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Genotype × Environment interaction and seasonal stability analysis for various quantitative traits in knolkhol (*Brassica oleracea var gongylodes* L.)

R. Dolkar*[1], S. Spaldon[2] and R. K. Samnotra[3]

[1] Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, J&K (India),
[2] High Mountain Arid Agriculture Institute, SKUAST-K, Leh, Ladakh
[3] Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, J&K (India), 180009

ABSTRACT

The goals of this study were to find stable Knolkhol genotypes for yield and yield attributing traits in the subtropical region of Jammu (J&K), India, and to examine genotype-environment (GE) interaction.Twenty five genotypes were studied in four environments (E1: Winter season (2015-16), E2: Spring- Summer (2016-17), E3: Rainy Season (2016-17) and E4: Autumn Season (2016-17).For all parameters except the number of leaves per plant, highly significant mean sum of squares for genotypes, environments, and genotype-environment interaction were recorded, showing that both linear and non linear components were relevant in constructing the total G* E interaction. Seasonal stability was estimated using the Eberhart and Russell method (1966). On the basis of three stability parameters (mean, regression coefficient and deviation from regression coefficient) the genotypes G-40, SJKK-02, and SJKK-03 have been found stable for early maturity. For leaf characteristics the genotypes G-40, SJKK-04 and Green Gold were stable for the number of leaves per plant, three genotypes Knolkhol White, Purple Vienna-I, and Nawpura Local were stable for leaf length and genotypes SJKK-02, SJKK-03, Pusa Virat and Mamta were stable in their performance for leaf width across all the season under study. In terms of knob yield traits the genotypes G40, SJKK-04, Early White Vienna and C-2002 were capable of giving a consistent performance across seasons for yield and yield attributing traits such as marketable knob diameter, gross weight per plant, marketable knob weight per plant and yield per plot and were ideal to be recommended for wide cultivation in all the four seasons of Jammu.

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CORRESPONDING AUTHOR: **R. Dolkar**

E-MAIL ID: **drinchan2012@gmail.com**

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Introduction

Knolkhol (*Brassica oleracea* var. *gongylodes* L.), belonging to the family *Brassicaceae* 2n=18, is a cool-season vegetable crop. The edible knob, generated by the thickening of stem tissue above the cotyledon, is a soft, fleshy larger stem formed immediately above ground. It is widely cultivated in Jammu and Kashmir, West Bengal, and, to a lesser extent, Maharashtra, Assam, Uttar Pradesh, and Punjab as a rare exotic vegetable [11]. The market for Knolkhol has grown in India because of its nutritious utility as a fresh vegetable (leaves and knob) and the value-added products that support the food needs of the people. It is a popular vegetable in Jammu and Kashmir among both rich and poor, and grown in almost all home gardens and also as a commercial crop around cities and towns. In Jammu Knolkhol is grown over an area of about 1961 ha with a production of 54977.60 mt [1] and is in high demand all over the year for its varied size of colored knobs and leaves. Plant breeders around the world have struggled to find high-yielding and stable accession in a variety of conditions [5]. Although a number of genotypes have been recommended for cultivation, information on their stable performance over the season is lacking for a variety of agro-climatic conditions in Jammu. Because most economic characters in knolkhol are quantitative in nature and susceptible to environmental fluctuations, it is critical to assess the stability of desirable genotypes capable of producing higher yields and having abiotic stress tolerance under a variety of agro-climatic conditions. The characterization of stable accession is often complicated by the frequent occurrence of genotype by environment interactions. Plant breeders, to address the genotype-environment interactions issue, evaluate genotypes in multi-environment trials, including both favorable and unfavorable conditions [8]. Stability has been characterized in a variety of ways, and numerous biometrical approaches for assessing stability have been devised, including univariate and multivariate methods. As a result, the study's goal was to find stable genotypes capable of delivering constant performance throughout the seasons in the subtropical Jammu region, thereby mitigating the effects of climate change.

Materials and method

Agroclimatically the location represents Zone V of Jammu and Kashmir and is characterized by a subtropical climate. The place experiences a hot, dry summer, a hot and humid rainy season, and cold winter months. The maximum temperature goes up to 45° C during summer months (May-June), and the minimum temperature falls to 1° C during the winter. The mean annual rainfall is about 1000-1200 mm. The experimental material, comprised of 25 genotypes of Knolkhol was collected from diverse agro-climatic regions of J&K, along with two genotypes from IARI, Katrain, one from CSKHPKV, Palampur, and three hybrids (Table 1), and was laid out in four environments during the winter season of 2015-16, spring –summer seasons, the rainy seasons and autumn season of 2016-17. The individual experiment was conducted in a Randomized Block Design with three replications. The uniform, healthy seedlings were planted in a plot size of 1.2 ×0.8 m maintaining inter and intra-row spacing of 30 cm in the field as per the layout of the experiment. The details of the environments (Seasons) are as follows:

