. Leaf is the primary source of photosynthesis activity in plant, so the plant with maximum leaf area captures maximum sunlight that's ultimately produces more photosynthate that eventually used for better growth, development and yield. The leaf area was recorded maximum in RAJ-2 and minimum in VRBTG-2.

The lowest number of nodes bearing first male and female flower is one of the key traits, that's directly correlated to yield, because nodes is the main site of flower emergence. If the nodes are appeared at lowest nodes, then there is chance to produces high number of flower and fruits per plant. The lowest number of nodes bearing first male flower was recorded in PDM and highest in VRBTG-8.The minimum number of nodes bearing first female flower was observed in KVS-7, while maximum in VRBTG-9. These finding are in corroboration with work of Laxuman (2005), Mohan (2005), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd. Early flowering is one of the most important traits, which decides who early the fruits reach to market, so for, earliness is concern this characters is very necessary. The minimumdays taken to opening of first male flower were noticed in VRBTG-6, while maximum in RAJ-1.The minimum days taken to opening of first female flower was noticed in VRBTG-2, while maximum in RAJ-1. The above results are found in conformity with the findings of Mohan (2006), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd.

3.2 Yield characteristics

Yield characteristic of various genotypes was given in figure 2. High percent of fruit setting directly related to high number of fruits per plant, while minimum days to first fruit harvest provide opportunity to enhance the harvesting duration of crop that directly influenced the crop yield in bitter gourd. The maximum percent of fruit setting was recorded in VRBTG-8 and minimum in VRBTG-1. The minimum days to first fruit harvest were recorded in VRBTG-6 and maximum in RAJ-2. The maximum number of fruits per vine was reported in VRBTG-6, while minimum fruit was recorded in VRBTG-1.The genotype HP-2 had maximum total fruit yield per vine and VRBTG-1 exhibited minimum. The results of present studies are in line with Shah *et. al.* (2016) in cucumber and Singh *et. al.* (2016) in bitter gourd.

Yield is a collective efforts of fruit length, fruit diameter and fruit weight, hence these the traits directly manipulate the total yield of a crop. The maximum fruit length was recorded in KVS-7, while minimum was recorded in VRBTG-1. The maximum weight of fruit was recorded in PSPB-14 and minimum in VRBTG-1. The genotype JP-1 recorded maximum fruit diameter and the genotypes VRBTG-3 and KVS-7 recorded minimum fruit diameter. Similar results were recorded by Mohan (2006), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd. The rind thickness of fruit is directly associated with the shelf life of fruit. The thickness of rind was recorded minimum in VRBTG-9 and the maximum in VRBTG-6. The minimum number of locules per fruit was exhibited in VRBTG-6 and MN-1 respectively and maximum in KVS-7. The genotype KVS-7 exhibited maximum fruit yield per plot, while VRBTG-1 recorded minimum. The maximum fruit yield per hectare was recorded by KVS-7 and minimum by VRBTG-1. Singh *et. al.* (2016) also obtained similar results in bitter gourd. The maximum duration of harvesting was recorded inVRBTG-6 and minimum in RAJ-2.

3.3 Seed and quality characteristics

Seed and quality characteristics are given in figure 3. The maximum carbohydrate content was recorded in VRBTG-8 and minimum in RAJ-2. The genotype RAJ-2 produces highest protein content, while HP-1 produces lowest. The maximum T.S.S was recorded in VRBTG-2 and minimum in GP-1.The genotype JP-1 had highest calcium content and VRBTG-2 recorded lowest. The vitamin C was found maximum in RAJ-2 and minimum in KVS-7. The phosphorus content was found maximum in JP-1 and minimum in PDM. Similar findings were also reported by Shah *et. al.* (2016) cucumber and Singh *et. al.* (2016) in bitter gourd. The maximum vitamin A was recorded in MN-1 and minimum in PDM. Yields are directly or indirectly influence by number of seeds per fruit, seed length and seed diameter. The maximum number of seeds per fruit was exhibited by MN-1, while minimum by VRBTG-1. The results are in similarly with Mohan (2006) & Singh *et. al.* (2016) in bitter gourd. The maximum seed length was recorded in VRBTG-1 and RAJ-1 respectively, while minimum in KVS-7. The maximum seed diameter was recorded in PDM and KVS-7 respectively,while minimum in PSPB-14. Test weight is directly or indirectly influences the seed viability and germination percentage, high test weight is the indicator of boldness of seed and healthy embryo. The maximum test weight of seed was recorded in VRBTG-8 and minimum in JP-1. The maximum seed viability was recorded in KVS-7, while minimum in PDM. The maximum germination percentage was observed in MN-1 and minimum in JP-1.

