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GENETIC VARIABILITY AMONG GENOTYPES AND CHARACTER ASSOCIATION IN *KHARIF* POTATO (*SOLANUM TUBEROSUM* L.) FOR DIFFERENT TRAITS

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ABSTRACT
A study was conducted during *kharif* season of 2014 and 2015 to estimate the genetic variability, heritability, genetic advance and correlation among 16 genotypes of potato (*Solanum tuberosum* L.) under rainfed conditions. Potato genotypes were evaluated for different growth parameters, yield attributes and yield characters. Statistical analysis for days to 50% flowering indicated significant variation among tested genotypes and Kufri Badshah recorded maximum value (43 days). Maximum number of tubers/plant were recorded in Kufri Ashok (7.81), which was statistically at par with genotypes Kufri Lalima, Kufri Pukhraj and Kufri Lalit. In terms of marketable yield, Kufri Pukhraj gave maximum yield of 107.4q/ha which was closely followed by Kufri Jyoti (107.3q/ha). Out of 18 parameters, eight parameters showed heritability >90%. High heritability coupled with high genetic advance was observed for leaflets/plant, leaf area, total tuber yield and marketable yield. Marketable yield had positive significant correlation with all the parameters except for plant height at 30 days after planting and tuber length width ratio. The high phenotypic and genotypic correlation was obtained for tubers/plant (0.953 and 0.922), total tuber yield (0.935 and 0.922). The study showed sufficient genetic variability among genotypes which can be exploited in future breeding programmes which would be effective in boosting *kharif* potato cultivation in Koraput region of Odisha.

INTRODUCTION

Potato is one among the most important horticultural crops in India. Potato is an Andean tuber crop that was originally domesticated in South America and its worldwide dissemination started in 16th century. Potato is major tetraploid species of Solanaceae family (night shade family). Global production of potato has crossed 370mt (FAOSTAT, 2016) and China leads the world. Nearly a third of world's potato is harvested from China (95mt) and India holds the second rank with a share of 11.3% (46mt). In Odisha state of India, potato is cultivated in an area of 15,810 ha area with a production of 2.69 lakh tonnes, accordingly average productivity is only 17.02 t/ha which is far below the national average (Horticulture Statistics, 2016). This is despite the fact that the state is blessed with good edaphic and climatic conditions for potato cultivation, whereas the average productivity of its neighbouring states like West Bengal and Bihar is much higher.

The performance of any crop or variety largely depends on genotypic and environmental interactions. As a result, cultivars which perform well at one region may not show same performance in other region of varying climatic condition. Therefore, it is necessary to evaluate the available germplasm to find out the most promising genotypes suitable for cultivation. The extent of genetic variability is of paramount importance for the improvement of a crop, as greater is the genetic variability in the existing germplasm better would be the chances of selecting superior genotypes (Vavilov 1951). Variability in the available cultivars may be due to the difference either in genetic constitution of cultivars or in the environments in which they grow (Sestra *et al.* 2007, Janaki *et al.*, 2015).

Potato is a vegetative propagated crop and selection is an easy method for improvement programme. Selection is effective only when the observed variability in the population is heritable in nature. As breeders are always interested in the improvement of several economic characters together, the knowledge of correlation among the traits is important to have the idea of concurrent changes which would be brought about in other traits while making selection for one trait (Bhatia, 2004; Kadwey *et al.*, 2015). The nature and the extent of association among the traits is of great importance for planning an efficient breeding programme (Panwar *et al.*, 2012). Keeping all the above facts in consideration, the present study was conceived and conducted with the aim to assess the performance of different genotypes and identify the most suitable for *kharif* cultivation and to ascertain the extent of genetic variability, heritability, genetic advance as well as to establish correlation among different traits.

MATERIALS AND METHODS

The Koraput region of Odisha comprises of amalgamation of hilly region of Eastern ghat highland zone. Climate of the study area was sub-tropical and sub-humid type with mean annual

maximum and minimum temperature of 30.6 and 17.0ºC, respectively. Night temperature dipping below 20ºC is conducive for tuberization. Mean annual rainfall of the area is 1450 mm, 80% of which is received during June to October. Hence the area and the climate offers enough scope for *kharif* cultivation of potato.

The 16 genotypes used in the study included released varieties and hybrids of potato belonging to *Solanum tuberosum* sub sp. *tuberosum*. These were evaluated during *kharif* season in 2014 and 2015. 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 row) and 60cm between rows. Fertilization, weeding, cultural practices and need based plant protection measures were followed as recommended for *kharif* season cultivation. The observations were recorded for quantitative characters namely shoots/plant, plant height (cm) 30 and 60 days after planting (DAP), leaflets, leaf area (cm^2), tuber number/plant, average tuber weight (g), tuber dry matter (%), total tuber yield (q/ha) and marketable tuber yield (>20 g tuber) q/ha. Tuber dry matter was estimated by oven drying 100g of chopped tubers to a constant weight at 105°C from composite samples drawn immediately after harvest. The data was recorded on five randomly selected plants from each replication. The recorded data was pooled and statistically analysed using the OPSTAT statistical package. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variability (PCV) were calculated by using formulae suggested by Singh and Choudhary (1997). Heritability in broad sense and expected genetic advance (GA) as percent of mean was calculated according to the formula suggested by Allard Bradshaw (1964). The correlation coefficient was estimated from analysis of variance for all the characters.