Environments (Season)	**Transplanting date**
E1: Winter season	: 13th Jan. 2015-2016
E2: Spring- Summer	: 19th March, 2016-17
E3: Rainy Season	: 10th July, 2016-17
E4: Autumn Season	: 19th Oct, 2016 -17

Statistical Analysis

The observations recorded on various parameters in four environments were analyzed using method [3] using Windostat Version 9.3. In this methodology three parameters namely (i) the overall mean of each genotype over a range of environments (μ), (ii) the regression of each genotype on the environmental index (b_i) and (iii) a function of the squared deviation from the regression ($S^2 d_i$) were estimated.

Results and Discussion

In vegetable breeding, assessing genotype-environment interactions is becoming more important for identifying genotypes with more adaptability. A statistical model for stability that is commonly used to examine genotype-environment interactions and draw reliable findings about genotype stability [3].

Analysis of variance over environments for various quantitative traits

Analysis of variance over environments presented in (Table 1) revealed that the mean sum of squares due to genotypes as well as environments were highly significant for all the traits studied which indicated not only the presence of genetic variability among the genotypes but also reflected the extent of diversity in growing conditions during the four seasons of experimentation. *Brasica oleracea* cultivars found similar results except for non significant mean square values in four traits, namely, plant height, plant frame, leaf width, number of leaves per plant, harvest index, and days to marketable maturity, which means less variation and less scope of selection for these traits, the presence of genotypes environment interaction was also significant for all traits, allowing for the selection of suitable genotypes with high mean for the trait of interest [2, 7, 9]. Similar results for petiole length, leaf length, gross weight/plant, curd weight, plant height, and plant spread were reported in cauliflower [6, 9].

Meansquares due to different sources of variation for various quantitative traits

The pooled analysis of variance for various traits in knolkhol over four environments (Table 3) revealed that the variation due to G × E interaction has been partitioned into two, the predictable component due to linear regression and the unpredictable one due to pooled deviations from regression. Plant height, plant frame, petiole length, number of leaves per plant, leaf length, leaf width, stalk length, gross weight/plant, marketable knob weight/plant, marketable knob diameter, days to marketable maturity, and yield/plot all showed the significant mean sum of squares due to Environment + (Genotype Environment), indicating the existence of genotype-environment interaction. For almost all of the traits studied, the linear contribution of environment on genotype performance was significant. For all traits except number of the leaves per plant and days to marketable maturity, the mean squares due to genotype-environment interaction (linear) were significant when tested against combined pooled deviations and pooled error, indicating that genotype behaviour could be predicted over environments more precisely and accurately than the GEM. These results were in conformity with the earlier reports of [6] for plant height, leaf length, leaf width, number of leaves per plant, petiole length, plant weight, curd diameter in cauliflower in Uttarakhand; for gross head weight in cabbage [5]; net head weight, head diameter, marketable yield and stalk length in cabbage under dry temperate zone of Himachal Pradesh [9]. Non significant effect of genotype × environment (linear) for number of leaves/plant and days to marketable maturity indicating possible absence of genetic differences among the genotypes for their regression on environmental index making difficult the prediction for the performance of these traits. When the pooled deviation was compared to the pooled error, it was found to be significant for the majority of the trait studied, indicating the importance of the non-predictable component. Similar results were reported in kale and cabbage, respectively [2, 7]

Stability Parameters

Once relevant genotype-environment interactions have been identified, the next step is to determine the genotype's adaptability and stability for knob yield and its component attributes. However, any generalization about genotype stability for all qualities is extremely challenging. The genotype studied did not have a consistent pattern of trait stability and response.

The stability of individual yield components can lead to simplification in the genetic explanation of yield stability and hence valuable to a breeder in the prediction and determination of the environments [4]. The three stability parameters viz, mean (μ), regression coefficient (b_i) and deviation from linear regression line ($S^2 d_i$) were estimated for all the traits and the results obtained are present in (Table 4).

