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Genotype × Environment Interaction and Stability Analysis of *Kharif* Potato in Koraput Region of Odisha, India

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A B S T R A C T

The present investigation was conducted during *kharif* seasons of 2014 and 2015 over four different environments to study stability analysis in potato during *Kharif* season in Koraput region of Odisha. The field study was laid out in randomised block design in three replications. The 16 genotypes used in the study included released varieties, hybrids of potato belonging to *Solanum tuberosum* sub sp. *Tuberosum*. Of the 16 varieties evaluated; Kufri Lalit, Kufri Lalima, Kufri Pukhraj and Kufri Jyoti showed better adaptability for yield/plant and marketable yield. As per the stability criteria of Eberhart and Russell (1966) for yield/plant and marketable yield, Kufri Jyoti and Kufri Ashok and Kufri Khyati were stable in all the locations. The mentioned varieties can be recommended to farmers for cultivation for off-season potato in Koraput region. The information obtained from the present study could be exploited in breeding programmes to develop superior genotypes for off-season potato cultivation in the region.

Introduction

Information about phenotypic stability is useful for the selection of crop varieties as well as for future breeding programs. The phenotypic performance of a genotype is not same under diverse agro-ecological conditions (Ali *et al.,* 2003). Some genotypes may perform well in certain environments, but, fail in several others. Genotype-environment (GE) interactions are extremely important in the development and evaluation of plant genotypes because they reduce the genotypic-stability values under diverse environments (Hebert *et al.,* 1995). 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 (Lin *et al.,* 1986; Becker and Leon, 1988). 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 (Tesemma *et al.,* 1998; Nagraja *et al.,* 2017).

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 *kharif* season potato is lacking particular for Koraput region in southern Odisha. Keeping all these points in consideration a study was planned with the objective to evaluate the yield of promising potato genotypes in different environments in Koraput region and to determine their stability.

Materials and Methods

The Koraput region of Odisha comprises amalgamation of hills in Eastern Ghats with an altitude of 950m. Climate of the study area was sub-tropical and sub-humid type with mean annual maximum and minimum temperature of 30.6 and 17.0 °C, respectively. Mean annual rainfall of the area is 1450mm, of which 80% is received during June to October. The rainfall data during the experimental period of year 2014 and 2015, recorded at the meteorological observatory of respective block office is presented in table 1. The effective rainfall during the period indicates the difference between rainwater and evapotranspiration. The 16 genotypes used in the study included released varieties, hybrids and exotic variety Atlantic released in USA belonging to *Solanum tuberosum* sub sp. *Tuberosum* (Table 2). Varieties for the study were obtained from the AICRP on potato centre -OUAT, Bhubaneswar. The genotypes were evaluated under four environments *i.e.* instructional farm of KVK-Semiliguda, villages: Luhaba (Semiliguda block), Muliaput (Nandapur block) and Jhaliaguda (Jeypore block) during *kharif* season of 2014 and 2015. The four locations were diverse in climate and altitude having scope of off-season potato cultivation. To analyze the soil properties representative soil samples were taken and analysis was done for evaluating the physico-chemical properties (Table 3) of the locations. The data indicates moderate levels of organic carbon and potassium and low available phosphorus. Each trial was laid out in a randomized complete block design with three replications. Each genotype in a replication was planted in a row spaced at 20cm within rows and 60cm between rows. Fertilization, weeding, other cultural practices and need based plant protection measures were followed as recommended for *kharif* season cultivation. Pooled stability analysis over all environments was done by following Eberhart and Russell (1966). The stability of genotypes in terms of 3 parameters namely, genotypic mean (gi), regression coefficient (bi) and deviation from the regression (s^2di) was analysed. According to this model, an ideal or most stable genotype is the one having high mean performance, unit regression and no/minimum deviation from regression.

Results and Discussion

The analysis of variance revealed that mean sum of squares (MSS) due to genotypes (G) and environments (E) was highly significant (at 1%) for both the characters (Table 4). The high significance levels of different traits of potato under pooled variance analysis indicate the presence of substantial variation among the genotypes over environments. However MSS of G×E interaction was significant for marketable yield only. This indicates that the trait differed between planting environment and genotypes. The significance of linear component of G×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 most of the characters indicates that linear component of G×E interaction was predominant. The MSS of

environment (linear) was highly significant (1% probability level) for both the characters.

