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IDENTIFICATION OF SUPERIOR PARENTS FOR POTATO BREEDING PROGRAMMES OF NEW CULTIVARS FOR PROCESSING

ABSTRACT

Combining ability of 27 potato parents was evaluated in three factorial cross experiments (North Carolina II design) at Młochów Research Center of Plant Breeding and Acclimatization Institute (IHAR). The pool of tested forms comprised 18 cultivars and 9 parental lines. Depending on the experiment 60 or 90 unselected individuals per each family were evaluated. Completely randomised block design was applied for the purposes of each experiment. Progenies were evaluated for 7 traits. Important from the point of view of processing quality traits: fry colour, percentage of defect–free chips, tuber shape and the incidence of secondary growth seem to be determined by both additive and non–additive action of genes. However, in the case of fry colour the proportion of general combining ability were considerably higher than that for specific combining ability. There were identified five valuable parents for breeding of cultivars suitable for chip processing (Atlantic, Brodick, Panda, Signal, M–62633), and two parents (Agria, Shepody) for breeding of cultivars for French fries processing.

Key words: combining ability, fry colour, parental choice, potato, tuber quality traits

INTRODUCTION

Development of new potato cultivars suitable for processing is an important objective of breeding programmes in most developed and developing countries. The major processing products are chips and French fries. Quality traits important both for cultivars used in chip and French fries manufacturing include low reducing sugar content as it determinates to large extent a light golden colour of fried product and freedom from defects (Dale and Mackay, 1994). Cultivars destined for chip–processing should have starch content within limits of 15–19 percent, round or round–oval shape of tubers with smooth skin. For frozen–processing into French fries, desirable cultivars are long in tuber shape and blocky with starch content within limits of 14–16 percent.

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The regular breeding work to develop cultivars specifically for production of potato chips has been started first in North America after 1960 (Love *et al.*, 1998) and next about 15 years later in Europe (Zgórska and Frydecka–Mazurczyk, 1997). For a long time, the selection of the parental combinations was mainly based on a phenotype evaluation of potential parents. The crosses between good chipping parents were the source of breeding populations for improving fry colour, a key characteristic of potato chips (Hoopes and Plaisted, 1987).

Breeding progress in new initiated programmes directed to the development of parental lines or cultivars that will produce acceptable chips after being stored at cold temperatures may be accelerated by the use of progeny test for fry colour and traits describing tuber appearance (Pereira *et al.*, 1995; Mackay *et al.*, 1997). Information on combining abilities of the potential parents enables the breeder identification of superior parental forms, next introducing them into crossing programme in order to generate genetic variation in new breeding populations. In such breeding populations the superior segregants appear with increased likelihood.

The purpose of this study was to evaluate the combining abilities of several West–European and North American cultivars well known from their good processing quality in respect of such traits as: fry colour, percentage of defect–free chips, mean tuber weight, tuber shape, depth of eyes, incidence of tubers with secondary growth and growth cracking.

MATERIAL AND METHODS

Plant materials

The material used for this study came from three crossing factorials (North Carolina II design) in which one set of parents comprised 18 cultivars, mainly West–European. Generally, cultivars used as parents were chosen on the basis of their diversity in ability for processing. Cultivars: Atlantic, Brodick, Ponto, Signal belonged to the group of chipping cultivars, while the group of cultivars used in French fries manufacturing was repesented by cvs: Agria, Disco and Shepody. The other set of parents consisted of 9 tetraploid parental lines chosen for their increased dry matter, resistance to viruses and *P. infestans*. All progenies were laid out in experiments in a completely randomised block design. The progenies in the number of 28 derived from crosses of seven maternal forms (cvs: Arkadia, Atlantic, Brodick, Mondial, Obelix, Ponto, Rustica) with the set of males (M–62410, M–62570, PW–341, PW–368) were evaluated in the 1st progeny test in 1998. Each cross was represented by two replicate plots of 30 field grown seedlings (60 unselected seedlings per cross). The 2nd progeny test in 1999 comprised of 12 progenies from crossing of parental lines (M–62543, M–62563, PW–363) with the set of males (cvs: Bimonda, Disco, Panda, Van Gogh). The 3rd progeny test in 2000 consisted od 21 progenies originated from crosses between set of female parents (Agria, Ditta, Santé, Shepody, Signal, Ajiba, Nikita) and parental lines (M–62410, M–62633, PW–392) as males. Each cross of 2nd and 3rd progeny test was represented by three replicate plots of 30 field grown seedlings (90 unselected seedlings per cross). Seedlings were spaced 67.5 cm between plants and rows.