Mean (μ), Regression Coefficient (b_i) and Mean Square Deviation ($S_2 d_i$)

A stable genotype, according to [3] has a high mean value, unit regression (bi = 1), and lowest deviation from regression (S2di = 0). It's simple to use, and the results are straight forward [12]. Early maturity and late maturity are genotypic features that are impacted by environmental factors of specific growing conditions and found to have negatively correlated with net knob weight. A perusal of stability parameters for days to marketable maturity exhibited that genotypes *viz.*, SJKK-04, SKKK-01, SKKK-03, Early Super White Vienna, Kargil Local, Knolkhol White, White Vienna, Baramullah Local, Ganderbal Local, Leh Local had low mean value compared to the average mean value (55.19)with regression coefficient close to unity and non significant deviation from regression line were stable in performance and adaptable to all the type of environments under study for this particular trait, while three genotypes Early White Vienna, Green Gold and C-2002 were found to be suitable for unfavourable environments for this trait. Four cauliflower genotypes found most stable for days to maturity under Uttarakhand conditions i,e. RGN-145, PCR-7, Rohini, and RGN-253 [6].

As per the stability parameters for plant heightthe genotypes *viz*. G-40, SJKK-03, SJKK-04, SKKK-01 and SKKK-03 (mean higher than average mean, b_i =1 and non-significant S^2di) were stable in performance across all the environments. For plant frame, none of the genotypes were found to be stable and adapted to all types of environments; however, the genotype Early Super White Vienna had a significant regression coefficient less than unity and non significant deviation from the regression line, indicating their suitability for unfavourable conditions. The estimate of the stability for plant spread ranged from 32.20 (Khanyari) to 56.13 cm (SH-K-24) across the environments and the genotypes SH-K-1 and SH-K-10 exhibited average stability for more spread [7].

The stability estimates for number of leaves per plant revealed that genotypes G-40, SJKK-4, and C-2002 had a higher mean value than the average (11.70), a regression coefficient close to unity, and no significant deviation from regression lines, indicating that they were stable genotypes capable of performing well for this trait in all environments studied. Among all the genotypes, the genotype Farashi Safed Local were adapted to unfavourable environments under study. Further it indicated the presence of only non linear G × E interaction significant for genotypes (SJKK-03, Early Super White Vienna, Purple Vienna-I, G-40, Purple Vienna-II, White Vienna, Farashi Lajwari Local, Baramullah Local and Mamta) indicating that the predictability regarding the stability of the trait for these genotypes would be difficult. Similar findings were reported by [7] in kale for seven genotypes under Kashmir conditions.

Short stalk length is favoured in knolkhol from a breeding standpoint to reduce crop lodging, and it was also reported that high stalk length had a negative and direct effect on knob weight/plant. When stability factors were compared to stalk length, it was revealed that just one genotype, Palam Tender Knob, was broadly adapted to the entire environment studied. The estimates of the mean square deviation from regression (S^2d_i) were significant for the genotypes *viz*., G-40, SJKK-02, SJKK-03, SJKK-04, SKKK-01, King of Market-I, Kargil Local, Purple Vienna-II, Palam Tender Knob, Farashi lajwari Local and Ganderbal Local indicated that stability of the trait for these genotypes were unpredictable across the environments. Similar findings for cabbage stem length were reported by [9].

In terms of marketable knob diameter, gross knob weight per plant, and marketable knob weight per plant, the genotypes G-40, SJKK-04, Early White Vienna, Farashi Safed Local, and C-2002 had higher mean values than average mean values, regression coefficient close to unity, and non significant deviation from regression line, and were considered stable genotypes as per stability parameters as suggested by [3] which also found to have a highest positive and direct effect on yield/plot as revealed from character association studies. Whereas only one genotypes Green Gold had high mean value than the average mean, a regression coefficient lesser than unity and non significant deviation from regression lines and found suitable for unfavourable environments for this traits. The response of cabbage genotypes were studied in diverse environments in terms of gross weight of head per plant, and found that Hybrid No. 10 was stable for gross weight of head in cabbage [2]. The genotype SKKK-03 had a high marketable knob weight mean value as compared to the average mean value with a regression coefficient less than unity, and showed above-average response among the 25 genotypes, making it adaptable to the unfavourable environment. Similar results were obtained by [9] who reported that only two genotypes of cabbage were suitable for varied environments studied under the temperate zone of Himachal Pradesh for two consecutive years, out of 13 genotypes. Similarly, seven out of 21 accessions significantly deviated from the regression line [5].Varied response of the genotypes for polar diameter was reported by [2] who found that two hybrids, Green Challenger and Hari Rani Gol, were stable for polar diameter in cabbage under Utter Pradesh conditions over eight environments, and root diameter in radish was stable under Rabi, Kharif, and summer season of Pundicherry conditions [1]