Significant G×E interaction for different characters indicate that genotypes under different environments behaved differently for the expression of characters of interest. The high significance of MSS (linear) indicates that environmental effects are additive. For pooled variance analysis similar results are reported by Patel *et al.,* (2008), Luthra *et al.,* (2009) for potato. Since the GXE interactions were found significant for both characters of *kharif* potato hence the data of the characters were subjected to stability analysis. Significant differences were noticed in yield/plant across the four locations as environment index showed wide variations. Highest yield/plant and marketable yield was exhibited by the plants grown at Nandapur location with environmental index values 9.18 to –12.08 and 3.14 and -6.54, respectively (Fig. 1 and 2).

Stability parameters for yield/plant is depicted through mean, regression and standard deviation in table 5 and presented in figure 3. Out of 16 tested genotypes only 7 genotypes exhibited greater mean value than population mean (167.6 g/plant). Out of these 7 genotypes Kufri Pukhraj had significant deviation from regression. The prominent high yielding varieties were Kufri Chipsona 3 (178g), Kufri Ashok (173g), and Kufri Lalit (175g). Minimum yield/plant was recorded in Kufri Arun (145g). As per the stability criteria of regression approaching 1, only Kufri Jyoti reached to a value of 0.76. This was closely followed by Kufri Ashok with regression value of 1.16. Kufri Jyoti and Kufri Ashok showed stability in all the environments. Three genotypes, Kufri Kanchan, Kufri Chipsona 1 and Kufri Chandramukhi showed regression coefficient spinning to 1, but the mean values were less than population mean. Hence the genotypes were classified as poorly adapted to all environments. Processing variety Kufri Chipsona 1 with unity regression coefficient along with low mean values displayed average adaptability to all the environmental conditions. The set of genotypes of Kufri Lalima, Kufri Pukhraj, Kufri Lalit, and Kufri Chipsona 3 were found better adapted to unfavourable locations. Similar results for yield/plant were reported by Haydar *et al.,* (2009).

Marketable yield showed wide variation in output under different environment locations and recorded the mean value was 93.3 q/ha (Table 5 and Fig. 4). Eight genotypes showed higher marketable yield over population mean while 8 were below the population mean. A total of six varieties had high mean values for marketable yield with significant regression coefficient value and non-significant deviation from regression. Kufri Pukhraj and Kufri Jyoti had maximum mean value of 107.4 q/ha and 107.3 q/ha respectively, while Kufri Arun had least mean value (69.2 q/ha).

Table.1 Crop duration and rainfall details

Location	Block	Crop duration (Days)		Total rainfall		Effective rainfall	
		2014	2015	2014	2015	2014	2015
KVK– I. Farm	Semiliguda	90	88	1324	780	617	394
Luhaba	Semiliguda	92	89	1266	798	625	391
Muliaput	Nandapur	91	90	1168	481	591	316
Jhaliaguda	Jeypore	89	92	1409	1090	598	453

Table.2 Details of genotypes analysed for stability analysis

Sl. no.	Genotype	Year of release	Parents
1.	Kufri Jyoti	1968	3069D(4) × 2814 A(1)=SLB-Z389(B)
2.	Kufri Chandramukhi	1968	SD.4485 × K. KUBER= A2708
3.	Atlantic	1978	WAUSEON × USDA B5141-6
4.	Kufri Badshah	1979	JYOTI × ALKR=JF4870
5.	Kufri Bahar	1980	K RED × GINEKE=E3797
6.	Kufri Lalima	1982	K RED × AG14(WISX37=BS/C-1753
7.	Kufri Ashok	1986	EM/C-1021 × CP1468
8.	Kufri Pukhraj	1998	CRAGS DEFIANCE × JE×/B-687JE×/C166
9.	Kufri Chipsona-1	1998	MP/90-83=CP2416 × MS/78-79
10.	Kufri Kanchan	1999	SLB/Z-405 × PIMPERNEL
11.	Kufri Arun	2005	MS/92-2105=K LALIMA × MS-82-797
12.	Kufri Pushkar	2005	QB/A-9-120 × CB-1462
13.	Kufri Lalit	2006	85-P-670 × CP 192
14.	Kufri Surya	2006	CP-3098 × MS/90-512
15.	Kufri Chipsona-3	2006	KCHIPS 2 × MP/91-86
16.	Kufri Khyati	2008	MS/82-638 × K. PUKHRAJ

Table.3 Site description and details of soil properties

Location	Block	Texture	pH	EC (dSm^{-1})	OC (%)	P ($kgha^{-1}$)	K ($kgha^{-1}$)
KVK– I. Farm	Semiliguda	Gravel loamy	6.1	0.25	0.68	15.4	250
Luhaba	Semiliguda	Loamy	5.7	0.31	0.79	12.9	364
Muliaput	Nandapur	Fine loamy	6.3	0.24	0.89	13.0	205
Jhaliaguda	Jeypore	Clayey skeletal	7.5	0.35	0.71	16.2	231

Table.4 Mean Squares due to different source of variation for various quality traits in Potato (*Solanum tuberosum* L.)

