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学术园地

Selection of Suitable Parents in the Development of Potato Hybrids in Bangladesh

M K Biswas[1*], M A A Mondal[2], M Hossain[1], R Islam[1]

(1. Department of Botany, University of Rajshahi, Rajshahi-6205, Bangladesh; 2. SSO, ARS, Burirhat, Rangpur, Bangladesh)

Abstract: Ten crosses involving seven parents crossed in line×tester design were studied for main stem height·plant^{-1}, main stem leaves·plant^{-1}, stems·plant^{-1}, plant weight·plant^{-1}, average tuber weight·plant^{-1} and tuber dry matter % in F_1 generation. The additive gene action was found to be more important for the characters, main stem height·plant^{-1}, main stem leaves·plant^{-1}, stems·plant^{-1}, plant weight·plant^{-1}, and average tuber weight·plant^{-1}. Among seven parents, Lalsilbilati, Lalpakri and Ausha were good combiners for the characters, main stem height·plant^{-1}, main stem leaves·plant^{-1}and average tuber weight·plant^{-1}, respectively. For average tuber weight·plant^{-1}, the crosses Patnae/TPS-67 and Lalpakri/TPS-13 showed significant positive specific combining ability effects. Ausha/TPS-67 showed significant positive specific combining ability effects for main stem leaves·plant^{-1}.

Key Words: combining ability; selection; potato

Potatoes (Solanum tuberosum L) are the third largest food crop in Bangladesh following rice and wheat and make a major contribution to the total food supply of the country. Although in many western countries potato is the number one staple food, it is almost entirely used as a vegetable in Bangladesh. The potato is a short duration crop that produces a large amount of calories in a short period of time[1]. The potato produces more protein and calories per unit area per unit time than any other major food plant[2]. The ratio of protein to calories, the quality of the protein and the high levels of vitamins and minerals are assets greatly needed in many countries. As a crop of high biological value for its protein and a sustainable amount of vitamins, minerals and trace elements, it can be a very important crop in the developing countries like Bangladesh.

Potato is widely cultivated in winter season all over Bangladesh. In 1997~1998, 134 000 hectares of land were under potato cultivation producing 1.5 million tons of potatoes with an average yield of 11.25 mt per hectare. The country's potato seed requirement is estimated at 180 000 mt. Use of high quality seeds of modern varieties is the single factor responsible for the increased yield of potatoes. Bangladesh has a huge potential for potato cultivation and, with coordinated efforts, can further increase yields.

It is a highly heterogeneous crop where non-additive gene action is known to be important for most of the economic characters. This makes it necessary to assess the combining ability of the parents before they are involved in crosses in a breeding programme[3]. Information on combining ability is needed to identify potentially superior parents and hybrids, and would also help to define the pattern of gene effects in the expression of quantitative traits[4]. The general combining ability (GCA) of each parent should be examined when the objective is the development of superior genotypes, while the specific combining ability (SCA) effects provide information about the performance of

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Biography：M K Biswas(1978-), male, research fellow. Research area: plant breeding and biotechnology.

*Corresponding author: manosh24@yahoo.com

hybrids[5]. The differences in GCA are mainly due to the additive genetic effects and higher order additive interactions, while the differences in SCA are attributed to the non-additive dominance and other types of epitasis[6]. This analysis, therefore, allows broad inferences on the nature of the gene effects for a trait under selection. The breeder can make use of this information to find the best strategy to select desirable parents or determine which breeding procedure will efficiently improve the performance of the traits of interest[7].

The objective of this study was to assess the combining ability of potato genotypes, aiming to a parental selection and germplasm improvement for breeding programs to increase production.

1 Materials and Methods

In the present study, seven parents and their ten hybrids of potato seeds were used. Among the parents five were used as female (line) and remaining two were used as male parents. Ten crosses were made in line×tester design. Potato seeds were sown in the field following randomized block design with three replications during October 2002 at Plant Breeding and Gene Engineering Lab's research field of Rajshahi University, Bangladesh. A spacing of 60 cm and 30 cm between rows and within the rows, respectively, was maintained. Each of the crosses and the parents were planted in single row plots, having 40 seeds/replication. Recommended agronomic practices were followed to raise the crop under irrigated conditions. Observations were recorded for different characters, such as main stem height·plant^{-1}, main stem leaves·plant^{-1}, stems·plant^{-1}, plant weight·plant^{-1}, average tuber weight·plant^{-1} and tuber dry matter %. The average tuber weight was calculated by dividing tuber yield by number of tubers. The data were analyzed according to line×tester method suggested by Kempthorn[8].

2 Results and Discussion

The analysis of variance (Table 1) revealed that the differences between genotypes were highly significant for all the characters except stems·plant^{-1}; the differences due to parents were significant for most of the characters except stems·plant^{-1} and tuber dry matter %. Hybrids were significant for main stem leaves·plant^{-1}, and plant weight·plant^{-1} indicating that there was considerable variation for these traits. The variance due to replications for all the characters was non-significant except in plant weight·plant^{-1} indicating a low environmental variation.