RESULTS AND DISCUSSION

Growth parameters

Potato genotypes under *kharif* season cultivation exhibited significant differences for different growth parameters (Table 1). Maximum number of shoots/plant were observed in Kufri Lalima (3.18) which was statistically at par with Kufri Pukhraj (3.17), Kufri Lalit (3.06), Kufri Khyati (3.09) and Kufri Jyoti (3.09). Whereas lowest value for shoots/plant (1.94) was recorded for Kufri Arun which was statistically at par to Kufri Chipsona 1 and Atlantic. The reason attributed for less number of shoots in Kufri Arun and exotic variety 'Atlantic' is poor germination *vis-a-vis* plant establishment leading to lower shoots/plant. Plant height values specifies that Kufri Chipsona 3 recorded tallest plants with values 34.0cm and 44.5cm for 30 and 60 DAP respectively closely followed by Kufri Chipsona 1 (32.3 and 43.3cm). Kufri Khyati and Kufri Lalima showed significant improvement and a quantitative jump (50% increase) from 30 to 60 DAP in 30 days duration. As the above mentioned genotypes are processing varieties the physiological growth and expansion takes place at an early stage followed by early bulking. Kufri Chipsona 3 showed its supremacy in number of leaflets/plant too by registering maximum value (233). On other hand, Kufri Atlantic, Kufri Bahar and Kufri Kanchan registered fewer leaflets (115, 114 and 116, respectively). Leaf area of Kufri Lalit logged maximum value of 111cm^2 which was statistically at par with Kufri Lalima (109.1cm^2) and Kufri Pukhraj (108.1cm^2). Exotic variety 'Atlantic' performed poorly with a meagre leaf area of 63.2cm^2. Availability of moisture through rainfall ensured good growth and height in medium duration varieties *viz*. Kufri Chipsona 3 and Kufri Chipsona 1. Joseph *et al.* (2005) and Panda (2015) observed similar results for different growth parameters with mentioned varieties.

Statistical analysis for days to 50% flowering indicated significant variation among tested genotypes with Kufri Badshah recorded maximum values of 43 days. This was closely followed by, Atlantic, Kufri Surya, Kufri Jyoti , Kufri Kanchan (all 42 days) and Kufri Pushkar (41 days) all being statistically at par. While minimum time taken for 50% flowering was 36 days for genotypes Kufri Pukhraj. This was statistically at par to Kufri Lalima and Kufri Khyati both recorded 37 days for 50% flowering. Based on the days taken for senescence,

Table 1: Mean performance of potato genotypes for different growth traits in *kharif* cultivation (Mean of 2014 and 2015)

Genotypes	SP	PH 30	PH 60	LTS/P	LA	DF-50	DSEN	TDM	T/P
Kufri Kanchan	2.15	28.7	40.4	116	66.7	42	81	16.2	5.11
Kufri Pukhraj	3.17	30.4	41.6	141	108.1	36	73	16.5	7.66
Kufri Chipsona 3	3.01	34.0	44.3	233	103.5	40	83	20.8	7.61
Kufri Badshah	2.42	29.9	39.3	122	70.0	43	83	16.0	5.49
Kufri Arun	1.94	29.7	39.4	139	64.6	40	76	15.0	4.93
Kufri Ashok	2.91	29.0	40.8	143	103.1	37	75	17.5	7.81
Kufri Chipsona 1	2.06	32.3	43.3	173	98.9	43	84	20.3	5.73
Kufri Puskar	2.70	29.1	39.8	125	68.7	41	80	16.0	6.43
Atlantic	1.97	28.7	39.2	115	63.2	42	81	16.2	5.15
Kufri Lalit	3.06	31.5	39.8	143	111.3	37	85	17.6	7.63
Kufri Bahar	2.38	28.3	37.0	114	67.6	40	79	16.0	4.95
Kufri Lalima	3.18	31.5	42.1	152	109.1	37	78	18.0	7.75
Kufri Khyati	3.09	29.3	41.4	143	101.0	37	75	17.6	7.56
Kufri Chandramukhi	2.36	31.9	39.8	130	90.3	38	77	18.1	5.37
Kufri Surya	2.49	30.0	40.2	126	89.4	42	78	16.1	5.94
Kufri Jyoti	3.09	31.2	39.7	148	103.7	42	83	17.0	7.58
S Em +	0.05	0.77	0.93	5.28	1.80	1.03	1.14	0.36	0.10
CD at 5%	0.15	2.24	2.68	15.3	5.23	3.01	3.30	1.05	0.31

SP- Shoots/ Plant, PH-30- Plant height (cm) 30 days after planting, PH-60- Plant height (cm) 60 days after planting, LTS/P- Leaflets/plant, LA- Leaf area (cm^2), DF-50- Days to 50 % flowering, DSEN Days to senesense TDM- Tuber dry matter (%),T/P- Tubers/ plant.

