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Phenotypic stability of some cultivars for tuber yield of potato (*Solanum tuberosum* L.)

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Abstract
Seven potato cultivars were evaluated for the stability for total and marketable tuber yield during *rabi* seasons of 2014-15 to 2016-17. The experiment was laid out in randomised block design in four replications. Genotype x Environment (G x E) interaction was significant for both the characters. Non-linear component was predominant in G x E interaction for both the characters. The cultivar Kufri Pukhraj had the highest phenotypic index, 'bi' value less than one and non significant S^2di for total tuber yield suggesting its adaptability to poor environment, while for marketable tuber yield S^2di was significant which make it unstable. The cultivar Kufri Khyati showed above average performance with 'bi' value more than one and non significant S^2di for both total and marketable tuber yield suggesting its adaptability to favourable environment only. The high yielding varieties Kufri Badshah and Kufri Pushkar had non significant 'bi' values but the presence of significant deviation from regression renders them unstable for both total and marketable tuber yield.

Keywords: potato, G x E interaction, stability, adaptability

Introduction
Potato (*Solanum tuberosum* L.) is one of the important crops in Gujarat. Tuber yield in potato is influenced by genotype x environment interaction. Therefore, stable genotypes are useful for successful cultivation under a wide range of environments and serve as base materials for the breeding programme. The concept of stability has been defined in different ways and several biometrical methods including univariate and multivariate ones have been developed to assess stability. The most widely used one is the regression method which is based on regressing the mean value of each genotype on the environmental index or marginal means of environments.
A good method to measure stability was previously proposed by Finlay and Wilkinson (1963) and was later improved by Eberhart and Russell (1966). The stability of varieties was defined by high mean yield and regression coefficient (bi = 1.0) and deviations from regression as small as possible ($S^2di=0$). The stability was defined as adaptation of varieties to unpredictable and transient environmental conditions and the technique has been used to select stable genotypes unaffected by environmental changes (Allard and Bradshaw, 1964). A number of stability studies have been carried out on different crop plants (Spaldon *et al.*, 2017). However, stability studies for potato is lacking particularly for Deesa region in north Gujarat. Keeping all these points in consideration the present study was undertaken to assess the phenotypic stability of seven released cultivars of potato.

Material and Methods
The experimental material consisted of seven cultivars of potato released by Central Potato Research Institute (CPRI), Shimla. The cultivars were evaluated in *rabi* seasons during 2014-15, 2015-16 and 2016-17, making three environments. The cultivars were planted in a randomized block design with four replications at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa (Gujarat). The plot size was 9.0 m^2 with row to row and plant to plant spacing of 50cm and 20cm, respectively. Recommended package of practices were followed to raise the crop under mini sprinkler irrigation. The crop was harvested at maturity. The total and marketable (>25g) tuber yield were recorded on plot basis and converted into tonnes per hectare. The stability analysis was carried out as suggested by Eberhart and Russell (1966).

Results and Discussion

The environmental indices (Table 2) showed that *rabi* 2015-16 was most favourable and *rabi* 2016-17 was unfavourable season. The stability analysis of variance (Table 1) showed that variances due to environments (E), genotypes (G) and G x E interaction were significant for both total and marketable tuber yield indicating differential performance of genotypes in different environments. Significant G x E interaction for tuber yield has been reported by Kang and Birhman (1990), Singh *et al.* (1999), Patel *et al*. (2008) and Luthra *et al.* (2009). Highly significant variance due to environment (E) + (G x E) for total and marketable tuber yield indicated variable response of genotypes to changing environments. Highly significant mean squares due to environment (linear) signified unit change in environmental index for each unit change in the environmental conditions. The significance of linear component of G x E interaction indicates the significant rate of linear response of the genotypes to environmental changes for these characters. The non significant effect on pooled deviation for both the characters indicates that linear components of G x E interaction were predominant.