The extent of variability in 37traits of different strains is given in (Table 2, 3 and 4).In the present research work, the phenotypic coefficient of variation and genotypic coefficient of variation were moderate too low for almost all the characters except total fruit yield per vine. Similar results were also confirmed by Singh *et. al.* (2009) sponge gourd; Hanchinamani*et. al.* (2011) in cucumber and **Jat*et. al.* (2014**) in kakari.The fruit yield per vine showed high phenotypic coefficient of variation and genotypic coefficient of variation. Similar result was also noted by Singh *et. al.* (2014) in bitter gourd. The phenotypic coefficient of variation (PCV) were reported to be higher most of the traits than the corresponding values of genotypic coefficient of variation (GCV) but they were close to one another implying that the influence of environment on the expression of these traits were negligible, hence selection based on phenotypic values would be feasible. These findings are also confirmed by Singh &Lal (2005) in musk melon; Kumar *et. al.* (2008) in cucumber; Jat*et. al.* (2014) in kakri and Singh *et. al.* (2014) in bitter gourd. Comparatively there were wide differences between estimates of PCV and GCV for germination rate, number of locules per fruit, T.S.S and seed diameter which indicated higher environmental effect on the expression of these characters. Similar result was also reported by Rabbani*et. al.* (2012) in ridge gourd.

Heritability are useful in selection, on the basis of phenotypic performance of the different traits and the characters with high heritability value could be improved to a great extent through selection since they are least affected by environment factors and are controlled by additive gene effect. In the present investigation, high heritability was reported for almost all the traits. Similar results were also reported by Arunkumar*et. al.* (2011) in cucumber and Jat*et. al.* (2014) in kakri for vine length, days taken to opening of first male and female flower, number of nodes bearing first male and female flower, number of fruit per vine, fruit yield per vine, rind thickness, fruit length and fruit diameter; Hanchinamani*et. al.* (2011) in cucumber for days to first fruit harvest, number of nodes per vine, average fruit weight, yield per plot and yield per hectare; Rabbani*et. al.* (2012) in ridge gourd for seed length and test weight and Kumar *et. al.* (2013) in cucumber reported high heritability for germination percentage. Three traits recorded moderate heritability (above 50%) like, days to first seed germination, germination rate and number of locules per fruit, whereas two traits *viz.*, T.S.S and seed diameter showed low heritability (below 50%) which indicates that these characters were highly influenced by environmental causes, so it need to be tested under diverse environmental conditions for effective selection. Similar result was also reported earlier by Kumar *et. al.* (2013) in cucumber. High heritability does not guarantee large gain from selection unless sufficient genetic advance attributable to additive gene action is present (Srivastava& Jain, 1994). The high heritability value along with high value of genetic advance as percent of mean is most effective condition for selection (Gandhi *et. al*., 1964).

According to Rajput *et. al.* (1996) the joint consideration of genetic advance and heritability suggested that all the characters were controlled by additive gene effect. Heritability coupled with genetic advance as percentage of mean were more useful than H^2 alone in predicting the resultant effect for selecting the best individual as explained by Johson*et. al.* (1955). In the present research work, the resemblance in the magnitude of heritability and genetic advance over mean in almost all the traits. Similar results were also obtained by Singh *et. al.* (2002) in ridge gourd; Hanchinamani*et. al.* (2011) in cucumber and Mandal*et. al.* (2015) in bottle gourd for number of primary branch per vine, number of nodes per vine, number of nodes bearing first male and female flower, days to first fruit harvest, fruit length, fruit diameter, average fruit weight, number of fruit per vine and total fruit yield per vine indicating that simple selection based on phenotypic performance of these traits may be effective to improve. Similar results were also reported by Sanwal*et. al.* (2007) in sweet gourd for days to first fruit harvest and ascorbic acid content.However, the estimates of high heritability accompanied with moderate genetic advance over mean were recorded for days taken to opening of first female flower, percent of fruit setting, harvesting duration, seed length and percentage of seed germination which signify that the existing variability among the strains is mainly due to additive type of gene action, so there is an ample scope for direct selection for these traits and also can be improve through mass selection. The results are in line with the findings of Arunkumar*et. al.* (2011) and Kumar *et. al.* (2011a) in cucumber. High heritability accompanied with low genetic advance over mean were revealed by test weight and seed viability which showed predominance of non-additive gene action, therefore selection in early for these traits may not be effective due to linkage and could be exploited through heterosis breeding. The moderate heritability accompanied with high genetic advance over mean were observed for first seed germination, germination rate and number of locules per fruit which is influence by the additive gene effects coupled with high environmental impact on these traits, so selection wound not be effective. The low heritability with low expected genetic advance as percent of mean was reported for total soluble solids and seed diameter, which is highly influenced by environmental factors and controlled by non-additive gene, thus limits the chances of improvement of this trait through direct selection. Hence, heterosis breeding would be rewarding.

