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Short Communication

Association of frost injury with tuber yield components in potato (*Solanum tuberosum* L.)

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In north-western and west-central sub-tropical plains of India, frost is known to influence the potato productivity by 10-50% depending upon intensity of frost and crop age. Information on frost tolerance is limited in sub-topical plains (Kang et al. 2007, Luthra et al. 2007) and association of frost injury with tuber yield components is lacking in potato. The tuber yield being complex polygenic trait is determined by interactions among various genetic as well as environmental factors. The genetic parameter gives an idea of the genetic advance to be expected from selection for a character (Johnson et al. 1955). Association among different characters helps in selection of better plant type. The present study was designed to estimate the variability, heritability, genetic advance and associations among various characters for identification of promising parental lines in potato.

One hundred fifty-eight potato genotypes (*Solanum tuberosum* subsp. *tuberosum*) including germplasm lines, commercial varieties and advance hybrids were evaluated at ICAR-Central Potato Research Institute, Reginal Station, Modipuram, Meerut. The trial was laid out in randomized block design with three replications. Fifteen tubers of each genotype were planted in a single row plot at inter- and intra-row spacing of 60 cm and 20 cm, respectively. Recommended cultural practices of the region were followed. The crop was dehaulmed 90 days after planting. The data was recorded on nine characters viz., plant vigour (on 1-5 scale, 1 being very poor and 5 being highly vigorous), stem number/plant, plant height (of main shoot, in cm), frost injury (on 0-10 scale, o being no foliage injury (frost tolerant) and 10 being total foliage injury due to frost (frost susceptible), total tuber yield/plant (g), tuber number/plant, average tuber weight (g), economic tuber yield (g/plant; tuber yield of >20g tuber) and tuber dry matter (%). The severe incidence of frost during January 7-9, 2006 provided an opportunity to record the frost injury in potato genotypes. The data was subjected to analysis for estimating the variability (Panse and Sukhatme 1985), coefficient of variation (Burton and De Vane 1953) and heritability in broad sense and genetic advance (Johnson et al. 1955). The correlation coefficients among characters were worked out as per method of Searle (1961).

The analysis of variance revealed significant differences among the genotypes for all the characters indicating prevalence of genetic variability. The results on the mean, range, coefficients of variation (genotypic and phenotypic), heritability and genetic advance for various characters are presented in Table 1. Phenotypic coefficients of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the traits, indicating the importance of environment in the manifestation of these characters. The highest values of PCV as well as GCV were observed for frost injury followed by tuber number, economic tuber yield, average tuber weight, total tuber yield, stem number, plant height, plant vigour and tuber dry matter, indicating that these characters will respond to selection. Singh et al. (2004) had also found high PCV for average tuber weight, tuber number and tuber yield. Heritability values for various characters ranged between 40% (stem number) to 98% (tuber dry matter). The estimates of heritability were high enough for selection to be

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Table 1: Genetic parameters for nine characters in potato

Genetic parameters	Mean	S.E.	Range	Coefficient of variation		h^2 (Broad Sense)	Genetic advance as 5% of mean
				Genotypic	Phenotypic		
Plant vigour	4.25	0.30	2.67-5.00	11.27	16.71	0.46	15.66
Stem number	3.98	0.53	2.00-6.60	18.83	29.93	0.40	24.42
Plant height	48.59	4.31	29.13-82.13	14.34	21.01	0.47	20.16
Total tuber yield	324.15	33.13	145.78-556.05	24.74	30.42	0.66	41.45
Tuber number	10.04	1.14	5.19-26.86	28.83	34.85	0.68	49.13
Average tuber weight	34.38	3.49	7.70-66.23	28.36	33.36	0.72	49.66
Economic tuber yield	296.66	32.10	92.44-511.65	27.96	33.66	0.69	47.85
Tuber dry matter (%)	19.43	0.16	15.04-23.67	9.68	9.79	0.98	19.73
Frost injury	5.47	0.83	1.67-9.00	31.75	41.19	0.59	50.42

effective in order of their values for tuber dry matter, average tuber weight, economic tuber yield, tuber number, total tuber yield and frost injury. High GCV and PCV associated with high heritability were observed for total tuber yield, tuber number, average tuber weigh, economic tuber yield and frost injury. Expected genetic advance was converted into percentage of mean so that comparisons could be made among various characters, which had different units of measurement. The maximum genetic advance was observed for frost injury followed by tuber number, average tuber weight, economic tuber yield and total tuber yield. The present finding of high genetic advance for tuber number, average tuber weight and tuber yield confirmed the findings of Birhman et al. (1984) and Luthra (2001).