Table 2: Mean performance of potato genotypes for different yield traits in *kharif* cultivation (Mean of 2014 and 2015)

Genotypes	TL	TW	TC	TLWR	SGY	ATW	Y/P	TTY	MY
Kufri Kanchan	4.11	3.20	9.34	1.29	1.090	23.8	165	107.5	86.4
Kufri Pukhraj	4.97	3.74	12.3	1.34	1.083	28.6	177	127.8	107.4
Kufri Chipsona 3	4.72	3.33	11.6	1.42	1.082	24.7	178	120.0	102.6
Kufri Badshah	4.61	3.24	11.6	1.44	1.088	24.5	152	100.5	79.8
Kufri Arun	4.23	3.02	11.1	1.42	1.068	22.8	145	84.2	69.2
Kufri Ashok	4.93	3.27	12.0	1.52	1.079	25.7	173	121.5	105.4
Kufri Chipsona 1	4.10	3.04	11.1	1.37	1.069	22.7	162	102.8	87.3
Kufri Puskar	4.60	3.18	11.8	1.47	1.080	24.9	157	109.3	95.2
Atlantic	3.87	2.97	11.3	1.31	1.069	23.7	164	106.7	85.7
Kufri Lalit	4.71	3.59	12.4	1.33	1.083	28.0	175	127.3	104.2
Kufri Bahar	4.18	3.22	11.4	1.30	1.069	22.6	165	106.8	87.3
Kufri Lalima	4.75	3.89	13.2	1.23	1.091	27.7	181	133.2	104.1
Kufri Khyati	4.81	3.42	12.3	1.44	1.079	26.3	181	126.3	102.5
Kufri Chandramukhi	4.56	3.23	11.4	1.42	1.078	24.9	157	102.9	81.9
Kufri Surya	4.35	3.32	8.24	1.32	1.077	22.8	167	107.6	86.4
Kufri Jyoti	4.77	3.28	12.1	1.47	1.079	28.9	182	127.5	107.3
S Em +	0.10	0.09	0.16	0.06	0.016	0.39	3.86	1.88	1.39
CD at 5%	0.29	0.28	0.46	0.17	NS	1.09	11.2	5.46	4.04

TL- Tuber length (cm), TB- Tuber width (cm), TC- Tuber circumference (cm), ATW- Average tuber weight (g), TLWR- Tuber length width ratio, SGY- Specific gravity, TTY- Total tuber yield (q/ha), MY- Marketable yield (q/ha), YP- Yield/ Plant (g)

Table 3: Variability parameters for different traits in *kharif* potato

Characters	Std. deviation	Std.error	Variance	Range		Mean	CV (%)
				Min.	Max.		
Shoots/plant	0.45	0.11	0.21	1.94	3.18	2.62	17.33
Plant height (cm) 30 DAP	1.59	0.40	2.53	28.25	33.9	30.33	5.24
Plant height (cm) 60 DAP	1.79	0.45	3.19	37.00	44.5	40.52	4.41
Total leaflets/ plant	29.00	7.25	841	114	232	141	20.50
Leaf area (cm^2)	18.48	4.62	341	63.20	111	88	20.84
Tubers/plant	1.19	0.30	1.41	4.93	7.81	6.42	18.50
Tuber dry matter (%)	1.59	0.40	2.52	14.96	20.79	17.18	9.24
Average tuber weight (g)	2.17	0.54	4.73	22.61	28.90	25.17	8.64
Total tuber yield (q/ha)	13.38	3.35	179	84.22	133	113	11.80
Marketable yield (q/ha)	11.75	2.94	137	69.17	107	93.3	12.60
Yield/plant	11.15	2.79	124	145	181	167	6.65
Days to 50% flowering	2.34	0.58	5.46	35.96	42.6	39.74	5.88
Days to senescence	3.67	0.92	13.4	72.75	85.0	79.48	4.61
Tuber length (cm)	0.33	0.08	0.11	3.87	4.97	4.52	7.36
Tuber width (cm)	0.25	0.06	0.06	2.97	3.89	3.31	7.58
Tuber circumference (cm)	0.57	0.14	0.32	11.06	13.20	11.77	4.84
Tuber length: width ratio	0.08	0.02	0.01	1.23	1.52	1.38	5.87
Specific gravity	0.01	0.001	0.001	1.07	1.09	1.08	0.68

genotypes can be categorised in to early, medium and long duration for the *kharif* season. Kufri Pukhraj took 73 days to senescence which was minimum among all the genotypes this was closely followed by Kufri Khyati, Kufri Arun, Kufri Ashok and Kufri Chandramukhi. While maximum days to senescence were observed in Kufri Lalit (85 days) closely followed by Kufri Jyoti (83 days) both being statistically at par. Hence Kufri Jyoti and Kufri Lalit can be categorised for long duration genotypes for *kharif* season.