Traits recorded

The yield of every seedling of all progeny tests was assessed for tuber weight – in kg/plot, mean tuber weight – in g, incidence of tubers with secondary growth and growth cracking – in percentage, tuber shape and depth of eyes were scored on 1–9 scale, where: (1 = round compressed, 9 = long) for tuber shape; (1 = extremely deep, 9 = very shallow) for depth of eyes.

A sample of 30 tubers of medium size (55–60 mm diameter) per family (1 tuber from each seedling, from the first two replicates) was used to determine fry colour and percent of defect–free chips. Chips were produced just after three months storage at 4°C and reconditioning (two weeks at 18°C). Two 1.6 mm thick slices were cut transversally from mid–section of each tuber, washed in water, dried onto paper towel, and fried in hydrogenated vegetable oil at about 180°C until bubbling ceased. Fry colour was scored, using the colour cards of IBVL, on a scale ranging from 1 to 9, where 9, means very pale. The chips were also inspected for defects. Chips scored ≥ 6.5 obtained status the defect–free ones.

Statistical analysis

The data per family across replicates were analysed according to factorial mating design (Comstock and Robinson, 1952; Węgrzyn, 1996). In the case of variables: incidence of tubers with secondary growth and growth cracking, percent of defect–free chips, the arcsine transformation was applied. Analysis of variance of the combining ability and estimates of GCA and SCA effects were performed using STATGRAPHICS *Plus* v. 4.1 Professional (Manugistic, Inc., Rockville) and SAS DGH2 (Kala *et al.* 1996) software packages.

RESULTS AND DISCUSSION

Initial analysis of variance revealed significant differences among studied crosses for all the traits. In analysed pool of parents (Tables 1–3) both general (GCA) and specific (SCA) combining ability effects were of significant importance in the expression of such traits as: fry colour, percentage of defect–free chips, tuber shape and the incidence of secondary growth. This means that both additive effects and genetic interactions are involved in determining the ability to chip, and other above mentioned traits. However, the role of GCA in the variation of fry colour among progenies seems to be more important than SCA effects. These

Table 1

Analysis of variance for combining ability of several traits in the 1st progeny test

Source of variance	DF	Mean squares: Fry colour	Percentage of defect–free chips	Mean tuber weight	Tuber shape	Depth of eyes	Incidence of: Secondary growth	Growth cracking
GCA of males (m)	3	4735.66**	1385.85**	116.10**	1137.94**	237.28**	131.89**	25.94
GCA of females (f)	6	4020.16**	909.27**	442.20**	864.71**	175.67**	33.63**	33.92*
SCA	18	664.55**	213.54**	109.20**	335.46**	25.83*	22.61**	25.58*
Error	27	255.60	65.01	24.75	85.30	12.14	2.04	10.60
Variance components								
$\sigma^2_{(m)}$		290.79	83.74	0.49	57.32	15.10	7.81	0.03
$\sigma^2_{(f)}$		419.45	86.97	41.62	66.16	18.73	1.38	1.04
$\sigma^2_{(fm)}$		204.48	74.26	42.22	125.10	6.85	10.29	7.49
Broad–sense heritability: h^2_s		0.88	0.88	0.87	0.85	0.87	0.95	0.62
Narrow–sense heritab.: h^2_n		0.68	0.62	0.44	0.42	0.72	0.45	0.08

*, ** – significant at α = 0.05 and α = 0.01 respectively
DF – degrees of freedom

Table 2

Analysis of variance for combining ability of several traits in the 2nd progeny test