In a plant breeding program, any genotype with a high yield potential and reliable performance in a variety of environments is quite valuable.The genotypes SJKK-02, SJKK-03, SJKK-04, Early White Vienna, Knolkhol White, Farashi Safed Local and C-2002 (3.49, 3.43, 4.43, 3.38, 3.51, 3.47 and 4.2 kg/plot) were stable in performance having high mean value than the average mean (3.34 kg/plot) for this particular trait and suitable for varied environments. Only two genotypes SKKK-03 and Green Gold exhibited above-average in response and were thus suited to unfavorable environments for yield (Figure 1). In general hybrids / varieties did not show uniform stability and linear trends for all the traits studied. However, the genotypes G40, SJKK-04, Early White Vienna and C-2002 may be considered stable on the basis of higher mean value for yield and its attributing traits. Similar results were reported in cabbage over eight environments at eastern plain zone of Utter Pradesh for yield traits [2]

Conclusion

The purpose of this study was to analyse the stability of different Knolkhol genotypes for wide range of environments. Environmental conditions change from season to season and over time, genotypes that are phenotypically stable are extremely important. Therefore, for wider popularity and cultivation of Knolkhol, genetic consistency and wide adaptation in the specific environment are crucial. In terms of knob yield traits in Knolkhol the genotypes G40, SJKK-04, Early White Vienna and C-2002 were capable of giving consistent performance across season for yield and yield attributing traits such as marketable knob diameter, gross weight per plant, marketable knob weight per plant and yield per plot and were ideal to be recommended for wide cultivation in all the four seasons of Jammu.

Table 1: Details of source of procurement of genotypes

S. No.	Code	Genotype	Source
1	G1	G-40	SKUAST-J
2	G2	SJKK-02	SKUAST-J
3	G3	SJKK-03	SKUAST-J
4	G4	SJKK-04	SKUAST-J
5	G6	SKKK-01	SKUAST-K
6	G8	SKKK-03	SKUAST-K

7	G9	Early White Vienna	Directorate of Agriculture ,Jammu
8	G10	King of Market-I	Directorate of Agriculture ,Jammu
9	G11	Early Super White Vienna	NFCC, Jammu
10	G12	Kargil Local	Kargil
11	G13	Purple Vienna-I	JK krishivikas Cooperative Ltd, Pulwama
12	G14	Knolkhol White	JK KrishiVikas Cooperative Ltd, Pulwama
13	G16	Purple Vienna-II	Sultan seeds, Munwarabad
14	G17	PusaVirat	IARI, Katrain (HP)
15	G18	White Vienna	IARI, Katrain (HP)
16	G19	Palam Tender Knob	CSKHPKV,Palampur
17	G20	FarashiLajwari Local	Sopore
18	G21	FarashiSafed Local	Sopore
19	G23	Baramullah Local	Baramullah
20	G24	Ganderbal Local	Ganderbal
21	G25	Leh Local	Leh
22	G27	Nawpura Local	Nawpora
23	G28	Mamta	Crop Life Hybrid Seeds, Punjab
24	G29	Green Gold	Indus Seeds, Banglore
25	G30	C-2002	Century Seeds, New Dehli

Table 2: Analysis of variance in individual environment for various yield attributing traits in knolkhol (Brassica oleracea var. gongyloidesL.)

Source of variation	**Df**	**Mean sum of square**			
		E_1 Winter season	**E_2 Spring- summer season**	**E_3 Rainy season**	**E_4 Autumn season**
Plant height (cm)					
Genotypes	24	127.21**	71.14**	15.32**	134.81**
Error	50	23.27	7.53	2.73	33.40
Leaf length (cm)					
Genotypes	24	30.79**	15.57**	16.98**	39.99**
Error	48	3.80	3.26	2.23	9.08
Leaf width (cm)					
Genotypes	24	14.92**	9.35**	7.23**	21.81**
Error	48	2.60	1.72	1.49	3.21
Number of leaves /plant					
Genotypes	24	4.96**	10.74**	5.40**	3.61**
Error	48	1.18	1.25	1.10	1.33
Petiole length (cm)					
Genotypes	24	16.36**	3.33**	6.78**	20.78**
Error	48	3.08	0.75	1.01	3.94
Plant frame (cm)					
Genotypes	24	110.44**	100.96**	51.33**	145.81**
Error	48	29.86	23.69	12.51	38.43
Marketable knob diameter (cm)					
Genotypes	24	2.51**	1.31**	3.66**	1.10**
Error	48	0.20	0.13	0.17	0.27
Stalk length (cm)					
Genotypes	24	0.99**	2.11**	2.26**	1.19**
Error	48	0.08	0.26	0.1341	0.11
Gross weight/plant					
Genotypes	24	15440.37**	7600.94**	5310.11**	10672.14**
Error	48	3809.00	2111.21	879.41	2577.99
Marketable knob weight/plant					
Genotypes	24	10702.43**	6195.77**	3134.74**	6890.51**
Error	48	2713.13	1377.45	534.44	1608.38
Days to marketable maturity					
Genotypes	24	53.48*	45.96**	54.46**	39.80**
Error	48	4.26	1.55	3.42	4.64
Yield/ plot (kg)					
Genotypes	24	1769496.88**	1034749.81**	705317.00**	1318934.63**
Error	48	483884.34	240608.16	120249.88	267278.72

** and ** significant at 5% and 1% probability levels respectively*

Table.3: Mean Squares due to different source of variation for various traits in knolkhol (Brassica oleracea var. gongyloidesL.)