Number of tubers per plant is considered as an important yield attributing trait in determining the yield of a genotype. Maximum number of tubers/plant were recorded in Kufri Ashok (7.81), which was statistically at par with genotypes Kufri Lalima, Kufri Pukhraj, Kufri Lalit, Kufri Jyoti, Kufri Chipsona 3 and Kufri Khyati. While minimum tubers/plant were observed in Kufri Arun (4.93) and Kufri Bahar (4.95). Being a genetic character the variation in numbers of tubers/plant was limited. Genotypes registered higher values for other growth parameters showed higher tubers/plant. More shoots/plant and leaf area has contributed to more number of tubers/plant (Pandey *et al.,* 2005). Tuber dry matter of processing varieties Kufri Chipsona 3 and Kufri Chipsona 1 registered statistically superior values of 20.8 and 20.3%, respectively. While Kufri Lalima and Kufri Chandramukhi were second for dry matter values of 18.0 and 18.1%, respectively. As the processing varieties are used in making wafers/chips so dry matter content is vital for their size and longer preservation. Consequently higher dry matter was obtained in these genotypes. It also signifies that the good performing genotypes varieties showed resistance to rottage due to rainfall received during *kharif* season. Findings on the yield attributes are corroborative of Kumar and Kang (2000) and Reshi *et al.,* 2013.

Yield traits

For tuber length, maximum value (4.97cm) was recorded for genotype Kufri Pukhraj closely followed by Kufri Ashok (4.93cm) as depicted in table 2. This was followed by genotypes Kufri Khyati (4.81 cm), Kufri Chipsona 3 (4.72cm), Kufri Badshah (4.61cm). Exotic genotype 'Atlantic' recorded minimum tuber length of 3.87cm which was statistically at par to Kufri Bahar (4.18cm) and Kufri Chipsona 1 (4.10cm). Maximum tuber width (3.89cm) was exhibited by genotype Kufri Lalima, closely followed by Kufri Pukhraj (3.74cm) and Kufri Lalit (3.59 cm). Minimum value was observed in Atlantic (2.97 cm) which showed at par performance with Kufri Kanchan (3.20 cm), Kufri Chipsona 1 (3.27 cm), Kufri Lalit (3.59cm) and Kufri Bahar (3.22cm). For tuber circumference, maximum values was in Kufri Lalima (13.2cm) followed Kufri Pukhraj (12.3cm), Kufri Ashok (12.0cm), Kufri Khyati (12.3cm) and Kufri Jyoti (12.1cm). The minimum values for circumference was observed for Kufri Chipsona 1 (11.1cm). Based on the length (L) and width (W) of tubers, the TLWR was computed. Here genotype Kufri Ashok (1.52) registered maximum values which was statistically at par to all other tested genotypes barring Kufri Bahar, Kufri Lalima, and Kufri Surya.

Kufri Jyoti registered maximum value of 28.9g for average tuber weight, followed by Kufri Pukhraj (28.6g) and Kufri Lalit (28.0g). Other good performing genotypes were Kufri Lalima and Kufri Lalit. While Kufri Bahar registered the lowest value of 22.6g for the parameter. Specific gravity parameter showed no significant difference among the tested genotypes. Maximum yield/plant to the tune of 182g was recorded in Kufri Jyoti closely followed by Kufri Lalima and Kufri Khyati (each 181g/ plant) and all the three varieties were statistically at par. Kufri Lalima recorded maximum tuber yield of 133.2q/ha which was statistically superior to all other tested varieties. The present experiment explores the performance of varieties under off-season conditions so the obtained yield are on lower side yet significant in economic terms. Other good performance genotypes were Kufri Lalima, Kufri Lalit and Kufri Khyati due to less rottage and pest attack.

Next rung of genotypes performing well were Kufri Pukhraj (127.8q/ha), Kufri Jyoti (127.5q/ha), Kufri Lalit (127.3q/ha) and Kufri Lalima (133.2q/ha) were statistically at par. So in terms of marketable yield, Kufri Pukhraj gave maximum yield of 107.4q/ ha which was closely followed by Kufri Jyoti (107.3q/ha). Following the trend of total tuber yield, Kufri Arun was poor performer with meagre yield of 69.2q/ha. Kufri Pukhraj yielded maximum due to its ability to bulk tubers in shorter time and yield higher marketable yield even under adverse conditions. Marketable yield signifies marketable tuber > 20g weight out of total yield, rottage and baby tubers are removed. As evident from comparison of yield data, non-marketable yield accounted 18-22% in tested varieties. The reason ascribed is that the crop is raised in off-season (*kharif*) and heavy rainfall during the late stage of the crop growth affected marketable yield.

Variability parameters

Variability prevailing in growth, yield attributes, yield and other parameters of *kharif* potato is described through mean, range, standard deviation and CV is presented in table 3. Among different parameters leaflets per plant gave maximum values for standard deviation, standard error and variance to the tune of 29, 7.25 and 841, respectively. This was also reflected in CV which was 20.5 for the said parameter. The range of data distribution was maximum (114 – 232) for leaflets per plant with a mean value of 141. Likewise other parameter; leaf area showed considerable variation in data distribution with standard deviation of 18.48 and variance value 341. The wide variation in range values (63.2-111cm^2) is also reflected in CV values ticking at 18.5. Among the 18 parameters, shoots/plant, leaflets/plant, leaf area, tubers/plant, total tuber yield and marketable yield showed variation of 17.3, 20.5, 20.8, 18.5, 11.8 and 12.6%, respectively. The reason attributed for high variation in shoots/plant, leaflets/plant, leaf area and tubers/ plant is the nature of the characters. There characters are highly variable and considerably influenced by environment, cultural practices and their association with other parameters. Highly stable character like Specific gravity showed no variation as