The results on phenotypic correlations (Table 2) showed that total tuber yield was positively associated with all other characters excepting tuber dry matter and frost injury, which were negatively associated. Tuber number possessed significantly negative correlation with average tuber weight but significantly positive association with stem number, however all were positively correlated with tuber yield. positive association of tuber number with stem number but its negative association with average

Table 2: Phenotypic correlation coefficients for nine characters in potato

Characters	Stem number	Plant height	Total tuber yield	Tuber number	Average tuber weight	Economic tuber yield	Tuber dry matter	Frost injury
Plant vigour	0.055	0.231 **	0.528 **	0.173 **	0.286 **	0.518 **	0.010	-0.523 **
Stem number		0.063	0.169 **	0.249 **	-0.086	0.135 **	-0.090	0.066
Plant height			0.160 **	-0.011	0.150 **	0.161 **	0.097 *	-0.233 **
Total tuber yield				0.250 **	0.592 **	0.986 **	-0.236 **	-0.509 **
Tuber number					-0.537 **	0.118 **	-0.077	-0.240 **
Average tuber weight						0.675 **	-0.112 *	-0.267 **
Economic tuber yield							-0.233 **	-0.483 **
Tuber dry matter								-0.063

*, ** Significant at P= 0.05 and 0.01, respectively.

tuber weight confirmed the findings of Desai and Jaimini (1998), Gopal (1999), Luthra (2001) and Luthra et al. (2006). Potato genotypes with many thin stems are known to produce numerous small sized tubers and such genotypes could be exploited in breeding for production of varieties suitable for baby potatoes. For production of high yielding table potato varieties, compromise between tuber number and average tuber weight can be made by selecting genotype having moderate number of 5-8 vigorous stems per plant. High tuber dry matter is the requirement of processing industry but its significant negative association with total tuber yield. Keeping in mind the tuber yield losses due to frost injury in north-western plains and its desirable significant negative association with tuber yield components, it is imperative to select the tall genotypes with high plant vigour, total tuber yield, tuber number or average tuber weight and economic tuber yield. Promising genotypes with significantly high mean values for important seven characters were identified (Table 3).

Table 3: Promising genotypes for important characters in potato

Plant vigour Mean: 4.25 LSD (0.05): 0.84 LSD (0.01): 1.11	61genotypes viz. CP1850, CP1918, CP1919, CP1922, CP1923, CP1927, CP1965, CP1970, CP1971, CP1985, CP1987, CP2002, CP2005, CP2006, CP2007, CP2013, CP2015, CP2021, CP2023, CP2025, CP2038, CP2059, CP2065, CP2072, CP2086, CP2089, CP2102, CP2124, CP2125, CP2127, CP2131, CP2142, CP2160, CP2164, CP2167, CP2170, CP2171, CP2172, CP2174, CP3359, CP3756, CP3763, CP3764, CP3765, CP3766, CP3770, CP3771, CP3773, CP3776, CP3779, CP3781, Kufri Anand, Kufri Arun, Kufri Bahar, Kufri Pukhraj, Kufri Sutlej, MS/95-117, MS/95-1309, MS/97-621, MS/98-6955, MS/98-7208. All genotypes were non-significant but highly vigorous
Total tuber yield (g/plant) Mean: 324.15 LSD (0.05): 92.18 LSD (0.01): 121.41	50 genotypes viz. CP1611*, CP1677*, CP1850*, CP1921**, CP1922*, CP1923**, CP1924*, CP1970*, CP1985**,, CP2002*, CP2013*, CP2023*, CP2052*, CP2065*, CP2071*, CP2073*, CP2089*, CP2124*, CP2127*, CP2131*, CP2160*, CP2164*, CP2170*, CP2171*, CP2174*, CP3359*, CP3756**, CP3762*, CP3763*, CP3764*, CP3767*, CP3771*, CP3773**, CP3781**, Kufri Anand**, Kufri Arun**, Kufri Ashoka*, Kufri Bahar*, Kufri Pukhraj**, Kufri Sutlej**, MS/92-1090*, MS/93-1344**, MS/94-1118*, MS/94-899**, MS/95-117*, MS/95-1309**, MS/97-1606*, MS/97-621**, MS/98-6955**, MS/98-7208**
Tuber number/plant Mean: 10.04 LSD (0.05): 3.16 LSD (0.01): 4.16	19 genotypes viz. CP1362**, CP1588**, CP1970**, CP2025**, CP2030*, CP2031**, CP2058**, CP2065**, CP2170**, CP2171**, CP2173*, CP2174*, CP2194**, CP2196**, CP2209**, CP3774**, MS/95-1309**, MS/97-621**, MS/98-7208*
Average tuber weight (g) Mean: 34.38 LSD (0.05): 9.70 LSD (0.01): 12.78	28 genotypes viz. CP1923**, CP1924*, CP2002*, CP2023**, CP2032**, CP2079*, CP2124**, CP2131*, CP2191**, CP3359*, CP3756**, CP3763**, CP3764**, CP3765*, CP3771**, CP3773*, CP3777**, CP3780**, CP3781**, Kufri Arun**, Kufri Ashoka*, Kufri Bahar**, Kufri Pukhraj*, MS/92-1090**, MS/93-1344**, MS/94-899**, MS/95-117*, MS/97-1606*
Economic tuber yield (g/plant) Mean: 296.66 LSD (0.05): 89.32 LSD (0.01): 117.65	28 genotypes viz. CP1921**, CP1923* , CP1985**, CP2023**, CP2131*, CP2160*, CP2164*, CP3359**, CP3756**, CP3763**, CP3764**, CP3767*, CP3773**, CP3781**, Kufri Anand**, Kufri Arun**, Kufri Bahar*, Kufri Pukhraj**, Kufri Sutlej**, MS/92-1090**, MS/93-1344**, MS/94-899**, MS/95-117*, MS/95-1309**, MS/97-1606*, MS/97-621**, MS/98-6955**, MS/98-7208*
Dry matter (%) Mean: 19.43 LSD (0.05): 0.45 LSD (0.01): 0.60	67 genotypes viz. CP1362*, CP1611**, CP1677**, CP1907**, CP1918**, CP1919**, CP1937**, CP1940**, CP1945**, CP1978**, CP1981**, CP1987*, CP1994**, CP1998**, CP2001**, CP2002**, CP2004**, CP2005**, CP2006**, CP2007**, CP2013**, CP2025**, CP2030**, CP2031**, CP2032**, CP2038**, CP2045**, CP2052**, CP2067**, CP2073**, CP2076**, CP2079**, CP2082**, CP2089**, CP2096**, CP2120*, CP2131**, CP2142**, CP2150**, CP2159**, CP2160**, CP2167**, CP2169**, CP2170**, CP2172**, CP2173**, CP2177**, CP2178**, CP2194**, CP2209**, CP2289**, CP3756**, CP3759**, CP3761*, CP3763**, CP3766**, CP3768**, CP3770**, CP3771**, CP3773**, CP3776**, CP3780**, CP3781**, Kufri Anand**, Kufri Arun**, Kufri Surya**, MS/93-1344**,
Frost injury Mean: 5.47 LSD (0.05): 2.30 LSD (0.01): 3.04	24 genotypes viz. CP1987**, CP1998**, CP2017**, CP2025*, CP2052*, CP2142**, CP2150*, CP2170*, CP2194**, CP3756**, CP3763*, CP3764*, CP3770*, CP3771*, Kufri Anand**, Kufri Arun**, MS/92-1090**, MS/93-1344**, MS/95-117**, MS/95-1309**, MS/97-1606*, MS/97-621**, MS/98-6955**, MS/98-7208**. These genotypes were frost tolerant as they possessed significantly less frost injury.

*, ** Significant at P= 0.05 and 0.01, respectively

The performance of genotypes varied for different characters, however some common genotypes were identified for priority-based characters like frost tolerance and tuber yield. As many as 24 genotypes were frost tolerant as compared to 50 genotypes with significantly high tuber yield out of the 158 genotypes studied. Based on significantly negative correlation of frost injury with most of the traits, it was evident that genotypes with high mean values for different characters are important for combining the characters of frost tolerance in progenies. The genotypes viz. CP2052, CP2170, CP3756, CP3763, CP3764, CP3771, Kufri Anand, Kufri Arun, MS/92-1090 and MS/93-1344 were promising on account of comparatively less frost injury (frost tolerance) and high tuber yield in addition to high mean values for some characters like plant vigour or tuber number or average tuber weight or economic tuber yield or dry matter. However negative association of tuber dry matter with tuber yield components advocates a strategy to identify the common superior genotype for tuber yield, tuber dry matter and frost tolerance and six genotypes namely CP2052, CP3756, CP3763, Kufri Anand, Kufri Arun and MS/93-1344 were found promising. The promising genotypes identified may be exploited in breeding programme for achieving high tuber yield, tuber dry matter and frost tolerance in potato.

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