Source of variation	Df	Plant height (cm)	Plant frame (cm)	Petiole length (cm)	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Stalk length (cm)	Gross weight/plant (g)	Marketable knob diameter (cm)	Yield/plot (kg)	Days to marketable maturity	Marketable knob weight/plant (g)
Genotypes	24.00	71.19**	64.84**	10.83**	4.53**	26.18**	12.98**	1.06**	9368.40**	1.79**	1354474.88**	63.10**	7225.14**
Environment + (Genotype × Environment)	75.00	156.92**	111.47**	18.98**	1.69	16.66**	7.31**	0.75**	18438.55**	2.31**	2076139.50**	16.13**	13679.52**
Environments	3.00	3563.27**	2216.13**	435.13**	12.42**	350.39**	144.49**	9.67**	431848.16**	49.13**	49863292.00**	391.52**	327993.31**
Genotype × Environment	72.00	14.99	23.78	1.64**	1.24	2.76**	1.60	0.37*	1213.15	0.36**	85008.23*	0.49	583.11
Environments (Linear)	1.00	10689.80**	6648.39**	1305.40**	37.26**	1051.18**	433.48**	29.02**	1295544.50**	147.40**	149589872.00**	1174.57**	983979.94**
Genotype × Environment (Linear)	24.00	21.41*	30.88**	3.69**	1.11	6.01**	2.58**	0.70**	1926.21**	0.70**	148510.14**	0.72*	911.18**
Pooled deviation	50.00	11.31**	19.42**	0.59	1.25**	1.08	1.06	0.20**	822.36	0.18**	51126.99	0.36	402.32
Pooled error	192.00	71.19	8.71	0.73	0.40	1.53	0.75	0.05	781.47	0.06	92668.42	1.16	519.45

*significant at 5% probability level, ** significant at 1% probability level

Table 4: Mean value (μ), regression coefficient (b_i) and variation due to deviation (s^2d_i) for various quantitative traits in knolkhol (Brassica oleraceavargongylodes L.)

			Plant height (cm)			Plant frame (cm)			Petiole length (cm)			Number of leaves per plant		
S. No.	Code	Genotype	(μ)	(b_i)	S^2d_i	(μ)	(b_i)	S^2d_i	(μ)	(b_i)	S^2d_i	(μ)	(b_i)	S^2d_i
1	G1	G-40	33.23	1.05	0.94	47.41	1.31*	-8.26	14.37	1.12	-0.68	12.51	1.09	-0.08
2	G2	SJKK-02	34.40	1.20	6.32	46.75	1.41	65.29**	15.30	1.21	-0.04	13.50	1.66	0.72
3	G3	SJKK-03	33.54	1.03	-1.39	44.96	1.28	26.43*	14.64	1.21	-0.39	12.88	2.34	2.30**
4	G4	SJKK-04	34.29	1.01	-2.99	46.61	1.11	5.88	15.52	1.14	-0.60	12.77	0.92	0.09
5	G6	SKKK-01	31.00	0.93	-2.64	44.44	0.91	-7.46	14.41	1.42	1.13	10.93	0.44	0.70
6	G8	SKKK-03	31.01	0.91	4.87	44.60	0.92	23.71*	14.69	1.09	3.43**	11.45	1.79	0.67
7	G9	Early White Vienna	28.23	0.76	-0.79	42.98	0.50	0.27	12.94	0.99	-0.21	11.17	0.80	0.07
8	G10	King of Market-I	36.25	1.13	28.97**	46.68	0.54	23.49*	15.55	1.21	-0.58	12.92	2.73	0.52
9	G11	Early Super White Vienna	29.44	1.01	-2.90	47.29	0.68*	-7.30	14.96	1.49**	-0.72	12.33	0.93	1.07*
10	G12	Kargil Local	27.82	1.17	-1.51	40.88	1.12	41.43**	13.76	1.03	-0.66	10.61	0.37	0.29
11	G13	Purple Vienna-I	38.03	1.46	6.81	53.36	1.55**	-7.94	15.86	0.82	0.52*	11.47	1.68	1.03**
12	G14	Knolkhol White	31.46	1.09	15.78*	45.91	0.84	13.84	14.29	0.97	-0.53	12.39	3.01	4.37**
13	G16	Purple Vienna-II	36.48	1.43	11.50*	53.83	1.53	23.09*	16.84	1.20	0.33	11.69	0.95	2.16**
14	G17	PusaVirat	22.50	0.50	32.73**	41.40	1.03	-5.15	9.95	0.37*	-0.48	10.44	-0.42	0.20
15	G18	White Vienna	24.35	0.81	-3.40	38.70	1.11	17.31	12.90	0.92	-0.16	10.89	0.32	1.97**
16	G19	Palam Tender Knob	24.69	0.87	1.86	43.54	0.40	8.17	12.44	0.65	-0.06	11.75	-0.14	0.40
17	G20	FarashiLajwari Local	23.83	0.62*	-3.61	40.30	0.58	-2.40	12.44	0.51	0.08	9.22	1.19	1.09*
18	G21	FarashiSafed Local	30.05	0.83	48.55**	44.09	1.15	12.82	14.40	1.05	0.72	11.89	0.63	-0.25
19	G23	Baramullah Local	28.68	1.05	4.14	43.67	0.92	32.26*	14.50	0.83	-0.37	11.57	0.81	1.28*
20	G24	Ganderbal Local	29.04	1.11	9.50*	45.69	1.13	16.84	16.22	1.02	-0.13	11.58	0.62	0.02
21	G25	Leh Local	25.30	1.02	-2.60	39.46	0.96	18.40*	12.18	0.81	-0.54	10.29	-0.25	0.45
22	G27	Nawpura Local	32.06	1.16	-3.52	48.27	1.59**	-8.52	17.53	1.35*	-0.18	10.63	0.16	0.59
23	G28	Mamta	34.86	1.22	-2.79	52.56	1.14*	-8.42	15.53	0.73*	-0.65	11.28	0.79	1.33**
24	G29	Green Gold	32.90	0.87	-2.29	43.52	0.64	2.84	14.40	0.93	-0.69	13.43	1.53	0.65
25	G30	C-2002	29.79	0.77	4.26	43.33	0.65	-6.35	13.93	0.96	-0.50	12.89	1.03	-0.38
Mean			30.50			45.21			14.38			11.70		