4. Conclusion

In the present investigation, it can be concluded that the strains used for this research work showed high amount of genetic variability with negligible differences between GCV and PCV, high to moderate heritability with genetic advance over mean for most of the characters that indicates good scope for selection and improvement in the future breeding programmed of bitter gourd. Resultants the characteristic of high heritability of plant depends on the first female flower, percent of fruit setting, seed length and percentage of seed germination, so there is ample scope for direct selection for these traits and also can be improved through mass selection. Hence, provides better opportunities for selection of bitter gourd.

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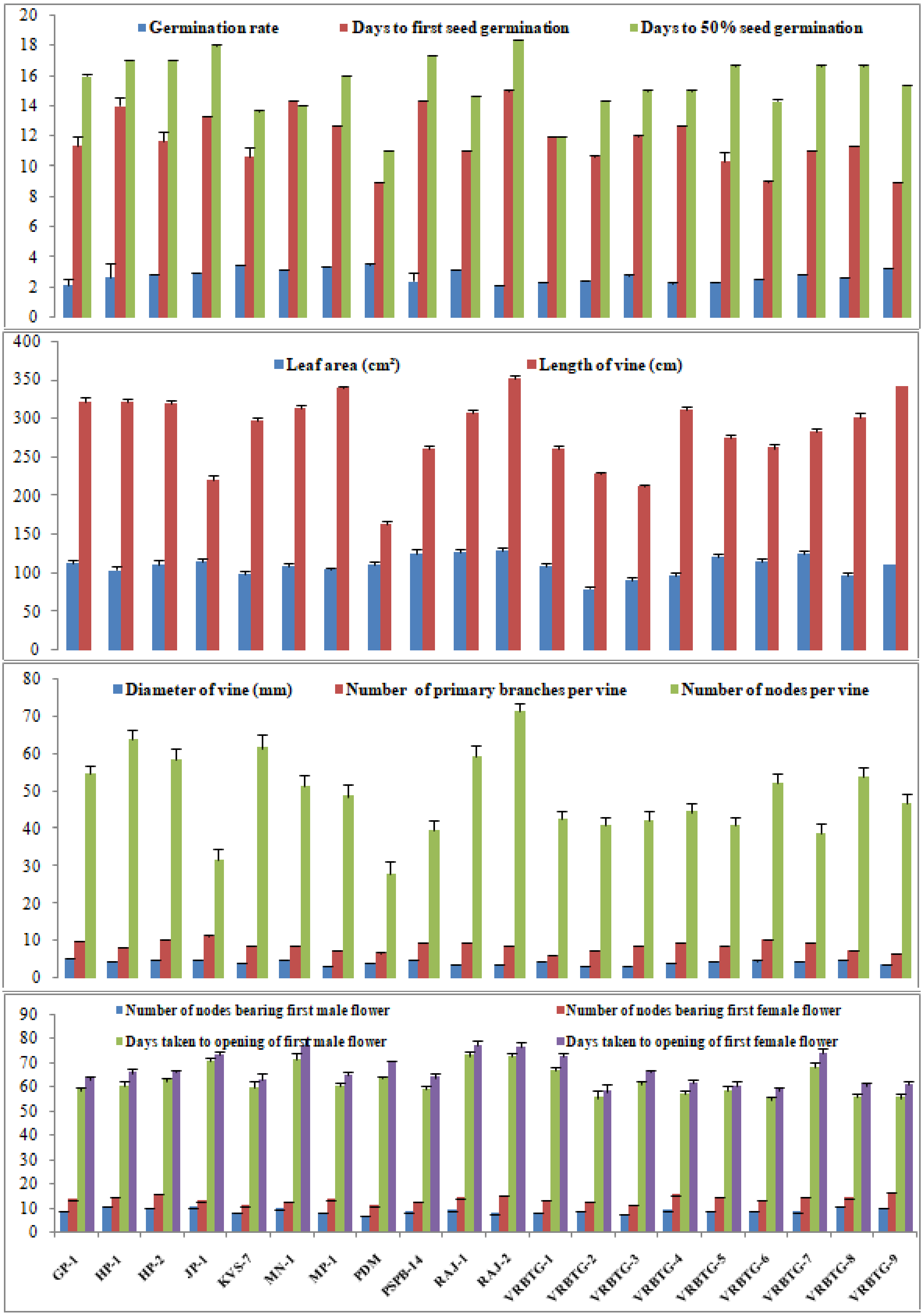