ANOVA due to line was significant for most of the characters except stems·plant^{-1}, average tuber weight·plant^{-1} and tuber dry matter %; on the other hand testers were significant only for tuber dry matter % indicating inter-allic action for these traits. Similar results were found by Sharma et al[9] and Gaur et al[3]. The magnitudes of mean square suggested that lines were more diverse than testers for main stem height·plant^{-1}, main stem leaves·plant^{-1}, stems·plant^{-1}, plant weight·plant^{-1} and average tuber weight·plant^{-1}, while the latter was more diverse than the former for the remaining traits.

Mean square values due to parent vs. hybrid were highly significant for main stem leaves·plant^{-1}, stems·plant^{-1}, plant weight·plant^{-1}, average tuber weight·plant^{-1}, and tuber dry matter % indicating a wide range of variation within parents and hybrids for these traits. Similarly, the mean square values due to line × tester were significant for main stem leaves·plant^{-1}, plant weight·plant^{-1} suggesting that there were high heterotic responses for these traits.

The importance of the source of variation is indicated by the relative magnitude of variance components. The variance component estimates of SCA were greater than that of GCA for main stem leaves·plant^{-1}, stems·plant^{-1}, plant weight·plant^{-1}, average tuber weight·plant^{-1}, and tuber dry matter % (Table 1) indicating the predominance of non-additive gene action in the expression of these characters. The results were further confirmed from the estimation of GCA/SCA variance ratio, which ranged from 0.025 for main stem leaves/plant to 0.294 for main stem height/plant. GCA variance was also found important for tuber number by other workers[10~12]. There may not be genes for yield as such, however, yield is an end product of multiplicative interactions between yield components[13, 14]. Therefore, the low GCA for tuber yield was essentially due to low GCA of yield components such as average tuber weight·plant^{-1}. High SCA variance for stems·plant^{-1} and predominance of non additive gene action for tuber yield·plant^{-1} in seedling generation was also observed by Dayal [15] and Thopmson [16]. Similarly, SCA variance was found important for tuber yield[11] and average tuber weight[17]. In addition, the ratio of the mean square components associated with variance of GCA and SCA was much less than the theoretical maximum of unity for all traits studied. These results tend to suggest that genetic variation among crosses was primarily of the non-additive type. The results of the analysis of variance for combining ability were also confirmed from the additive (σ^2A) and dominance (σ^2D) components of variance (Table 1).

Table 1 Analysis of variance for combining ability for different characters in true potato seed population

Soure	DF	Main stem height·plant^{-1}(cm)	Main stem leaves·plant^{-1}	Stems·plant^{-1}	Plant weight·plant^{-1}	Average tuber weight·plant^{-1}	Tuber dry matter(%)
Replication	2	1.183ns	63.898ns	0.656ns	575.826**	20.578ns	2.911ns
Genotypes	16	197.482***	502.106***	0.597ns	4635.559***	179.194***	6.024**
Parents	6	470.603***	854.848***	0.651ns	9929.455***	444.994***	3.646ns
Parents vs							
Hybrids	1	0.001ns	699.272***	3.207**	9671.534***	69.195*	46.073***
Hybrids	9	37.344ns	245.037***	0.272ns	546.742***	14.217ns	3.159ns
Line	4	69.769*	322.398***	0.172ns	544.244**	7.955ns	2.203ns
Tester	1	44.004ns	72.593ns	0.033ns	31.348ns	2.268ns	8.495*
Line×Tester	4	3.254ns	210.787***	0.431ns	678.089***	23.466ns	2.781ns
Error	32	19.336	23.592	0.320	98.108	11.082	1.812
Variance components estimates							
σ^2GCA(line)		11.086	18.602	-0.043	-22.307	-2.585	-0.096
σ^2GCA(tester)		2.717	-9.213	-0.027	-43.116	-1.413	0.381
σ^2GCA(Average)		1.573	1.581	-0.007	-6.062	-0.427	0.017
σ^2SCA		-5.361	62.398	0.037	193.327	4.128	0.323
σ^2GCA/σ^2SCA		-0.294	0.025	-0.198	-0.031	-0.103	0.054
Additive components of variance(σ^2A)		25.168	25.296	-0.112	-96.992	-6.832	0.272
Dominant components of variance(σ^2D)		21.444	249.592	0.148	773.308	1.032	1.292
Proportional contribution to total variances							
Line		83.035	58.476	28.139	44.241	24.868	30.993
Tester		13.093	3.292	1.362	0.637	1.773	29.877
Line-tester		3.872	38.232	70.499	55.122	73.359	39.130

*, ** and *** Significant at 5%, 1% and 0.1% level, respectively.