Three parameters of stability: (a) genotypic mean over array of environments (gi) expressed in as phenotypic index (Pi), (b) regression coefficient i.e. linear response (bi) and (c) deviation from linearity (S^2di) of seven cultivars for total and marketable tuber yield are presented in Table 3. The genotypic mean (gi), when expressed as phenotypic index, was the highest for Kufri Pukhraj (Pi = +10.73 & +10.61) followed by Kufri Khyati (Pi = +8.12 & +8.51), Kufri Badshah (Pi = +5.86 & +5.98) and Kufri Pushkar (Pi = +5.53 & +4.41), whereas, it was the lowest for Kufri Bahar (Pi = -14.34 & -13.95) followed by Kufri Jyoti (Pi = -12.34 & -13.02) and Kufri Surya (Pi = -3.42 & -2.53) for total and marketable tuber yield, respectively. Further, regression co-efficient (bi) values of all the cultivars except Kufri Jyoti were non significantly differed from unity for both the characters which inferred that most of a the cultivars tested were average in stability. Kufri Jyoti (bi = -0.11 & -0.26) specifically stable in poor environment for both total and marketable tuber yield. The 'bi' value of Kufri Pukraj was less than one for both the characters indicated its adaptability in poor environment, whereas, Kufri Khyati, Kufri Badshah and Kufri Pushkar exhibited tendency to yield better in favourable environments as their 'bi' values were more than one. The deviation from regression (S^2di), third stability parameter was non significant for Kufri Jyoti, Kufri Bahar and Kufri Khyati for both total and marketable tuber yield, while, for Kufri Pukhraj, it was non significant only for total tuber yield.

Cultivar Kufri Pukhraj had the highest phenotypic index (Pi = +10.73 & +10.61), average response (bi = 0.78 & 0.73) and non significant S^2di for total tuber yield suggesting its adaptability to poor environment, while for marketable tuber yield S^2di was significant which make it unstable. The cultivar Kufri Khyati showed above average performance (Pi = +8.12 & +8.51) with average response (bi = 1.30 & 1.30) and non significant S^2di for both total and marketable tuber yield, respectively, suggesting its adaptability to favourable environment only. The high yielding varieties Kufri Badshah and Kufri Pushkar had non significant 'bi' values but the presence of significant deviation from regression render them unstable for both total and marketable tuber yield.

Table 1: Analysis of variance for genotype x environment interaction for total and marketable tuber yield of potato

Source	df	Mean sum of square	
		Total tuber yield (t/ha)	Marketable tuber yield (t/ha)
Genotypes (G)	6	306.96**	305.43**
Environments (E)	2	362.01**	331.42**
G x E	12	30.19*	29.29*
E + (G x E)	14	77.60**	72.46**
E (Linear)	1	724.03**	662.84**
G x E (Linear)	6	52.11**	50.10**
Pooled deviation	7	7.09	7.28
Pooled error	54	13.00	13.93

*, **Significant at 5% and 1% levels, respectively

Table 2: Environments and environmental indices

Environment	Year	Environmental index	
		Total tuber yield (t/ha)	Marketable tuber yield (t/ha)
1	2014-15	+2.70	+2.68
2	2015-16	+5.45	+5.14
3	2016-17	-8.15	-7.82

Table 3: Stability parameters for total and marketable tuber yield of potato

Cultivars	Stability parameters					
	Total tuber yield (t/ha)			Marketable tuber yield (t/ha)		
	Mean gi (Pi)	Regression coefficient (bi)	Deviation from linearity (S^2di)	Mean gi (Pi)	Regression coefficient (bi)	Deviation from linearity (S^2di)
Kufri Jyoti	35.26 (-12.34)	-0.11*	-2.72	32.36 (-13.02)	-0.26*	-2.72
Kufri Bahar	33.26 (-14.34)	0.84	0.75	31.43 (-13.95)	1.07	-0.90
Kufri Badshah	53.31 (+5.71)	1.60	5.56**	51.36 (+5.98)	1.65	4.62**
Kufri Pushkar	53.13 (+5.53)	2.04	18.92**	49.79 (+4.41)	1.92	17.14**
Kufri Surya	44.18 (-3.42)	0.56	7.39**	42.85 (-2.53)	0.59	8.33**
Kufri Khyati	55.72 (+8.12)	1.30	-1.07	53.89 (+8.51)	1.30	-0.96

Kufri Pukhraj	58.33 (+10.73)	0.78	-0.19	55.99 (+10.61)	0.73	2.70*
Mean	47.60	1.00		45.38	1.00	
S.E. ±	1.88	0.26		1.91	0.28	

Pi= Phenotypic index expressed as deviation of genotypic mean (gi) from general mean
*, **Significant at 5% and 1% levels, respectively

Conclusion
It is concluded that, under north Gujarat condition, Kufri Pukhraj has good adaptability in poor environment, while, Kufri Khyati adapted to favourable environment only. The cultivars Kufri Badshah and Kufri Pushkar were unstable in their performance over the years.

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