Table 4: Estimates of genetic parameters for different traits in *kharif* potato

Characters	Heritability (%)	Coefficient of variation (%)		Genetic advance (GA)	G gain
		Genotypic	Phenotypic		
Shoots/plant	96.41	17.43	17.75	0.92	35.25
Plant height (cm) 30 DAP	58.49	5.19	6.79	2.50	8.18
Plant height (cm) 60 DAP	59.93	4.60	5.94	2.99	7.33
Total leaflets/ plant	90.67	20.15	21.16	55.93	39.52
Leaf area (cm^2)	97.41	20.81	21.09	37.55	42.31
Tubers/plant	97.68	18.48	18.69	2.41	37.62
Tuber dry matter (%)	86.13	8.86	9.55	2.91	16.94
Average tuber weight (g)	93.76	9.31	9.61	4.72	18.56
Total tuber yield (q/ha)	94.28	11.70	12.05	26.50	23.39
Marketable yield (q/ha)	95.91	12.50	12.76	23.53	25.22
Yield/plant	71.16	6.28	7.44	18.29	10.91
Days to 50% flowering	57.70	5.28	6.95	3.29	8.26
Days to senescence	75.99	4.41	5.06	6.30	7.91
Tuber length (cm)	76.79	7.00	7.98	0.57	12.63
Tuber width (cm)	65.71	6.99	8.62	0.39	11.67
Tuber circumference (cm)	79.82	4.63	5.19	1.00	8.53
Tuber length: width ratio	25.66	4.21	8.31	0.06	4.39
Specific gravity	92.79	8.87	9.21	4.15	17.61

Table 5: Genotypic (G) and phenotypic (P) correlation coefficient among different traits in *kharif* potato

	r	SP	PH 30	PH 60	LTS	LA	T/P	TDM	ATW	TTY	MY	Y/P	DF-50	DSEN	TL	TB	TD	TLWR
SP	G																	
	P																	
PH 30	G	0.361*																
	P	0.302*																
PH 60	G	0.380**	0.945**															
	P	0.296*	0.618**															
LTS	G	0.389**	0.702**	0.748**														
	P	0.337*	0.531**	0.517**														
LA	G	0.791**	0.408**	0.452**	0.585**													
	P	0.771**	0.293*	0.291*	0.557**													
T/P	G	0.953**	0.419**	0.512**	0.517**	0.874**												
	P	0.922**	0.319*	0.410**	0.488**	0.843**												
TDM	G	0.306*	0.656**	0.676**	0.868**	0.669**	0.437**											
	P	0.288*	0.476**	0.514**	0.775**	0.615**	0.399**											
ATW	G	0.811**	0.207	0.076	0.092	0.692**	0.775**	0.082										
	P	0.757**	0.175	0.069	0.098	0.650**	0.746**	0.069										
TTY	G	0.935**	0.231	0.331*	0.302*	0.797**	0.912**	0.377**	0.776**									
	P	0.877**	0.132	0.212	0.291*	0.768**	0.869**	0.343*	0.736**									
MY	G	0.926**	0.331	0.437**	0.391**	0.794**	0.942**	0.401**	0.735**	0.972**								
	P	0.885**	0.231	0.327*	0.383**	0.774**	0.910**	0.382**	0.707**	0.945**								
Y/P	G	0.883**	0.156	0.290*	0.426**	0.827**	0.879**	0.467**	0.642**	0.967**	0.960**							
	P	0.697**	-0.007	0.143	0.362	0.689**	0.731**	0.411**	0.531**	0.901**	0.823**							
DF-50	G	-0.720**	0.049	-0.073	-0.103	0.855**	-0.683**	-0.119	-0.617**	-0.637**	-0.596**	-0.533**						
	P	-0.525**	-0.19	-0.025	-0.089	-0.495**	-0.524**	-0.044	-0.480**	-0.474**	-0.457**	-0.336*						
DSEN	G	-0.174	0.387**	0.097	0.266	-0.057	-0.102	0.349*	-0.050	-0.054	-0.020	-0.009	0.620**					
	P	-0.128	0.258	0.061	0.201	-0.038	-0.110	0.288*	-0.086	-0.039	-0.044	-0.022	0.596**					
TL	G	0.946**	0.409**	0.393**	0.358*	0.755**	0.917**	0.212	0.851**	0.744**	0.779**	0.617**	-0.746**	-0.350*				
	P	0.814**	0.255	0.251	0.282	0.663**	0.769**	0.200	0.706**	0.642**	0.668**	0.447**	-0.575**	-0.252				
TB	G	0.872**	0.161	0.235	0.195	0.756**	0.774**	0.189	0.766**	0.872**	0.734**	0.762**	-0.845**	-0.314	0.806**			
	P	0.726**	0.182	0.180	0.147	0.592**	0.626**	0.231	0.596**	0.659**	0.581**	0.503**	-0.491**	-0.211	0.539**			
TD	G	0.874**	0.119	0.220	0.115	0.650**	0.822**	0.146	0.829**	0.911**	0.803**	0.805**	-0.776**	-0.238	0.754**	1.014		
	P	0.785**	0.143	0.179	.047	0.595**	0.713**	0.107	0.704**	0.793**	0.695**	-0.211	-0.472**	-0.130	0.615**	0.723**		
TLWR	G	0.222	0.522**	0.354*	0.278	0.075	0.322*	0.050	0.253	-0.144	0.130	-0.080	0.082	-0.085	0.422**	-0.195	-0.299*	
	P	0.076	0.064	0.074	0.119	0.067	0.136	-0.043	0.103	-0.035	0.070	0.637**	-0.087	-0.048	0.462**	-0.490**	-0.109	
SGY	G	0.810**	0.203	0.060	0.092	0.695**	0.779**	0.085	1.008**	0.770**	0.739**	0.637**	-0.618**	-0.0151	0.833**	0.773**	0.810**	0.206
	P	0.754**	0.159	0.041	0.093	0.657**	0.738**	0.050	0.980**	0.739**	0.705**	0.545**	-0.500**	-0.101	0.723**	0.546**	0.698**	0.176