Figure 1: Seed germination and growth parameters of different genotypes of bitter gourd

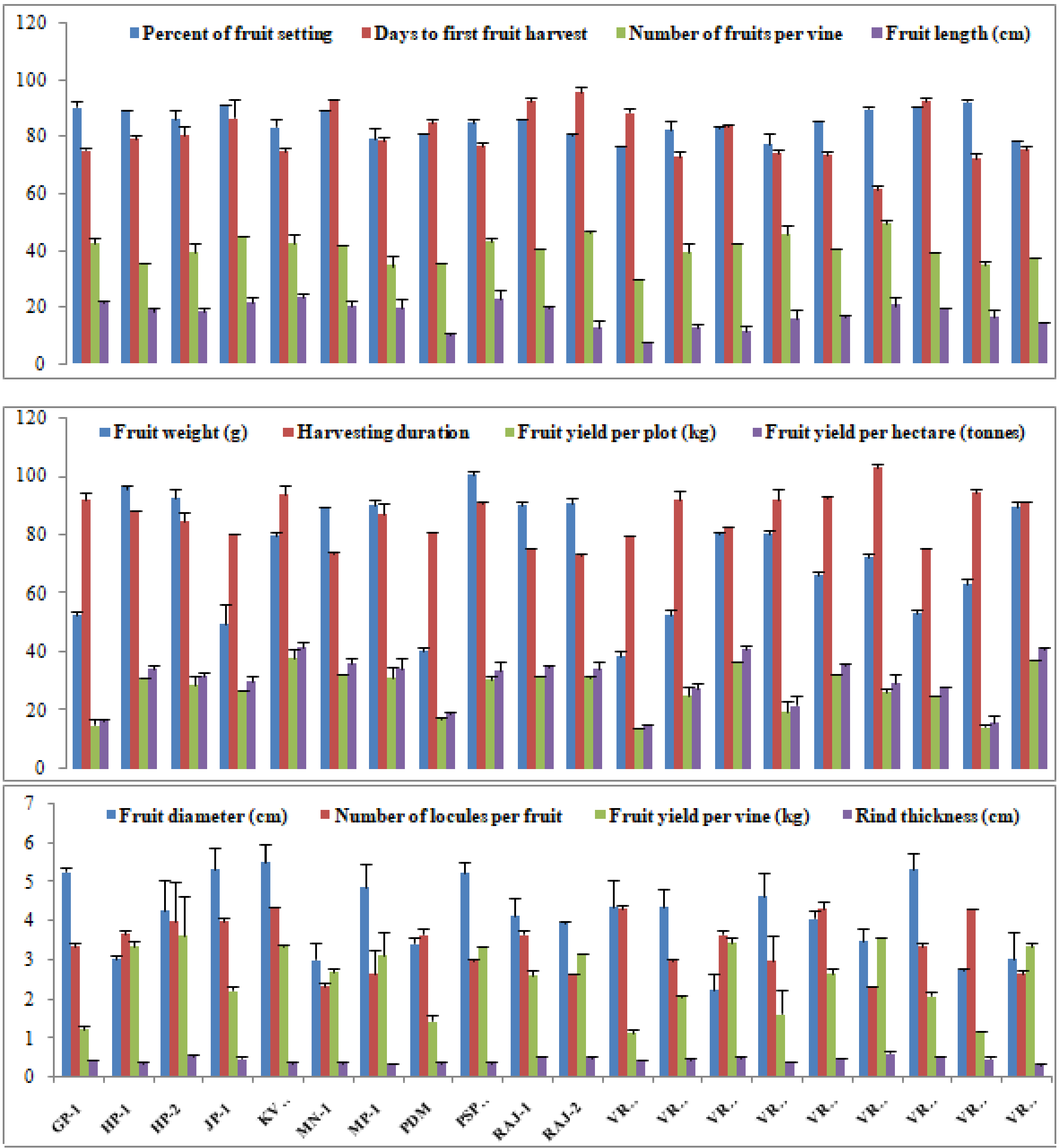
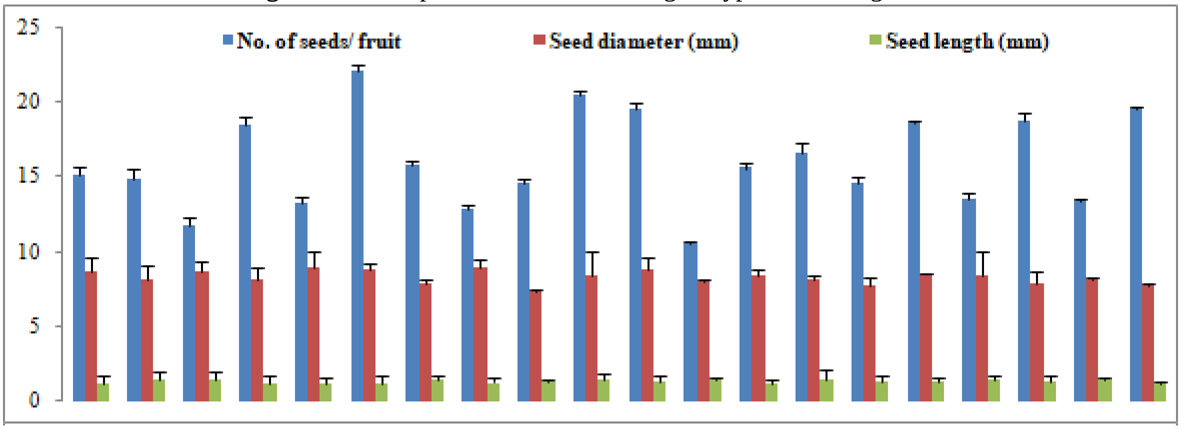