*significant at 5% probability level, ** significant at 1% probability level

Contd..

			Leaf length (cm)			Leaf width (cm)			Stalk length (cm)			Days to marketable maturity		
S. No.	Code	**Genotype**	**(μ)**	**(b_i)**	**S^2d_i**	**(μ)**	**(b_i)**	**S^2d_i**	**(μ)**	**(b_i)**	**S^2d_i**	**(μ)**	**(b_i)**	**S^2d_i**
1	G1	G-40	21.14	1.38*	1.40	14.74	1.46	-0.52	2.35	0.94	0.59**	51.67	1.12	-0.97
2	G2	SJKK-02	19.58	1.35	-0.96	14.16	0.96	-0.54	2.65	0.69	0.56**	53.33	1.14	-0.81
3	G3	SJKK-03	19.62	1.32	0.56	14.24	1.08	0.17	2.54	1.75	0.75**	53.84	1.19	-0.78
4	G4	SJKK-04	21.78	1.23*	-1.50	14.66	1.19	-0.36	2.43	0.63	0.19**	52.83	1.06	-0.72
5	G6	SKKK-01	17.08	1.49	0.83	11.60	1.17	-0.47	1.82	0.22	0.30**	53.00	0.96	-0.77
6	G8	SKKK-03	17.21	1.42*	-1.25	12.78	0.93	-0.62	3.14	1.33	0.01	52.17	0.86	-0.20
7	G9	Early White Vienna	17.31	0.57	2.43	11.77	0.82	1.05*	3.17	2.28	0.08	51.97	0.83	-0.80
8	G10	King of Market-I	22.18	1.59*	-1.10	15.08	1.28	0.05	3.31	2.27	0.17**	58.50	1.02	1.08*
9	G11	Early Super White Vienna	17.19	0.79	0.25	12.83	0.70	0.13	2.98	2.48*	0.08	48.25	0.96	-0.93
10	G12	Kargil Local	17.33	1.52	-0.41	12.98	1.51	0.91*	2.53	0.71	0.21**	53.50	0.98	-0.97
11	G13	Purple Vienna-I	22.87	1.06	-0.47	16.80	1.22	-0.51	3.80	1.70	0.06	61.42	1.23	-0.52
12	G14	Knolkhol White	19.64	0.97	-1.34	13.34	0.39*	-0.56	3.02	0.66	-0.01	52.58	0.94	-0.91
13	G16	Purple Vienna-II	23.74	1.31*	-1.41	16.92	1.48*	-0.67	3.60	1.18	0.13**	61.25	1.09	-0.63
14	G17	PusaVirat	15.95	0.48	-0.86	14.00	0.90	0.84*	1.65	1.58*	-0.04	61.17	0.78	0.41*
15	G18	White Vienna	15.58	0.70	-1.15	10.85	0.85	-0.37	3.46	1.24	0.02	53.34	0.97	1.09
16	G19	Palam Tender Knob	17.43	0.44*	-1.43	12.15	0.93	-0.70	2.58	0.89	0.14**	54.75	0.89	-1.02
17	G20	FarashiLajwari Local	16.45	0.49*	-1.07	13.32	0.77	1.00	3.10	1.51	0.25**	62.59	0.97	-1.03
18	G21	FarashiSafed Local	18.00	0.67	-0.65	12.41	0.44	-0.40	2.90	1.24	0.05	56.06	1.02	-1.10
19	G23	Baramullah Local	19.92	0.65	0.83	12.53	0.57	-0.46	2.50	-0.67*	0.05	54.47	1.03	-1.06
20	G24	Ganderbal Local	20.36	1.22	-1.31	15.09	1.85	-0.02	2.68	0.24	0.14*	54.12	1.03	1.04
21	G25	Leh Local	16.29	0.90	1.36	10.79	1.19	0.06	3.00	1.12	0.08	53.92	1.00	1.12
22	G27	Nawpura Local	22.76	0.98	0.14	16.54	1.40	8.89**	3.37	0.53	0.01	61.17	1.15	0.16*
23	G28	Mamta	23.96	1.28	1.73	16.70	1.01	0.49*	2.95	-0.25*	0.04	61.08	1.15	0.46*
24	G29	Green Gold	20.41	0.54	1.27	13.29	0.58	-0.11	2.51	0.15	0.03	51.33	0.80	-0.65
25	G30	C-2002	18.31	0.64*	-1.38	12.42	0.32	-0.21	2.34	0.60*	-0.04	51.58	0.83	-0.82
Mean			19.28			13.68			2.81			55.19		