depicted with a range value of 1.07-1.09 and CV 0.68. Considerable variation was observed in yield parameters for which total tuber yield, marketable yield and yield/plant showed the values ranging from 84-133 q/ha, 69-107 q/ha and 145-181 g/plant, respectively. For tuber biometrics, yield attributes and yield parameters; the CV varied between 5 to 10%. Tuber biometrics, days to 50% flowering and days to senescence are genetically stable characters hence did not show much variation. The medium level of variation in yield parameters indicates the characters are influenced by a mix of genetic as well as environmental factors. Wide range of variation in potato relating to component characters has been reported by Ummayiah *et al*. (2010), Khan *et al*. (2011) and Patel *et al*. (2013).

Genetic parameters

The effectiveness of selection for any character depends, not only the extent of genetic variability but also in the extent to which it will be transferred from one generation to the other, because only heritable portion of variation is exploitable through selection. Different genetic parameters *viz*. heritability, phenotypic and genotypic CV, GA and genetic gain have been worked out for different parameters of *kharif* potato (Table 4). GCV helps in measurement of the range of genetic diversity in a character and provide means to compare the genetic variability in the quantitative characters. The GCV along with heritability estimate provides a better picture of the amount of GA to be expected by phenotypic selection (Burton 1952). The heritability of characters determine how much the phenotype of a plant is a guideline to the genotype and thus, help the breeder to base his selection on the phenotypic performance of the plant (Kumar *et al*. 2012). The heritability estimates was interpreted as low (< 30%), moderate (30-50%), high (50-70%) and very high (> 70%) as per classification of Hallauer and Miranda (1981).

Sixteen potato genotypes showed considerable variation in heritability values (25.66 – 97.41) for different parameters. Out of 18 parameters, eight parameters showed heritability > 90%. Leaf area and tubers/plant showed maximum values for heritability to the tune of 97.41 and 97.68, respectively. While TLWR showed lowest heritability of 25.66. Among high heritability values; parameters were shoots/plant, 96.41, leaflets/plant 90.67, leaf area 97.41, tubers/plant 97.68, tuber dry matter 86.13, average tuber weight 93.76, tuber yield 94.28 and marketable yield 95.91%, respectively. Under moderate category plant height at 30 and 60 DAP, days to 50% flowering, tuber width recorded heritability values to the tune of 58.5, 59.9, 57.7 and 65.7, respectively. While remaining parameters showed moderately high values (tuber dry matter, 86.13, yield/plant; 71.16, days to senescence; 76, tuber length; 76.7 and tuber diameter; 79.8%, respectively). In spite of high heritability for many characters the CV (both genotypic and phenotypic) was low which was reflected in GA as well as genetic gain. High heritability with moderate GA indicate the presence of dominant and epistatic genes and these traits can be improved through hybridization. Higher GA for tuber yield than its components namely number of tubers and average tuber weight observed in this study agrees with Gaur *et al*. (1978), Sidhu and Pandita (1979), but differs from Chaudhary and Sharma (1984).

Results indicates that adequate phenotypic as well as genotypic variation was present only for a few characters (leaflets/plant, leaf area, tubers/plant, total tuber yield and marketable yield) and remaining parameters showed poor genotypic as well phenotypic coefficient of variation. Genotypic CV and heritability are not sufficient to determine the amount of variations which are heritable and heritable variations could be determined with greater accuracy when heritability along with GA is studied. Due to high heritability and low CV, expected GA was low for many characters. GA for leaflets/plant (55.9) was highest among different parameters followed by leaf area (37.55). While total tuber yield and marketable yield showed moderate GA to the tune of 26.5 and 23.5, respectively. The genetic gain values obtained in different parameters were of medium range and maximum value was obtained for leaf area (42.31) followed by total leaflets/plant (39.52). For total tuber yield as well as marketable yield the values obtained were mediocre (23.39 and 25.22, respectively). The low heritability estimates for this character might be due to the predominance of genotype × environment interaction. Expected GA for tuber yield/plant was of moderate magnitude (12-20%), due to low variability for this character though the heritability values were high. This could be due to higher environmental variation. High heritability with low GA indicating the influence of non-additive genes effect on this trait. This demands selection with adequate progeny testing.