The estimates of general combining ability effects (Table 2) showed that the good combiners for main stem height·plant^{-1} was Lalsilbilati; for main stem leaves·plant^{-1} were Patnae and Lalpakri; for plant weight·plant^{-1}was Lalpakri. Among the parents Ausha showed significant positive GCA effects for average tuber weight·plant^{-1}. It may be used to develop high yielding hybrids. The GCA effects for yield and average tuber weight appeared to be positively correlated which confirmed the observation of Gaur et al[3].

Table 2　Estimation of general combining ability (GCA) effects of parent lines for different traits

Parent lines	Main stem height·plant^{-1}(cm)	Main stem leaves·plant^{-1}	Stems·plant^{-1}	Plant weight·plant^{-1} (g)	Average tuber weight·plant^{-1}	Tuber dry matter(%)
Line						
Lalsibilati	5.611*	4.611	-0.078	-0.789	0.98*	-0.993
Patnae	-1.444	-6.056*	-0.244	2.211	-0.209	0.596
Lalpakri	-1.278	9.111**	0.200	14.767*	-1.274	0.117
Challisha	0.444	0.889	0.089	-6.067	-0.878	0.333
Ausha	-3.333	-8.556	0.033	-10.122	1.381*	-0.053
S. E. (gj)	1.795	1.983	0.231	4.044	1.359	0.550
S. E. (gi-gj)	2.539	2.804	0.327	5.719	1.922	0.777
Tester						
TPS-67	-1.211	-1.556	0.033	-1.022	0.275	0.532
TPS-13	1.211	1.556	-0.033	1.022	-0.275	-0.532
S. E. (gi)	1.135	1.254	0.146	2.557	0.860	0.348
S. E. (gi-gj)	1.606	1.774	0.207	3.617	1.216	0.492

*, ** Significant at 5%, 1% level, respectively.

Out of 10 crosses studied, only one Ausha/TPS-67 showed significant positive SCA effects for main stem leaves·plant^{-1}. For average tuber weight·plant^{-1}, the crosses Patnae/TPS-67 and Lalpakri/TPS-13 showed significant positive SCA effects (Table 3). There did not appear to be any relationship between the combining ability of the parents and the SCA effects observed in the crosses for above two characters. This indicated that selection of parents on the basis of combining ability will not limit the exploitation of SCA effects for the improvement of these characters. The poor combiners, however, invariably showed absence of SCA effect in the cross. For tuber dry matter %, five crosses showed positive SCA effects, the highest being in Ausha/TPS-13 followed by Patnae/TPS-67 and Lalpakri/TPS-13 in general. The crosses involving one good combiner and the other average or poor combiner showed significantly positive SCA effect.

The cross population with high GCA and SCA effects holds promise for producing desirable segregants in cultivated potatoes. The crosses having one parent with high GCA effects and other parent with low or average are expected to throw desirable transgress segregants if additive genetic system present in high combiner and complimentary epistatic effects present in the cross combination act in the same direction. However, it is total genetic variance which is appropriate to gauge the effectiveness of selection in potato since potato is grown through vegetative propagation from tubers or as heterozygous progeny

Table 3 Estimation of specific combining ability (SCA) effects of crosses for different characters in potato

Crosses	Main stem height·plant-1(cm)	Main stem leaves·plant-1	Stems·plant-1	Plant weight·plant-1(gm)	Average tuber weight·plant-1	Tuber dry matter(%)
Lalsibilati/TPS-67	-0.456	-5.833	-0.144	-8.478	-0.997	0.396
Patnae/TPS-67	0.156	3.167	0.356	9.633	2.590*	0.690
Lalpakri/TPS-67	1.211	-3.667	-0.311	-12.144	-2.378*	-0.458
Challisha/TPS-67	-0.289	-2.444	-0.089	11.800	-0.602	0.324
Ausha/TPS-67	-0.622	8.778*	0.189	-0.811	1.387	-0.952
Lalsilbilati/TPS-13	0.456	5.833	0.144	8.478	0.997	-0.396
Patnae/TPS-13	-0.156	-3.167	-0.356	-9.633	-2.590*	-0.690
Lalpakri/TPS-13	-1.211	3.667	0.311	12.144	2.378*	0.458
Challisha/TPS-13	0.289	2.444	0.089	-11.800	0.602	-0.324
Ausha/TPS-13	0.622	-8.778*	-0.189	0.811	-1.387	0.952
S. E.	2.539	2.804	0.327	5.719	1.922	0.777

*, ** Significant at 5%, 1% level, respectively.

from tuber potato seed (TPS), so not only will additive genetic effects remain "fixed" but also dominance and epistatic effects which are desirable for crop performance. Hence exploitation of additive and non-additive components of genetic variance by "population breeding" based on large scale crossing and recurrent selection with progeny testing is contemplated for improving the tuber yield in potato.

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