Contd..

			Marketable knob diameter (cm)			Gross weight (kg/plant)			Marketable knob weight (kg/plant)			Yield/plot (kg)		
S. No.	Code	Genotype	(μ)	(b_i)	S^2d_i	(μ)	(b_i)	S^2d_i	(μ)	(b_i)	S^2d_i	(μ)	(b_i)	S^2d_i
1	G1	G-40	6.42	0.91	-0.03	380.23	1.13*	-737.43	301.78	1.10	-451.16	4.21	1.03*	-86.01
2	G2	SJKK-02	5.98	0.77**	-0.05	346.02	1.17*	181.30	265.68	1.15	-332.68	3.49	1.06*	-91.08
3	G3	SJKK-03	6.09	0.78	-0.05	342.46	1.15	142.64	260.74	1.16	-396.36	3.44	1.14	-81.81
4	G4	SJKK-04	6.47	0.86	-0.05	402.53	1.05	-748.70	322.24	1.08	-464.03	4.43	1.11	-80.21
5	G6	SKKK-01	5.53	0.97	-0.04	285.73	0.93	-128.40	219.36	0.91*	-520.11	2.94	0.90*	-90.32
6	G8	SKKK-03	6.09	0.88	-0.06	324.58	0.94	691.31	249.03	0.84	-205.04	3.35	0.82	-18.46
7	G9	Early White Vienna	6.04	0.93	0.05	327.00	1.05	408.37	251.83	1.06	-379.31	3.38	1.05	-57.69
8	G10	King of Market-I	5.78	1.06	-0.04	332.55	1.14	3177.35**	245.50	1.01	1575.51**	3.56	1.25	142.89**
9	G11	Early Super White Vienna	6.74	1.03	0.02	373.02	1.17	36.77	309.93	1.22	-409.90	4.25	1.29**	-87.57
10	G12	Kargil Local	5.68	1.00	0.26	280.56	1.13	-702.42	214.74	1.05	-222.40	2.94	1.12	-70.87
11	G13	Purple Vienna-I	5.19	1.51	0.08**	339.18	1.36	-219.08	235.12	1.20	-412.14	3.09	1.15	-69.34
12	G14	Knolkhol White	6.18	0.93	-0.05	342.28	0.84*	-726.44	261.70	1.03	-150.02	3.51	1.01	-25.01
13	G16	Purple Vienna-II	5.03	1.56	0.06*	326.88	1.30	614.18**	230.50	1.20	204.80*	3.10	1.18	28.75**
14	G17	PusaVirat	4.87	0.61	0.30	234.74	0.60	-94.35	191.48	0.67*	-351.91	2.65	0.72	-61.78
15	G18	White Vienna	5.82	0.84**	-0.06	264.44	0.73	486.94	204.18	0.85	-182.07	2.83	0.90	-20.19
16	G19	Palam Tender Knob	6.24	0.91	-0.03	297.35	0.99	-692.40	239.11	1.02	-494.58	3.40	1.06	-79.58
17	G20	FarashiLajwari Local	4.61	0.94	0.04	260.00	0.74	514.23	201.28	0.82	-342.69	2.76	0.85	-40.55
18	G21	FarashiSafed Local	5.62	1.67	0.46**	324.17	0.93	-555.81	254.22	1.07	-233.69	3.47	1.07	-26.68
19	G23	Baramullah Local	4.66	0.33	0.85**	260.61	0.71	463.87	188.91	0.64	783.32*	2.55	0.64	45.75*
20	G24	Ganderbal Local	4.46	0.55	0.90**	293.50	1.21	-552.24	216.48	1.09	548.84*	2.82	1.01	-11.44
21	G25	Leh Local	5.26	1.29	0.01	247.70	1.01	49.58	184.83	0.92	1.88*	2.57	0.91	-69.53
22	G27	Nawpura Local	4.97	1.65	0.10*	322.28	0.93	665.69	211.34	0.95	30.76	2.79	0.86	-67.27
23	G28	Mamta	5.24	1.46	0.29**	364.96	1.11	-369.26	256.91	1.12	-370.96	3.37	1.07	30.64*
24	G29	Green Gold	6.65	0.82	-0.03	413.78	0.82	-380.67	332.73	0.93	-156.20	4.51	0.87	-23.40
25	G30	C-2002	6.38	0.73**	-0.06	377.53	0.88	95.33	308.06	0.94	-21.79	4.20	0.94	-39.12
		Mean	5.68			322.56			246.31			3.34		