Correlation studies

Correlation coefficient is a statistical measure, which denotes the degree and magnitude of association between any two variables. This association can be of pleiotropic gene action or linkage or more likely both. Since the association pattern among yield components help to select the superior genotypes from divergent population based on more than one interrelated characters. Thus, information on the degree and magnitude of association between characters is of prime importance for the breeder to initiate any selection plan. The genotypic and phenotypic correlations were analysed to obtain information on the relationship among 18 traits of different genotypes of *kharif* potato (table 5). The genotypic correlation coefficients exhibited higher values than the phenotypic for all the 18 traits. Higher genotypic correlations than phenotypic might be attributed to modifying or masking effect of environment in the expression of the characters (Nandipuri *et al.,* 1973). Johnson *et al*. (1955) reported that higher genotypic correlation than phenotypic correlation indicate an inherent association between various characters.

Tuber dry matter was positively and significantly related with leaflets/plant and leaf area with genotypic correlation of 0.868 and 0.669, respectively. As evident from results more leaf area contributes to higher dry matter by higher photosynthesis and dry matter accumulation (Vedula, 2015). This is an important trait for selection of genotypes. However for other parameters *viz*. Total tuber yield, marketable yield and yield/plant the correlation coefficient values were in moderate range (0.50-0.60). Tubers/plant was significantly and highly correlated with shoots/plant (0.922) and leaf area (0.843). Tubers/plant and marketable yield showed significant high phenotypic and genotypic relationship as evident from correlation values of 0.942 and 0.910, respectively. Tubers/

plant was significantly and highly correlated with shoots/plant and leaf area. It can be concluded from high correlation values that shoots/plant, leaf area as well as leaflets/plant could be used as selection criteria in breeding *kharif* potato varieties for high yield.

Specific gravity and average tuber weight showed the perfect genotypic and phenotypic correlation value of 1.00 and 0.980, respectively. Different growth parameters *viz*. leaf area, leaflets/ plant, tubers/plant, plant height at 30 and 60 DAP had significant genotypic and phenotypic relationship among themselves. But the values of correlation were of medium range. The perfect correlation (genotypic and phenotypic) values between specific gravity and average tuber weight signifies that specific gravity and tuber weight are directly related and selection/breeding efforts should be made for improving average tuber weight of a genotype. Whereas for specific gravity and tuber biometrics genotypic and phenotypic correlation was highly significant but in moderate range. This specifies that tuber biometrics have a limited influence on the specific gravity and as earlier mentioned this parameter is more related to weight parameter.

Leaf area showed promising genotypic and phenotypic correlation coefficient values with all the parameters except for days to senescence and TLWR. Total tuber yield showed significant positive high phenotypic and genotypic correlation with shoots/plant (0.935 and 0.877), tubers/plant (0.972 and 0.945), marketable yield (0.912 and 0.869) and yield/plant (0.967 and 0.901). Total tuber yield exhibited higher values for both phenotypic and genotypic correlation coefficient with shoots/plant, leaf area, tubers/plant and average tuber weight. A similar trend was also observed for marketable yield for the above-mentioned parameters. Similar findings for the parameter in correlation studies are reported by Sattar *et al*. (2007) and Darabad (2014).

Marketable yield had positive and significant correlation with all the parameters except plant height at 30 DAP and TLWR. Other parameters *viz*. plant height at 60 DAP (0.437), total leaflets (0.391), dry matter (0.401), leaf area (0.794), tubers/ plant (0.942) and average tuber wt. (0.735) exhibited low to medium genotypic correlation over phenotypic correlation. Days to 50% flowering and tuber biometrics gave negative but significant values. Shoots/plant exhibited significant genotypic as well as phenotypic correlation with most of the parameters except for TLWR. The high value based phenotypic and genotypic correlation was obtained for tubers/ plant (0.953 and 0.922), total tuber yield (0.935 and 0.922). While for tuber biometrics and shoots/plant the correlation levels for both phenotypic and genotypic was of medium level. Results of this analysis indicate that for increasing yield, selection might be directed towards plants having higher number of shoots/plant, leaf area, average tuber weight and tubers/plant. Days to 50% flowering and tuber biometrics gave negative but significant values. Form the negative values, it can be established that the earliness or long duration of a genotypes affects the biometrics of the tubers.

REFERENCES

Allard, R. W. and Bradshaw, A. D. 1964. Implications of genotype environment interaction in applied plant breeding. *Crop Science*, **4**: 503-598.

Bhatia, R. 2004. Genetic variability and correlation studies in gladiolus. M.Sc. thesis, Punjab Agricultural University Ludhiana.

Burton, G. W. 1952. Quantitative inheritance in grasses. *Proceedings of 6th International Grassland Congress*. pp. 277-83.

Chaudhary, S. K. and Sharma, S. K. 1984. Genetic variability for yield and its components in potato breeding material. *Indian J. Agric. Sci.* **54:** 941-42.

Darabad, G. R. 2014. Study the relationships between yield and yield components of potato varieties using correlation analysis and regression analysis and causality. *Intl. J. Plant, Animal and Env. Sci.* **2(4):** 584-589.