Source of variance	DF	Mean squares: Fry colour	Percentage of defect–free chips	Mean tuber weight	Tuber shape	Depth of eyes	Incidence of: Secondary growth	Growth cracking
GCA of males (m)	3	2662.42**	326.03**	1310.97**	706.43**	156.27**	111.35**	11.88
GCA of females (f)	2	3173.72**	113.23*	1161.62**	1713.80**	590.85**	24.21	66.52**
SCA	6	857.09*	116.81**	308.02**	611.49**	29.29	42.96*	24.97*
Error	22/11 1/	268.57	17.12	64.69	92.52	23.54	11.91	7.39
Variance components								
$\sigma^2_{(m)}$		300.89	34.87	111.41	10.55	14.11	7.60	0.00
$\sigma^2_{(f)}$		289.58	0.00	71.13	91.86	46.80	0.00	4.62
$\sigma^2_{(fm)}$		294.26	49.84	81.11	172.99	1.92	10.35	5.86
Broad–sense heritability: h^2_s		0.77	0.83	0.80	0.75	0.89	0.82	0.81
Narrow–sense heritab.: h^2_n		0.51	0.34	0.56	0.28	0.86	0.35	0.36

*, ** – significant at α = 0.05 and α = 0.01 respectively
1/ – for traits: fry colour and percentage of defect–free chips; DF – degrees of freedom

results agree with those of Cuningham and Stevenson (1963) and Loiselle *et al.* (1990). A good example of the parent with high breeding value for chipping quality is variety Lanape which can be found in the pedigree of 12 North American cultivars bred specifically for potato chip–industry (Love *et al.*, 1998). The relative importance of GCA effects in the expression of tuber shape were found by Neele *et al.* (1991) and Domański *et al.* (2000).

Table 3

Analysis of variance for combining ability of several traits in the 3rd progeny test

Source of variance	DF	Mean squares: Fry colour	Percentage of defect–free chips	Mean tuber weight	Tuber shape	Depth of eyes	Incidence of: Secondary growth	Growth crack–ing
GCA of males (m)	2	2850.26**	259.69**	432.26**	26.75	966.35**	91.00**	51.42**
GCA of females (f)	6	2248.89**	208.02**	1270.41**	2033.92**	81.95*	83.29**	48.83**
SCA	12	764.88*	114.76**	104.02	204.59*	44.51	31.59*	20.34**
Error	40/20[1/]	299.45	26.55	75.34	84.48	29.28	13.75	4.04
Variance components								
$\sigma^2_{(m)}$		148.96	10.35	15.63	0.00	43.90	2.83	1.48
$\sigma^2_{(f)}$		247.34	15.54	129.60	203.26	4.16	5.74	3.17
$\sigma^2_{(fm)}$		232.72	44.11	9.56	40.04	5.08	5.95	5.43
Broad–sense heritability	h^2_s	0.81	0.84	0.86	0.90	0.84	0.76	0.88
Narrow–sense heritab.:	h^2_n	0.51	0.31	0.81	0.75	0.76	0.45	0.41

* , ** – significant at α = 0.05 and α = 0.01 respectively
[1/] – for traits: fry colour and percentage of defect–free chips

Table 4

Estimates of GCA effects in the 1st progeny test

Parents	Chip colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with: Secondary growth [degrees]	Growth cracking [degrees]
Males							
M–62410	18.48**	9.40**	–0.58	6.36**	1.49	1.03**	–1.91*
M–62570	–10.79**	–3.39	2.99*	7.87**	4.38**	–0.52	–0.02
PW–341	–20.08**	–12.47**	1.32	–11.59**	–0.47	–3.92**	1.14
PW–368	12.39**	6.46**	–3.73**	–2.64	–5.40**	3.40**	0.79
Females							
Arkadia	–5.74	–4.74	–0.04	–3.66	–4.16**	3.04**	0.08
Atlantic	16.18**	5.68*	9.23**	–10.48**	–4.81**	–3.83**	1.36
Brodick	36.62**	19.72**	4.68**	–3.64	0.05	0.19	1.77
Mondial	–26.08**	–12.83**	3.07	8.67**	4.98**	–0.17	0.65
Obelix	–26.01**	–8.33**	1.53	12.08**	7.42**	0.60	–3.88**
Ponto	4.77	1.69	–4.67**	–13.46**	–3.40**	–0.55	–1.56
Rustica	0.26	–1.19	–13.82**	10.48**	–0.08	0.73	1.58

* , ** – significant at α = 0.05 and α = 0.01 respectively

The coefficient of broad–sense heritability for the incidence of growth cracking was generally higher than the narrow–sense one, which means that in determining the above mentioned trait a major role is played by non–additive gene effects. Significant effects of specific combining ability for this trait were also reported by Killick (1977).