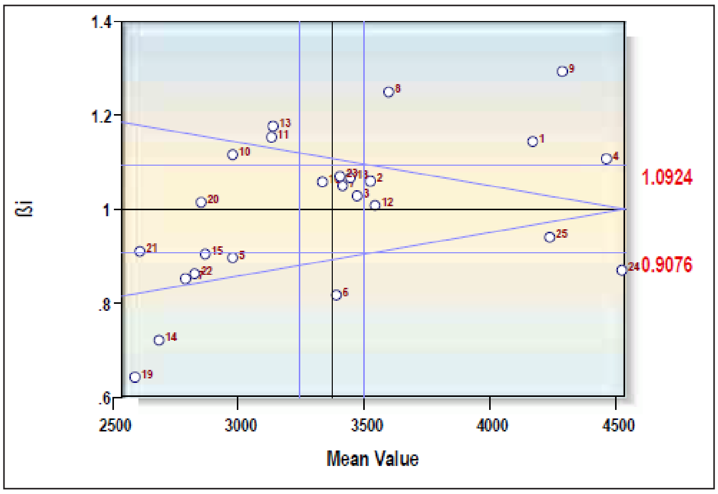
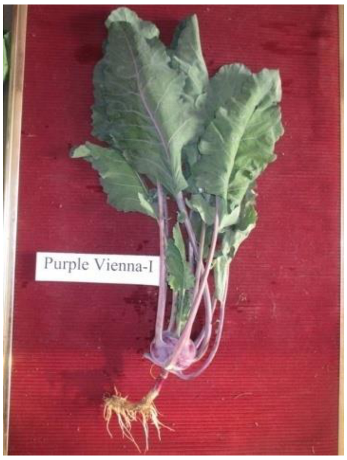
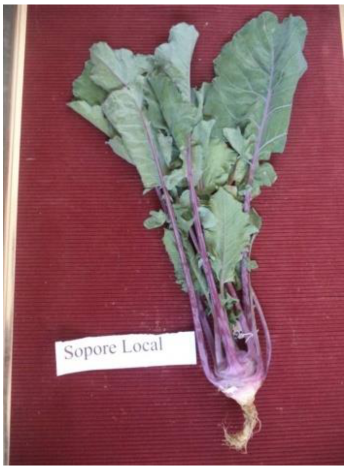


Figure 1: Scatter graph of mean values versus regression coefficient for yield per plot (kg)

S.No.	Stability parameters (μ, b_i and S^2d_i)	Genotypes identified
1	Stable genotypes	SJKK-02 , SJKK-04 , SJKK-03 , SKKK-03 , Early White Vienna ,Knolkhol White and C-2002
2	Genotypes suitable for favourable environments	G-40 and Early Super White Vienna
3	Genotypes suitable for un favourable environments	SKKK-03 and Green Gold





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