Figure 2: Yield parametersof different genotypes of bitter gourd



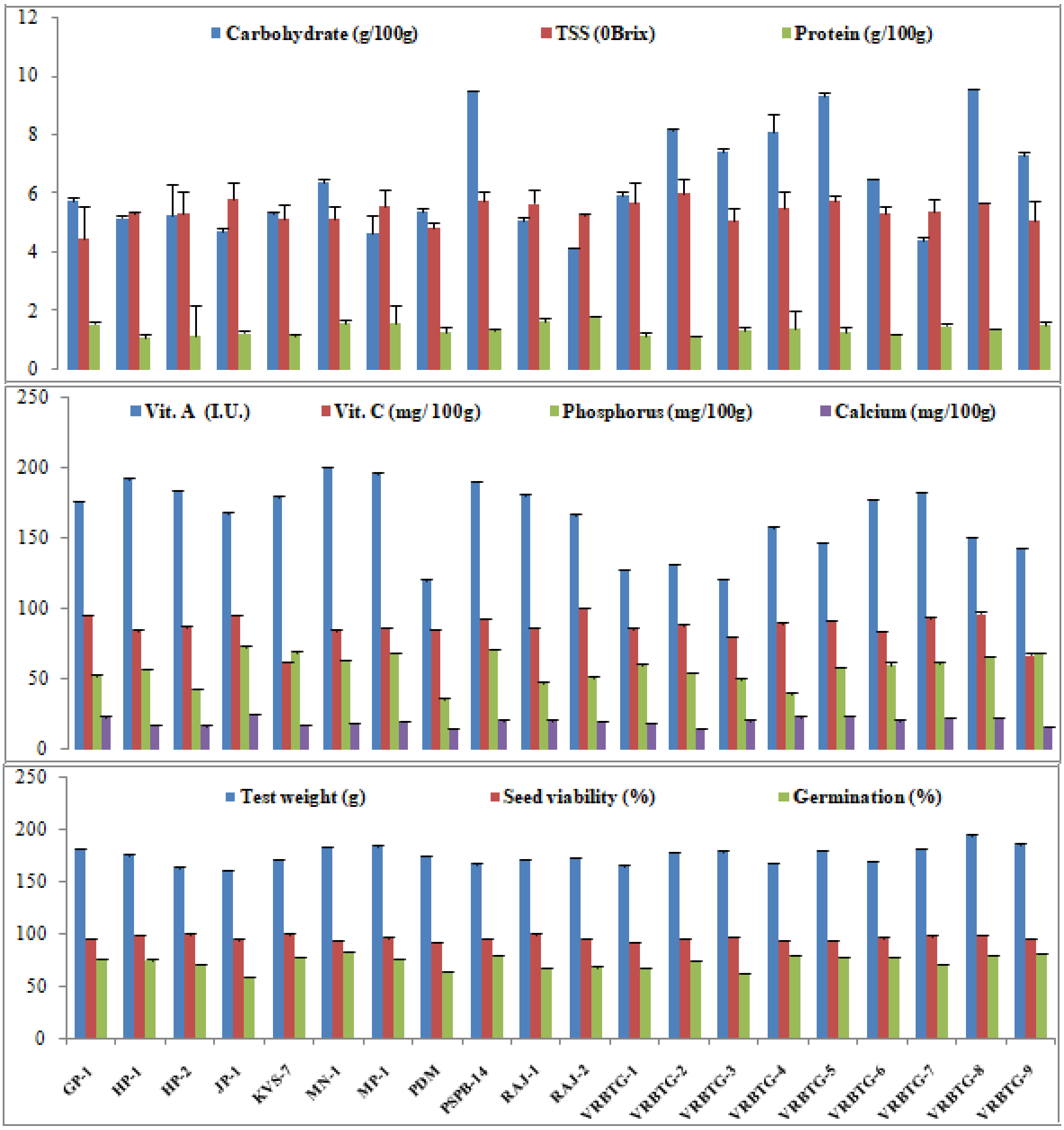


Figure 3: Quality and seed parametersof different genotypes of bitter gourd

Table 1: Analysis of variance of bitter gourd genotypes for quantitative, qualitative and seed parameters

Source of variance	Mean sum of square		
	Replication	Treatment	Error
Degree of freedom	2	19	38
Days to first seed germination	4.116	9.757*	1.555
Days to 50 percent seed germination	0.600	10.851*	0.670
Germination rate	0.005	0.555*	0.103
Length of vine (cm)	1.597	7269.234*	1.211
Diameter of vine (mm)	0.006	0.012*	0.003
Number of primary branches per vine	0.064	5.821**	0.097
Number of nodes per vine	0.653	369.388	0.224
Leaf area (cm²)	0.029	479.812*	0.056
Days taken to opening of first male flower	1.248	111.142*	0.401
Number of nodes bearing first male flower	0.076	3.366**	0.227
Days taken to opening of first female flower	1.009	124.822**	0.400
Number of nodes bearing first female flower	0.047	7.194*	0.206
Percent of fruit setting	0.028	73.911**	0.488