For potatoes, an asexually propagated crop heritability in the broad sense should be used to predict the response to selection within breeding population (Tai and Young, 1984; Bradshaw *et al.*, 1998)

Table 5

Estimates of GCA effects in the 2nd progeny test

Parents	Chip colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with	
						Secondary growth [degrees]	Growth cracking [degrees]
Males							
Bimonda	–10.25	–1.86	–7.29**	–6.95*	–2.76	–3.06**	–1.44
Disco	–13.33*	–2.77	13.93**	12.69**	5.24**	2.81**	1.22
Panda	31.42**	10.72**	5.83*	–0.32	–3.88*	3.28**	0.54
Van Gogh	–7.83	–6.09**	–12.48**	5.43	1.41	–3.03**	–0.31
Females							
PW–363	18.44**	3.85**	–10.20**	–12.35**	–4.91**	1.50	–2.07**
M–62543	–21.13**	–3.67*	9.44**	1.12	8.04**	–1.32	2.56**
M–61563	2.67	–0.19	0.76	11.23**	–3.13*	–0.19	–0.49

*, ** – significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

In the studied population there is still large amount of GCA variation for mean tuber weight and depth of eyes, which can be exploited in further breeding work. Estimates of GCA effects of the 11 parents (progeny test 1st) are presented in Table 4. With regard to traits important for processing, fry colour and percentage of defect–free chips breeding lines: M–62410, PW–368, and cultivars: Atlantic, Brodick were good general combiners. These required traits in case of cvs Atlantic and Brodick were associated with positive GCA effect for mean tuber weight and ability to transmit round tuber shape to the offspring. The parental line PW–368 should be crossed to good general combiners for: mean tuber weight, eye depth and freedom from secondary growth, because of its negative effects for these traits. The breeding value of the remaining parents from 1st progeny test is too low to generate good chipping offspring.

Among tested parents in the 2nd progeny test (Table 5) the cv. Panda was the best at transmitting pale chip colour and large tuber to their offspring. Value of the clone PW–363 as a parent was comparable to that presented by the clone PW–368.

Out of all the maternal forms from 3rd progeny test (Table 6) cvs Agria and Shepody can be utilized in the breeding programmes for French fries–processing because of their positive GCA effects for: fry colour, mean tuber weight and elongated tuber shape. Interesting as parents for breeding programmes for chip–processing was the clone M–62633 combining significantly favourable GCA effects for chip colour, percentage of defect–free chips, mean tuber weight and round tuber shape.

Information about the value of potential parents useful in the developing of cultivars for processing into French fries are very limited. A tuber progeny test for fry colour, tuber shape and size, and incidence of defects has been used to identify the most promising crosses for processing (Mackay *et al.*, 1997).

Table 6

Estimates of GCA effects in the 3rd progeny test

Parents	Chip colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with	
						Secondary growth [degrees]	Growth cracking [degrees]
Males							
M–62410	2.13	1.97	2.14	–1.29	–7.04**	0.76	–1.81*
M–62633	13.07**	2.97*	3.06	0.50	2.28*	–2.35**	0.90*
PW–392	–15.20**	–4.94**	–5.20**	0.79	4.77**	1.60*	0.91*
Females							
Agria	20.70**	7.46**	14.25**	5.34	1.17	3.17**	–0.70
Ditta	–19.46**	–7.42**	–15.60**	22.76**	4.06*	0.53	–1.48*
Santé	–9.96	–2.61	–14.18**	–24.79**	0.97	–4.67**	0.37
Shepody	15.84*	6.05**	9.03**	7.69**	–2.30	2.70*	–2.66**
Signal	18.17*	3.46	8.87**	–11.65**	0.99	–2.08	4.71**
Ajiba	2.20	–0.49	–5.47*	0.24	0.35	–2.24	0.35
Nikita	–27.50**	–6.46**	3.11	0.41	–5.42**	2.60*	–0.59

*, ** – significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

On total number of 427 SCA effects (Tables 7–9) there were found 47/50 significant positive effects of SCA which could be useful respectively in the developing of cultivars for chip–processing/French fries–processing. Significant positive SCA effects were found for the fry colour a key characteristic of potato chips in case of 6 crosses: Ponto × PW–341, Rustica × M–62410, PW–363 × Disco, M–62563 × Bimonda, Signal × M–62410, Nikita × M–62633.