Source of variation	dof	Yield/plant (g)	Marketable yield (q/ha)
Genotype	15	496.9**	552**
Environment	3	1278**	321**
Genotype ×Environment	45	52.0	13.2*
Environment (Linear)	1	3834**	963.8**
Environment ×Genotype (Linear)	15	80.60**	18.94**
Pooled error	120	20.01	7.96
Pooled deviation	32	35.35	9.70
*significant at 5% level of significance ** significant at 1% level of significance			

Table.5 Mean value, regression coefficient (bi) and variation due to deviation (s^2di) for 16 potato genotypes

Genotypes	Yield/plant			Marketable yield (q/ha)		
	Mean	bi	S^2di	Mean	bi	S^2di
Kufri Kanchan	165	0.90**	-33	86.4	1.19*	18.40
Kufri Pukhraj	177	0.30	125*	107.4	0.31	8.96
Kufri Chipsona 3	178	0.32**	-40	102.6	0.77*	1.38
Kufri Badshah	152	0.70**	-25	79.8	0.95**	-6.57
Kufri Arun	145	1.58**	-3	69.2	0.85**	-7.85
Kufri Ashok	173	1.15**	-9	105.4	0.92**	-5.50
Kufri Chipsona 1	162	1.06**	-12	87.3	1.46**	-4.67
Kufri Puskar	157	1.82**	-19	95.2	2.65**	14.72
Atlantic	164	2.14**	7	85.7	1.60**	-5.68
Kufri Lalima	175	0.53**	-32	104.1	0.49	3.11
Kufri Bahar	165	1.54**	40	87.3	0.97	20.84
Kufri Lalit	181	0.20	-24	104.2	0.43	-1.63
Kufri Khyati	181	0.53**	-40	102.5	0.67*	1.04
Kufri Chandramukhi	157	0.98**	-36	81.9	0.77**	-6.94
Kufri Surya	167	1.48**	-40	86.4	1.17**	-7.22
Kufri Jyoti	182	0.76*	1	107.3	0.79*	5.51
Population mean	167.6			93.3		

*significant at 5% level of significance
** significant at 1% level of significance

Figure.1 Linear regression of yield/planton environment indices showing different genotypes

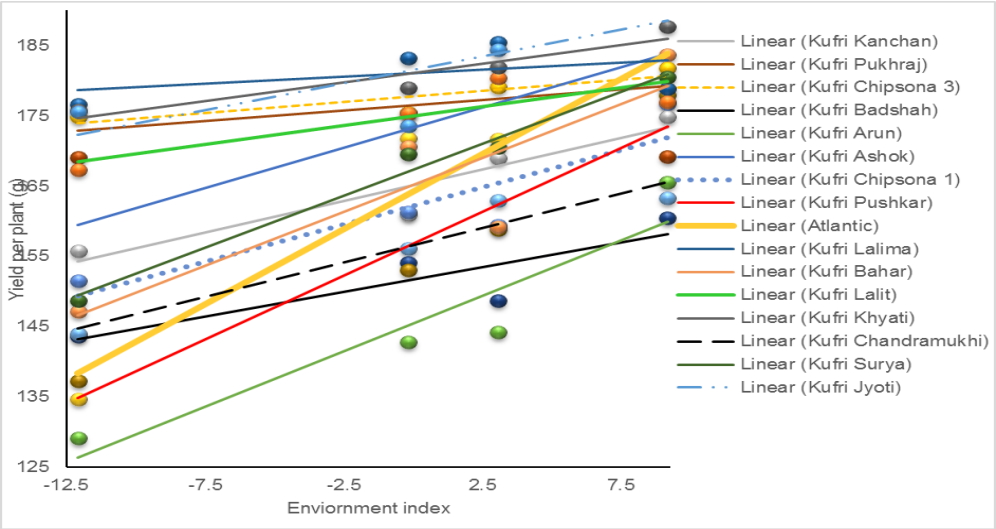


Figure.2 Linear regression of marketable yield on environment indices showing different genotypes