FAOSTAT. 2016. Food and Agricultural organization. *Statistical database. UN, Rome, Italy*

Gaur, P. C., Kishore, H. and Gupta, P. K. 1978. Studies on character association in potatoes. *J. Agri. Sci. Cambridge*. **90:** 215-19.

Hallauer, A. R. and Miranda, J. B. 1981. Quantitative Genetics in Maize Breeding. *Iowa University Press, Ames, Iowa, USA*.

Horticultural Statistics at a Glance. 2016. Horticulture Statistics Division, Department of Agriculture, Cooperation, Ministry of Agriculture and Farmers Welfare, Government of India.

Janaki, M., Naram L. N., Venkata, C. R and Paratpara, M. R. 2015. Assessment of genetic variability, heritability and genetic advance for quantitative traits in chilli (*Capsicum annuum* L.) *The Bioscan* (Supplement on Genetics and Plant Breeding) **10(2):** 729-733.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimation of genetic and environmental variability in soybean. *Agronomy J.* **47:** 314-318.

Joseph, T. A., Gopal, J. and Sood, S. K. 2005. Genetic parameters and character associations in potato under subtropical plains and temperate hill conditions. *Potato J.* **32(1-2):** 49-53.

Kadwey, S., Dadiga, A., Prajapati, S. and Telugu, R. K. 2015. Correlation and path co-efficient analysis of quantitative and qualitative traits in chilli (*Capsicum annuum* L.) *The Bioscan* (Supplement on Genetics and Plant Breeding) **10(4):** 1909-1914,

Khan, S. H., Hussain, K., Jabeen, N., Chattoo, M. A. and Afroza, M. 2011. Agro diversity of potato (*Solanum tuberosum* L.) *Asian J. Horticulture*. **6(2):** 275-279.

Kumar, R. and Kang, G. S. 2000. Characterizing genetic diversity in *andigena* potato using non-hierarchical Euclidean cluster analysis. *Potato Global Res. and Dev. Proceedings*. **1:** 146-149.

Kumar, R., Deka, B. C. and Venugopalan, R. 2012. Genetic variability and trait association studies in gerbera (*Gerbera jamesoni*) for quantitative traits. *Indian J. Agri. Sci.* **82(7):** 615-9.

Nandipuri, B. S., Singh, B. S. and Lal, T. 1973. Studies on the genetic variability and correlation of some economic characters in tomato. *J. Research*. **10:** 316-321.

Panda, A. 2015. Assessment of zinc application in potato (*Solanum tuberosum* L.). Master Thesis submitted to Department of Vegetable Science, *Orissa University of Agriculture and Technology, Bhubaneswar*.

Pandey, S. K., Singh, S. V. and Manivel P. 2005. Yield structure, agronomic performance and stability of new potato (*Solanum tuberosum*) hybrids in western Uttar Pradesh. *Indian J. Agricultural Sciences*. **75(7):** 417-421.

Panwar, S., Singh, K. P., Prasad, K. V., Satyavathi, C. T. and Namita. 2012. Character association and path coefficient analysis in rose (Rosa × Hybrida). *Indian J. Horticulture*. **69(2):** 231-8.

Patel, C. J., Patel, N. H., Gami, R. A., Patel, A. K. and Chauhan, R. M. 2013. Assessment of Potato (*Solanum tuberosum* L.) hybrids-Varieties for Processing Purpose among Yield and Quality Traits,

Trends in Biosci. **6(5):** 676-681.

Reshi, M., Bhat, A., Kaul, R. K. and Gupta, M. 2013. Evaluation of various potato cultivars of Jammu region for processing attributes. *The Bioscan (Supplement on Genetics and Plant Breeding)* **8(4):** 1203-1205.

Sattar, M. A., Sultana, N., Hossain, M. M., Rashid, M. H. and Islam, A. K. M. A. 2007. Genetic variability, correlation and path analysis in potato (*Solanum tuberosum* L.) *Bangladesh J. Plant Breeding Genetics*, **20(1):** 33-38.

Sestra, R., Mihalte, L., Sestra, A., Bondrea, I. and Baciu, A. 2007. The variability and heritability of several traits at different cultivars of tulips. *Buletinul Usamv-CN*. **64:** 1-2.

Sidhu, A. S. and Pandita, M. L. 1979. Genetic variability and correlation studies on potato (Solanum tuberosum L.) *J. Indian Potato Assoc*. **6:** 103-08.

Singh, P. K. and Choudhary, R. D. 1997. Biometrical Methods in Quantitative Genetic Analysis, Kalyani Publishers, New Delhi. pp. 178-185.

Ummayiah, H. M., Khan, S. H., Wani, K. P., Hussain, K. and Junaif. 2010. Genetic variability in potato (*Solanum tuberosum* L.). *Asian J. Horticulture*. **5(1):** 61-66.

Vavilov, N. I. 1951. The origin, variation, immunity and breeding of cultivated plants. *Chronica Botanica*. **1:** 364.

Vedula, S. K. 2015. Variability studies in potato (*Solanum tuberosum* L.). Master Thesis submitted to Department of Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar.