

VARIABILITY, INTER-RELATIONSHIPS AND UTILIZATION OF ANDIGENA POTATO GERMPLASM

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Tuber yield, its component and quality characteristics were studied in 108 genotypes of Andigena potato. Wide genetic variability was found for tuber number, tuber weight, tuber yield and dry matter, percentage vitamin C, proteins, phenols, total sugar and reducing sugars. The maximum variation was noted for reducing sugars and the minimum for dry matter. Tuber weight was more important than tuber number in determining tuber yield. Tuber yield and quality characteristics were not correlated. Promising genotypes have been identified for use in cultivation or breeding.

Among crop plants, potato produces highest energy and good quality protein per unit land area per day, which is similar to milk protein with EAA index : 76-79. Potato tuber is a rich source of vitamins, minerals and trace elements (Ross, 1986; Talburt and Smith, 1987; Woolfe, 1987) and can play a major role in alleviating energy and protein malnutrition in developing countries (Swaminathan and Sawyer, 1983).

High temperature, soon after harvesting, in sub-tropical countries requires cold storage of potatoes. Insufficient cold storage capacity in the country causes wide price fluctuations, uneven supply of potatoes over space and time and substantial losses due to rotting etc. (Nayar, 1986). To avoid this and to ensure higher per capita consumption, processing of potatoes is very important. Efforts to improve total food production have so far concentrated on breeding for crop yield and resistance to diseases. Hence, there is a need to put greater emphasis on initiating potato breeding programmes to improve tuber quality by isolating genotypes having the desirable attributes. To achieve this, wide genetic variability in the available

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germplasm is essential (Hawkes, 1990a). Due to its narrow genetic base and repeated cycles of inbreeding and selection *Tuberosum* (*Solanum tuberosum* subsp. *tuberosum* Hawkes) potatoes have limited genetic variability (Simmonds, 1962; Hawkes, 1990b). On the other hand *Andigena* (*Solanum tuberosum* subsp. *andigena* Hawkes) potatoes are storehouse of genetic variability (Simmonds, 1964; Ross, 1986; Hosaka and Hanneman, 1988; Birkman and Kaul, 1989 a, b; Waugh *et al.*, 1990). For formulation of an efficient breeding programme analysis of variability is vital (Hawkes, 1990 a). In the present study, genetic variability for tuber yield and quality traits and their inter-relationship was investigated in *Andigena* potatoes and the results are presented in this paper.

MATERIALS AND METHODS

One hundred and eight *andigena* (*Solanum tuberosum* subsp. *andigena* Hawkes) potato genotypes from four South American countries, viz., Argentina (5), Bolivia (11), Columbia (82) and Peru (10) were planted in a randomized complete block design with three replications at Central Potato Research Station, Modipuram, Meerut, UP. Each genotype was represented by one row of 15 plants per replication at a distance of 20 cm in rows kept 60 cm apart. Inorganic fertilizer was applied @ N : P : K :: 120 : 80 : 80 kg/ha. Half of the nitrogen and all phosphorus and potas were placed in bands before ridge making. The rest of the nitrogen was applied at the time of ridge making. Routine cultural practices were followed during the crop season.

Total tuber yield and tuber number per plant were recorded at harvest time. For tuber quality trait, a composite sample of 10 tubers was taken. Dry matter content was estimated by chopping and drying (at 90 °C for 48 hr.) 100g tuber tissue. For estimating vitamin C, true protein, phenols, total sugars and reducing sugars, methods were followed as described earlier (Rao, 1954; Swaminathan *et al.*, 1973; Spies, 1957., Dubois *et al.*, 1956; Nelson, 1944). Replication means were used for statistical and biometrical analysis. Analysis of variance was done as described by Snedecor (1968) for the randomized complete block design. Statistical parameters like measure of central tendencies, measure of dispersion and correlation coefficients were computed by the methods of Snedecor (1968).

RESULTS AND DISCUSSION

Intensive cultivation and repeated cycles of selection on regional basis have reduced the genetic variability of the *tuberosum* potatoes. On the other hand in its native place, South America, Andean potato germplasm lodges, absorbs, disseminates and perpetuates huge genetic variability (Brush *et al.*, 1981; Johns and Keen, 1986; Hawkes and Hjerting, 1989; Quiros *et al.*, 1990; Rabinowitz *et al.*, 1990). Results from the present investigations confirm

these findings (Fig. 1). Inter-genotypic variation was significant for all the traits (Table 1). All traits, except protein content and tuber weight, exhibited higher genetic variability in *andigena* potatoes to that previously recorded in *tuberosum* potatoes (Birhman and Kaul, 1989a; Talburt and Smith, 1987). The variation was maximum for reducing sugars and minimum for dry matter content.

Table 1. Variability parameters of 108 Andigena potato genotypes

Trait	Range	Mean \pm SE	Coefficient of Variation
Tuber yield (g)	251 - 923	495 \pm 11.9	25.05
Tuber number	11.7 - 38.3	20.9 \pm 0.47	23.40
Tuber weight (g)	12.4 - 48.1	24.6 \pm 0.68	28.78
Dry matter (%)	14.1 - 28.7	20.9 \pm 0.27	13.57
Vitamin C*	7.0 - 17.0	11.6 \pm 0.21	18.30
True protein*	565 - 1331	925 \pm 19.3	21.73
Phenols*	18 - 105	63.7 \pm 1.5	24.47
Total sugars*	149 - 1276	452 \pm 18.2	41.69
Reducing sugars*	12 - 998	102 \pm 14.2	144.43

*mg per 100 g fresh tuber weight

Yield is a polygenically controlled trait and many components add to this trait, the principal being tuber weight and number. Both these yield components exhibited considerable variability (Table 1). Tuber number exhibited low coefficient of variation. Though the mean tuber number was 20.9, it ranged between 11.7 to 38.3 in these genotypes. The least number of tubers were produced by JEX/A 676 and the maximum by JEX/A 578. Heaviest tubers were produced by JEX/A 324 and the lightest by JEX/A 314. Genotype JEX/A 789 had the least tuber yield and JEX/A 578 the maximum.

The overall variability in tuber dry matter content ranged from 14.1% to 28.7%, the lowest being in genotype JEX/A 653 and the highest in JEX/A 68. There was a large inter-genotypic variation in vitamin C content, the range being from 7 to 17 mg, least being in JEX/A 121 and the highest in JEX/A 226. Genotype JEX/A 584 had the lowest and genotype JEX/A 592 the highest protein content per 100g tuber tissue. In the genotypes, phenols per 100g tuber tissue varied from 18 to 105 mg with genotype JEX/A 695 having the least and JEX/A 102 the maximum. However, despite this large range, nearly 70 per cent genotypes fell in 62 to 66 mg range (Table 1). Reducing sugars followed by total sugars had the highest coefficient of variation.

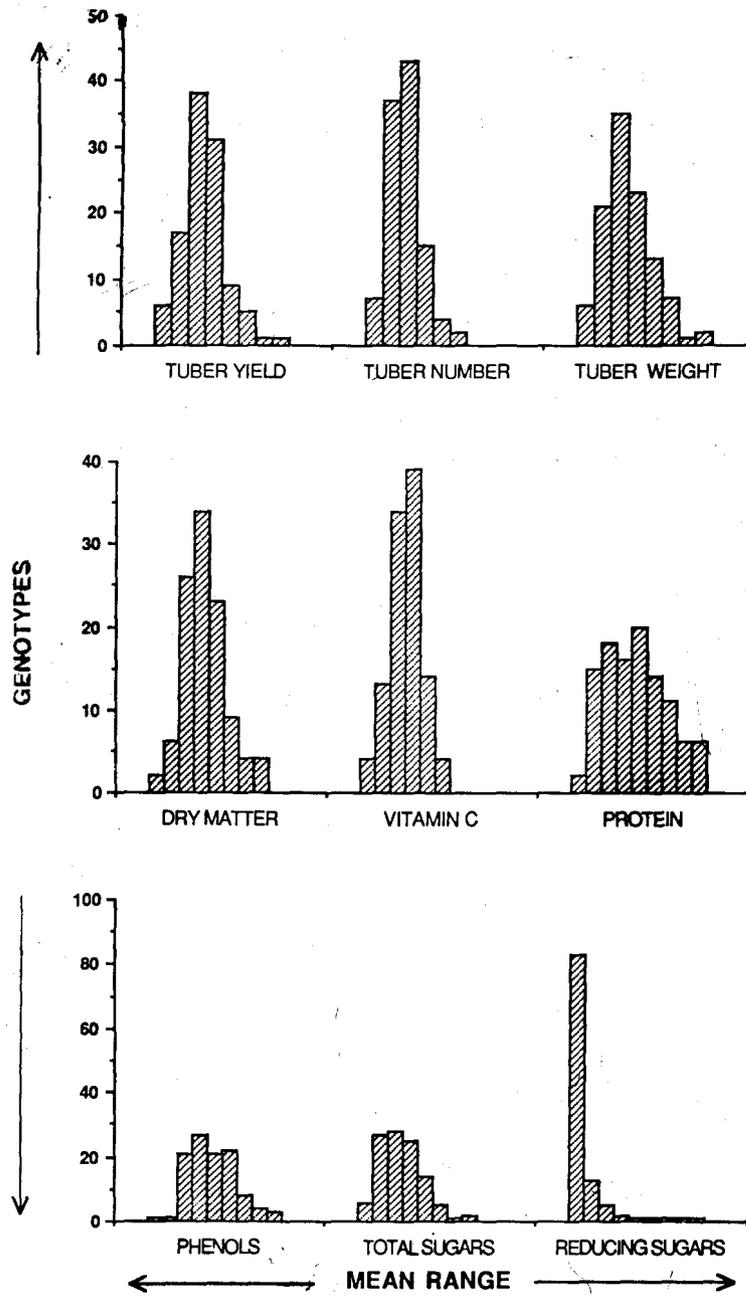


Figure 1 : Frequency distribution of metric characters in 108 Andigena potato genotypes (Histograms based on genotype means)

Maximum total sugars occurred in the tubers of genotype JEX/A 32 and the minimum in the tubers of the genotype JEX/A 701. The tubers of the genotype JEX/A 271 had the highest reducing sugars and of JEX/A 79 the least.

Tuber yield was significantly positively correlated with both of its components (Table 2; Maris, 1969; Sidhu and Pandita, 1979; Birhman and Verma, 1986). No significant association was observed between tuber yield and tuber quality traits (Killick, 1977; Gaur *et al.*, 1978; Singh *et al.*, 1988; Haynes *et al.*, 1989). Tuber number and tuber weight were negatively correlated with each other (Maris, 1969; Killick, 1977; Gaur *et al.*, 1978; Birhman and Verma, 1986; Singh *et al.*, 1988). While significant positive correlation existed between, dry matter and protein (Gaur *et al.*, 1978), total sugars and reducing sugars and phenols and reducing sugar, significant negative correlation was noted between tuber weight and dry matter (Gaur *et al.*, 1978) and dry matter and reducing sugars.

Percentage of dry matter in potato tubers is an indication of texture of cooked potatoes, mealiness and breakdown of tissues on cooking and is important for suitability for processing in different forms. Sugar content, especially the percentage of the reducing sugars, in the tubers is of great importance for potato processing. High sugar content causes discoloration of chips and dehydrated products. The amount of phenols in the tubers is regarded as the genetically most important factor for enzymic and non-enzymic browning of potatoes. The vitamin C and protein are nutritionally important (Hunius, 1981; Talburt and Smith, 1987; Woolfe, 1987). Existence

Table 2. Correlation coefficient in *Andigena* potatoes*

Trait	TN	TW	DM	Vit. C	Protein	Phenols	TS	RS
TY	0.29**	0.63**	0.16	0.06	0.07	0.04	0.04	0.05
TN		-0.52**	0.08	0.10	0.05	-0.05	0.03	-0.01
TW			-0.20*	-0.02	-0.10	0.02	0.03	0.07
DM				0.06	0.25*	-0.10	-0.11	-0.21*
Vit C				0.04	0.15	0.10	-0.04	
Protein						-0.17	-0.09	-0.04
Phenols							0.07	0.19*
TS								0.56**
RS								

*N = 108

TY = tuber yield; TN = tuber number; TW = tuber weight; DM = dry matter;

Vit C = vitamin C; TS = total sugars; RS = reducing sugars

* P < 0.05; **P < 0.01

of high inter-genotypic variability for tuber yield and its components and tuber quality characteristics in *Andigena* germplasm led to isolation of the promising genotypes for various economically important agronomic attributes (Table 3). The most promising genotypes were JEX/A nos. 68, 79, 175, 426, 592 and 695. These could be utilized in breeding and cultivation. Most important accessions for isolating promising genotypes were found to be PI nos. 225627, 225633, 230473, 243381, 243410, 243438, and 243471.

Potato tuber yield is a function of the tuber number and average tuber weight. Sidhu and Pandita (1979) and Lepage and Caesar (1990) considered tuber number to be more important than average tuber weight in determining yield, where as Maris (1969), Birhman and Verma (1986) and Joseph *et al.* (1992) considered the contrary to be true. Maris (1988) and Lynch and Kozub (1991) observed that while tuber number was more important for determining tuber yield in some of the progenies and environments, it was average tuber weight that was more important for tuber yield determination

Table 3. Promising *Andigena* potato genotypes

Traits	Genotypes (JEX/A Nos.) ^a
Tuber yield (> 700 g/plant)	37 (225627), 79 (230473), 578 (243436) 592 (243438), 674 (243470)
Tuber number (< 30/plant)	18 (205624), 314 (243399), 426 (243410), 578 (243436), 791 (280869)
Tuber weight (> 35 g)	37 (225627), 57 (225632), 324 (243396), 496 (243423), 770 (258927)
Dry matter (< 27%)	68 (225633), 357 (243402), 426 (243410) 455 (243417), 695 (243373)
Vitamin C (< 15 mg ^b)	63 (225633), 68 (225633), 208 (243420), 218 (WRF 1299), 226 (243373)
Protein (< 1300 mg ^b)	275 (243381), 403 (243407), 592 (243438), 653 (243452), 663 (243453)
Phenols (C 45 mgb)	3 (Haw 2154), 10 (Haw 2154), 558 (243434), 695 (243471), 728 (246499)
Total sugars (9 < 200 mg ^b)	69 (230471), 275 (243381), 391 (243486), 426 (243410), 701 (243471)
Reducing sugars (< 20 mg ^b)	36 (225627), 79 (230473), 121 (233988), 359 (243404), 695 (243471)

^a Numbers in parenthesis are PI Numbers.

^b per 100 g fresh tuber tissue

in other genotypes and environments. The results from the present study suggest that tuber weight is more important in determining tuber yield in *Andigena* potatoes. Similarly, various authors have reported either positive, negative or absence of relationship between tuber number and tuber weight. A significant negative correlation was found between tuber number and tuber weight in the *Andigena* potato genotypes investigated presently. Strong and divergent variations in estimated values of correlation coefficients can be because the correlation coefficients between two traits constitute properties of not only the two traits but also of the population and environmental circumstances to which the individuals are subjected (Falconer, 1987).

Absence of undesirable association between tuber yield and tuber quality traits paves the way to combine these traits in all permutation and combination (Haynes and Haynes, 1990). Positive correlation between dry matter and protein, phenols and reducing sugars and total sugars and reducing sugars will help in identification of the desirable genotypes in a potato improvement programme. Negative correlation between tuber number and tuber weight will pose difficulty in simultaneous increase in tuber number and weight that is necessary for maximal yield gain. For enhancement of tuber yield, priority should be given to tuber weight because tuber yield has stronger association with tuber weight (standard partial regression coefficient = 1.1) than with tuber number (standard partial regression coefficient = 0.8). However, bigger tuber size will tend to reduce the dry matter content in tubers. This calls for optimization in selection for tuber number and weight.

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