Days to first fruit harvest	0.320	235.924*	0.266
Number of fruits per vine	0.048	67.143**	0.018
Fruit yield per vine (kg)	0.003	2.295**	0.002
Length of fruit (cm)	0.009	59.852	0.029

Weight of fruit (g)	0.075	1163.461*	0.092
Diameter of fruit (cm)	0.016	2.880**	0.005
Rind thickness (cm)	0.001	0.021*	0.001
Number of locules per fruit	0.054	1.399*	0.260
Fruit yield per plot (kg)	7.332	171.756**	6.687
Fruit yield per hectare (tonnes)	0.014	155.401*	0.005
Harvesting duration	5.049	202.522**	1.751
Carbohydrate (g/100g)	0.003	9.140*	0.005
Protein (g/100g)	0.003	0.120**	0.003
Vitamin A (I.U.)	0.990	1974.402**	1.908
Vitamin C (mg/100g)	3.097	253.695*	1.982
T.S.S. (^{0}Brix)	0.025	0.421**	0.136
Calcium (mg/100g)	0.520	28.186**	0.920
Phosphorus (mg/100g)	0.140	347.153*	0.609
Number of seeds per fruit	0.152	29.372*	0.279
Seed length (mm)	0.001	0.036*	0.004
Seed diameter (mm)	0.294	0.604	0.592
Test weight (g)	0.420	217.705**	2.170
Seed viability (%)	0.020	16.473**	0.390
Germination percentage	0.013	135.813**	0.322