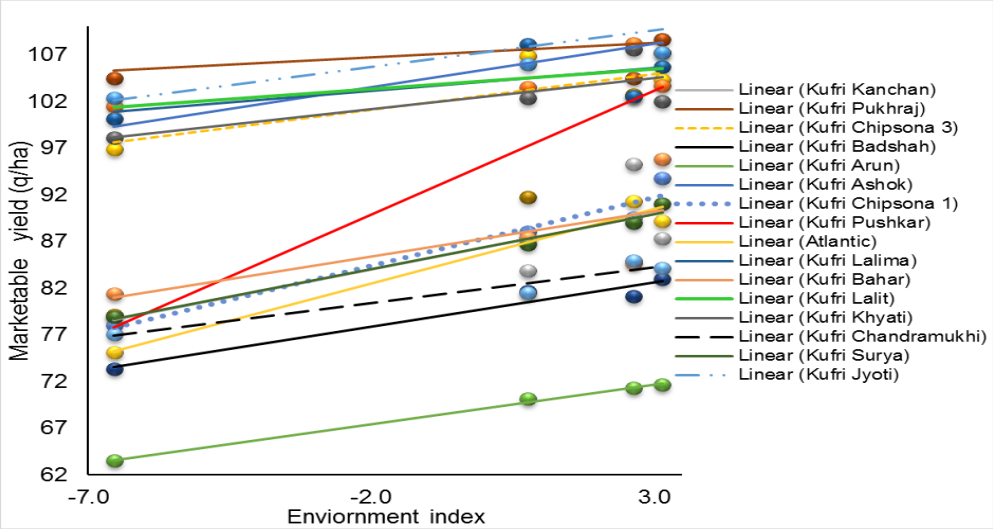


Figure.3 Relationship between regression coefficients and mean yield/plant for 16 potato genotypes

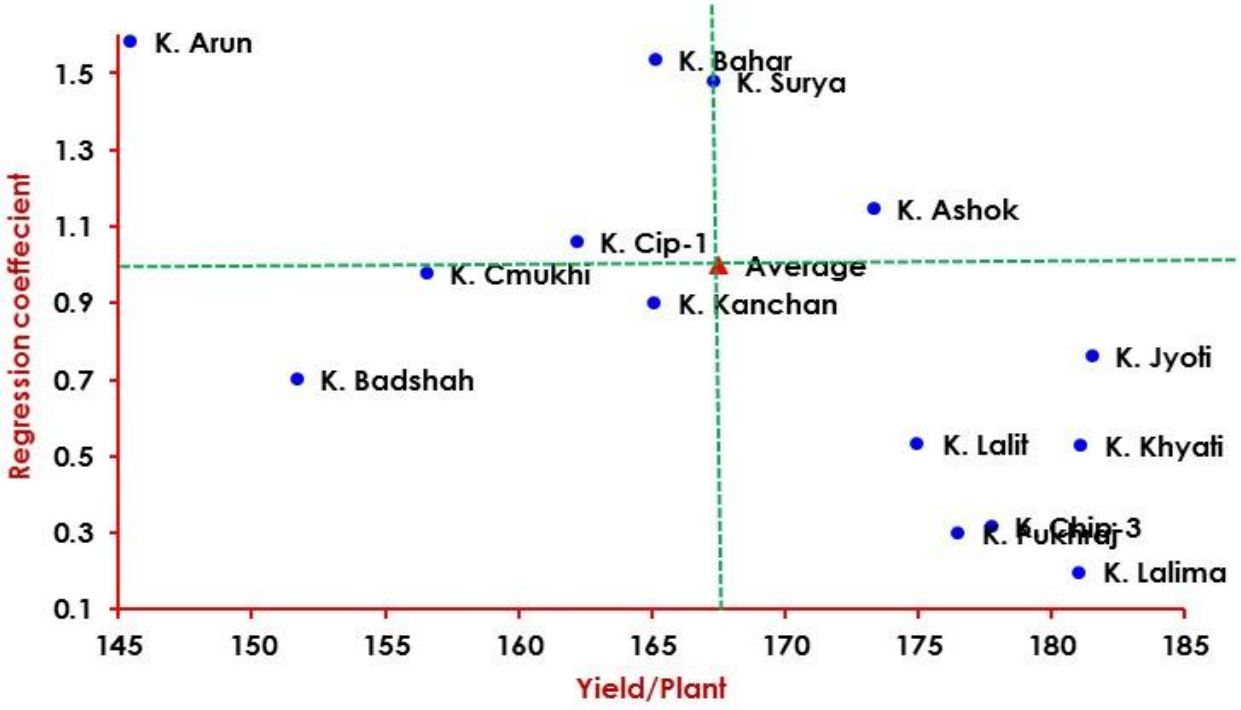
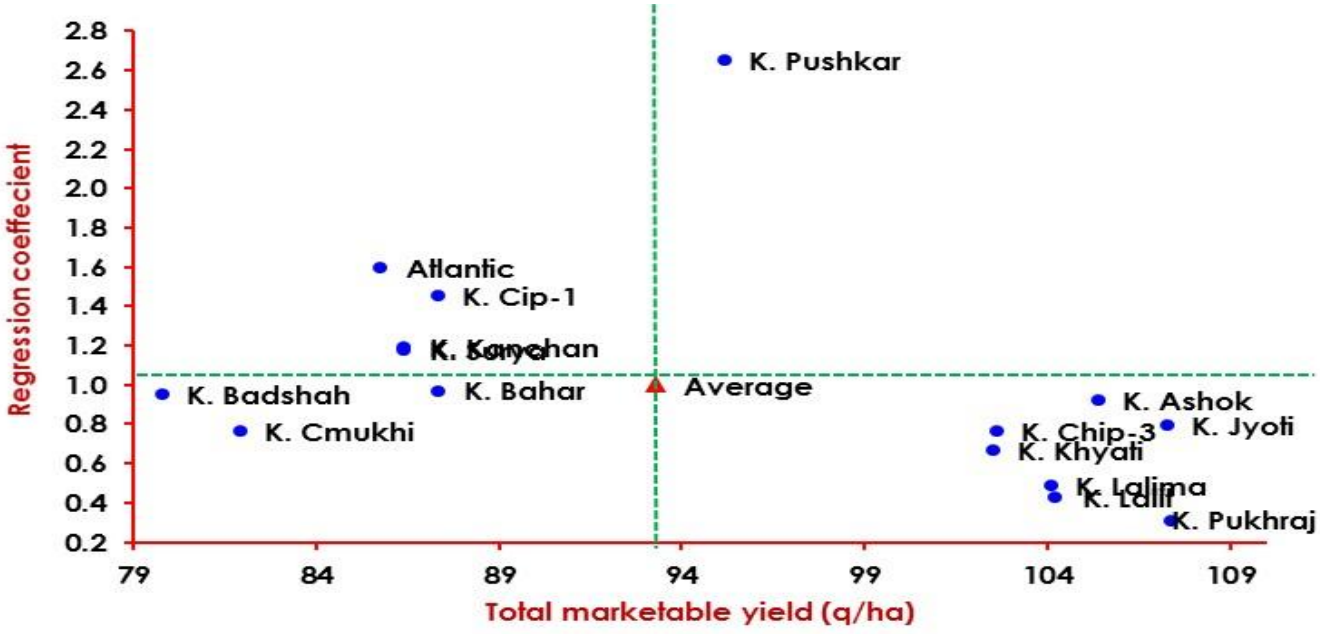