Table 7

Estimates of SCA effects for crosses of the 1st progeny test

Cross combination	Fry colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with	
						Secondary growth [degrees]	Growth cracking [degrees]
Arkadia × M–62410	–22.41*	–12.92**	5.68	9.55	–1.44	0.48	–1.37
Arkadia × M–62570	13.66	2.41	11.66**	–4.46	–0.28	–1.41	–3.15
Arkadia × PW–341	4.76	8.29	–10.42**	–6.24	–2.88	–1.53	0.21
Arkadia × PW–368	3.99	2.21	–6.92*	1.16	4.60*	2.45**	4.32*
Atlantic × M–62410	3.32	8.60	–5.43	–1.58	–0.24	–2.43**	3.09
Atlantic × M–62570	–13.96	–6.81	0.59	–3.08	1.12	–0.60	4.13*
Atlantic × PW–341	15.88	–5.28	–2.39	–3.12	–0.73	0.17	–5.30**
Atlantic × PW–368	–5.24	3.49	7.25*	7.78	–0.15	2.86**	–1.93
Brodick × M–62410	2.63	–1.33	5.55	–9.91	0.15	–4.91**	–0.91
Brodick × M–62570	–1.85	–2.14	–5.26	12.83*	1.75	6.18**	4.25*
Brodick × PW–341	–6.46	–2.22	–0.04	12.24*	3.26	–1.76*	–0.64
Brodick × PW–368	5.67	5.70	–0.25	–15.16**	–5.16*	0.49	–2.70
Mondial × M–62410	–5.77	–0.08	–9.84**	10.57	1.02	–0.45	1.86

Table 7

Estimates of SCA effects for crosses of the 1st progeny test (Continued)

Cross combination	Fry colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with	
						Secondary growth [degrees]	Growth cracking [degrees]
Mondial × M–62570	10.95	0.90	3.65	–29.03**	–7.62**	2.18*	3.09
Mondial × PW–341	–11.46	–0.07	11.72**	13.18*	5.84**	–2.20*	–2.19
Mondial × PW–368	6.27	–0.75	–5.54	5.28	0.76	0.47	–2.76
Obelix × M–62410	–17.49	–10.78*	5.75	–7.94	–1.97	4.12**	–2.40
Obelix × M–62570	6.48	14.90**	–9.11**	9.30	3.59	–1.69*	–1.35
Obelix × PW–341	–1.93	–5.07	1.76	–8.08	–3.45	–2.22*	5.34**
Obelix × PW–368	12.95	0.95	1.60	6.72	1.83	–0.21	–1.58
Ponto × M–62410	–0.42	–2.86	–5.15	–12.35*	0.15	1.29	–2.24
Ponto × M–62570	4.15	2.38	3.94	3.69	–1.15	–0.91	–2.71
Ponto × PW–341	23.09*	15.26**	–2.74	1.61	–0.84	1.64	1.60
Ponto × PW–368	–26.83**	–14.77**	3.95	7.06	1.84	–2.02*	3.35
Rustika × M–62410	40.14**	19.38**	3.45	11.66*	2.33	1.89*	1.98
Rustika × M–62570	–19.44*	–11.64*	–5.46	10.75*	2.59	–3.75**	–4.25*
Rustika × PW–341	–23.89*	–10.91*	2.11	–9.58	–1.20	5.90**	0.97
Rustika × PW–368	3.19	3.16	–0.10	–12.83*	–3.72	–4.04**	1.30

*, ** – significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

Table 8

Estimates of SCA effects for crosses of the 2nd progeny test

Cross combination	Fry colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with	
						Secondary growth [degrees]	Growth cracking [degrees]
PW–363 × Bimonda	–19.44*	–7.13**	–3.84	–10.73*	–2.59	2.27	–1.33
PW–363 × Disco	20.40*	5.33*	–5.96	–6.27	2.12	1.43	0.49
PW–363 × Panda	–1.10	0.50	–2.63	–0.76	–1.72	2.77	3.29**
PW–363 × Van Gogh	0.15	1.30	12.42**	17.75**	2.19	–6.46**	–2.46*
M–61543 × Bimonda	–10.38	–5.16*	–7.50*	0.57	–0.11	–1.50	–0.81
M–61543 × Disco	–1.79	–0.91	1.74	–3.21	–3.36	–0.17	–1.14
M–61543 × Panda	14.96	5.57*	5.54	–2.90	2.03	–1.22	–2.05
M–61543 × Van Gogh	–2.79	0.50	0.22	5.54	1.44	2.89	4.00**
M–62563 × Bimonda	29.81**	12.29**	11.34**	10.16*	2.70	–0.77	2.13
M–62563 × Disco	–18.60*	–4.42	4.22	9.48*	1.24	–1.25	0.65
M–62563 × Panda	–13.85	–6.07*	–2.92	3.66	–0.31	–1.55	–1.24
M–62563 × Van Gogh	2.65	–1.80	–12.64**	–23.30**	–3.63	3.58*	–1.55

*, ** – significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

Table 9

Estimates of SCA effects for crosses of the 3rd progeny test

Cross combination	Fry colour [Σ scores/plot]	% of defect–free chips [degrees]	Mean tuber weight [g]	Tuber shape [Σ scores/plot]	Depth of eyes [Σ scores/plot]	Incidence of tubers with: Secondary growth [degrees]	Incidence of tubers with: Growth cracking [degrees]
Agria × M–62410	–15.26	–8.50**	1.13	1.39	–2.15	2.17	0.82
Agria × M–62633	8.10	7.09*	7.32	–0.33	3.20	–1.40	1.27
Agria × PW–392	7.17	1.41	–8.45*	–1.06	–0.39	–0.77	–2.08*
Ditta × M–62410	6.70	0.78	6.89	8.97*	–0.60	1.29	0.76
Ditta × M–62633	–13.14	–2.25	–7.60	–1.35	1.61	1.73	1.74
Ditta × PW–392	6.43	1.46	0.70	–7.62	–1.01	–3.02	–2.49**
Santé x M–62410	5.30	–1.76	0.37	8.85*	8.72**	3.06	–0.46
Santé x M–62633	9.66	2.52	–0.28	–1.31	–6.67**	–0.65	0.62
Santé × PW–392	–14.97	–0.76	–0.08	–7.54	–2.05	–2.41	–0.16
Shepody × M–62410	4.90	7.48*	–1.21	–10.13*	–2.90	–1.72	4.04**
Shepody × M–62633	–13.34	–8.13**	–4.33	7.88	3.58	1.88	–0.94
Shepody × PW–392	8.43	0.65	5.54	2.25	0.68	–0.16	–3.10**
Signal × M–62410	24.67*	12.96**	–1.92	4.85	–5.30*	0.31	–2.92**
Signal × M–62633	–29.57**	–9.86**	–2.61	–6.11	–0.46	2.66	–0.69
Signal × PW–392	4.90	–3.10	4.53	1.26	5.76*	–2.96	3.62**
Ajiba × M–62410	–2.56	–2.73	–3.51	–9.21*	2.11	–2.68	–1.40
Ajiba × M–62633	4.30	5.48	7.90*	7.03	–3.21	–1.34	–1.43
Ajiba × PW–392	–1.73	–2.75	–4.40	2.17	1.10	4.02*	2.83**
Nikita × M–62410	–23.76*	–8.23**	–1.75	–4.72	0.78	–2.43	–0.83
Nikita × M–62633	34.00**	5.15	–0.41	–5.81	1.95	–2.87	–0.56
Nikita × PW–392	–0.23	3.09	2.16	10.53*	–2.73	5.30**	1.39

*, ** – significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

CONCLUSIONS

Traits important from the point of view of chipping quality like: fry colour after cold storage and reconditioning, percentage of defect–free chips, tuber shape and the incidence of secondary growth seem to be determined by both additive and non–additive action of genes. However, in the case of fry colour the proportion of general combining ability were considerably higher than that for specific combining ability.

Five valuable parents were identified for breeding programmes directed on the developing of progenies with good chip quality: cultivars – Atlantic, Brodick, Panda, and Signal with significant positive GCA effects for fry colour, percentage of defect–free chips and mean tuber weight; the parental line – M–62633 with significant positive effects of GCA for fry colour, percentage of defect–free chips, depth of eyes and lack of secondary growth.

Cultivars Agria and Shepody can be utilized as parents in the breeding programmes for French fries–processing because of their positive GCA effects for fry colour, mean tuber weight and elongated tuber shape.

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