*** Significant at 5% level** **** Significant at 1% level**

Table 2: Estimation of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance over mean for growth parameters in bitter gourd genotypes

Characters	Range	Coefficients of variance (%)		Heritability h² (%)	Genetic advance (GA)	Genetic advance over mean (%)
		GCV	PCV			
Days to first seed germination	9-15	14.05	17.60	64	2.72	23.11
Days to 50% seed germination	11-18.33	11.92	13.05	84	3.47	22.45
Germination rate	2.12-3.52	14.02	18.21	59	0.62	22.23
Length of vine (cm)	163.44-351.50	17.31	17.32	100	101.37	35.66
Diameter of vine (mm)	3.10-5.20	14.99	15.51	93	0.13	29.82
Number of primary branches per vine	6.02-8.68	15.90	16.30	95	2.78	31.96
Number of nodes per vine	27.71-71.43	22.89	22.91	100	22.83	47.10
Leaf area (cm²)	79.67-128.50	11.53	11.54	100	26.05	23.76
Days taken to opening of first male flower	54.83-72.90	9.76	9.81	99	12.45	20.00
Number of nodes bearing first male flower	6.65-10.49	11.73	12.95	82	1.91	21.90
Days taken to opening of first female flower	58.01-77.33	9.65	9.70	99	13.20	19.79
Number of nodes bearing first female flower	10.77-16.38	11.30	11.79	92	3.01	22.30

Table 3: Estimation of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance over mean for yield parameters in bitter gourd genotypes

Characters	Range	Coefficients of variance (%)		Heritability h² (%)	Genetic advance (GA)	Genetic advance over mean (%)
		GCV	PCV			
Percent of fruit setting	76.48-92.28	5.82	5.88	98	10.09	11.88
Days to first fruit harvest	61.71-95.91	10.99	11.01	100	18.23	22.60
Number of fruits per vine	29.60-49.61	11.74	11.75	100	9.74	24.18
Fruit yield per vine (kg)	1.15-3.64	33.95	33.96	100	1.80	69.93
Length of fruit (cm)	7.53-23.55	25.82	25.84	100	9.19	53.15
Weight of fruit (g)	38.74-100.28	26.85	26.85	100	40.56	55.30
Diameter of fruit (cm)	2.25-5.53	23.74	23.81	99	2.01	48.77
Rind thickness (cm)	0.32-0.62	18.57	18.69	99	0.17	38.00
Number of locules per fruit	2.33-4.36	18.03	23.41	59	0.98	28.61
Fruit yield per plot (kg)	13.80-37.68	27.33	28.94	89	14.43	53.16
Fruit yield per hectare (tonnes)	15.28-36.06	25.01	25.01	100	14.83	51.51
Harvesting duration	72.70-103.01	9.51	9.63	97	16.64	19.33

Table 4: Estimation of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance over mean for quality and seed parameters in bitter gourd genotypes

Characters	Range	Coefficient of variance (%)		Heritability h² (%)	Genetic advance (GA)	Genetic advance over mean (%)
		GCV	PCV			
Carbohydrate (g/100g)	4.15-9.55	27.23	27.26	100	3.59	56.05
Protein (g/100g)	1.10-1.84	14.50	14.55	99	0.41	29.75
Vitamin A (I.U.)	120.25-200.36	15.60	15.62	100	52.75	32.09
Vitamin C (mg/100g)	62.24-100.32	10.56	10.68	98	18.65	21.50
T.S.S. (^{0} Brix)	4.44-6.01	5.72	8.94	41	0.41	7.54
Calcium (mg/100g)	14.50-25.31	15.23	15.99	91	5.92	29.90
Phosphorus (mg/100g)	35.71-72.82	18.73	18.77	99	22.08	38.47
Number of seeds per fruit	10.52-22.03	19.48	19.76	97	6.32	39.57
Seed length (mm)	1.15-1.48	8.17	8.32	96	0.22	16.52
Seed diameter (mm)	7.40-9.00	0.76	9.29	10	0.01	0.13
Test weight (g)	161.40-194.10	4.84	4.91	97	17.20	9.82
Seed viability (%)	91.98-99.94	2.41	2.49	93	4.60	4.79
Germination percentage	59.93-84.11	9.06	9.09	99	13.79	18.60