Figure.4 Relationship between regression coefficients and mean marketable yield for 16 potato genotypes



For regression coefficient the genotypes Kufri Lalima, Kufri Pukhraj, Kufri Lalit remained non-significant while Kufri Khyati, Kufri Jyoti, Kufri Chipsona 3 and Kufri Kanchan showed significance at 5% probability level. The regression coefficient of Kufri Ashok, Kufri Chipsona 3, Kufri Jyoti, Kufri Bahar, Kufri Badshah and Kufri Surya was entangled approximately to 1. This signs their adaptability to all the 4 locations. Similar results for Kufri Lalit, Kufri Jyoti and Kufri Chipsona 3 at Meerut were reported by Singh *et al.*, (1999) in an assessment of 24 potato genotypes. While Kufri Surya and Kufri Chandramukhi with lower mean than population mean and regression coefficient approaching unity are considered as genotypes poorly adapted to all the environments. Kufri Bahar with lower mean yield than the population mean and unit regression coefficient was registered as unstable for all the environments. Kufri Lalima, Kufri Khyati and Kufri Pukhraj showed regression coefficient less 1 than but mean greater than population mean. Hence these genotypes were classified as specifically adapted to poor (unfavourable) environments. Remaining genotypes marketable yield values deviated significantly from regression hence found unstable over all location for *kharif* cultivation.

Adaptability is the result of homoeostasis which refers to the buffering capacity of a genotype to environmental fluctuation. Genetically homogeneous populations such as pure line varieties depend heavily on individual buffering to stabilise productivity (Allard and Bradshaw, 1964). General adaptability of Kufri Lalima, Kufri Pukhraj, Kufri Lalit, Kufri Khyati, Kufri Jyoti and Kufri Ashok to different locations might be ascribed to their greater individual buffering ability. Of the 16 varieties evaluated; Kufri Lalit, Kufri Lalima, Kufri Pukhraj and Kufri Jyoti showed better adaptability for both the characters. Based on the yield/plant and marketable yield the mentioned varieties can be recommended to farmers for cultivation for off-season potato cultivation in Koraput region.

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