Phenotypic Stability for tuber yield and Late Blight resistance in advanced clones from B3C3

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Group B3C3, comes from the cross between elite clones of B3C2, started in 2011, planting 30,000 genotypes in greenhouses in La Molina, at harvest 21685 clones were selected for their good agronomic characters, then in 2011-2012, they were planted in the field in Huancayo and the harvest, 3005 clones were selected for yield and good agronomic characters such as skin color, flesh color, tuber shape and eyes depth, plant vigor, uniformity of tubers.

In 2012-2013 these clones were planted in Oxapampa in order to evaluate their late blight (LB) resistance, tuber yield, selecting 507 at harvest. These clones continued to be evaluated and selected in Oxapampa and Huancayo for LB resistance and yield respectively during 2013 to 2015, 80 clones were selected with high level of LB resistance, high yiled, some of them good aptitude for french fries and/or chips, resistance to virus PVX and/or PVX, heat tolerance, precocity 90 days) and low glycoalkaloid content. The best 30 clones of them were taken for this study.

During 2016 until 2018, with the objective of studying phenotypic stability for late blight resistance and tuber yield in 30 advanced clones belonging to population B group B3, third cycle 3 - B3C3 (table 1). Eight experiments were performed; Three in Oxapampa -OXA (2000 masl) to study the phenotypic stability of resistance to late blight and five in La Molina-LAM 2016 (150 masl), Huancayo – HYO, 2016 and 2017 (3200 masl) and San Ramon – SRA, 2016 and 2017 (800 masl) for the tuber yield.

The randomized complete blocks statistical design was used, with three repetitions of 10 plants each.
Information on late blight resistance was taken, through the percentage of leaf area damaged by this disease, for 6 weeks at 7-day intervals. With the information obtained, the area under the curve of progress of the disease, AUDPC and the scale of susceptibility to late blight (SAUDPC), with values from 1 to 9 were calculated. At harvest for tuber yield, we taken the number of plants harvested, the number and weight of commercial and, non-commercial tubers, then the commercial (MTY) and total yield (TTY) per Hectare was calculated.

For the analysis of phenotypic stability, the AMMI (additive main effects and multiplicative interaction) methodology. We used for the late blight resistance, the values of AUDPC and the Scale of susceptibility to late blight and for tuber yield we used commercial and total yield per hectare.
Analysis of variance for total and commercial tuber yield and resistance to late blight (AUDPC and SAUDPC), shows statistically significant differences (α=0.01) for environments, clones and the interaction of clones x environments, the CVs were within the normal range. Principal components (PC) contributed significantly in the explain of the interaction clones x environment (Table 2).

In the biplot of the AMMI phenotypic stability analysis, for the resistance to the late blight, measured through the AUDPC, shows in Figure 1 that the principal components PC1 and PC2 explain 60.6% and 39.4% of the interaction of clones x environments respectively. 24 of the 30 clones under study are phenotypically stable in their resistance to late blight with average values of AUDPC from 78.33 to 535.69 and 6 clones do not show stability in their resistance. These results indicate that stable clones maintain their resistance in comparison to non-stable clones that vary in their resistance over time.

In the biplot for the commercial tuber yield, the principal components PC1 and PC2 explain 48.5% and 34.5% of the interaction clones x environments respectively. (Figure 3), showing that the clones CIP308427.194, CIP308436.173, CIP308436.245, CIP308441.201, CIP308452.167, CIP308482.163, CIP308486.187, CIP308486.355, CIP308490.407, CIP308493.22, CIP308510.80, CIP308513.318, CIP308518.201 and CIP308518.7 are phenotypically stable with average tuber yields in the range of 22.57 to 28.32 th^{-1}. The clones CIP308480.287, CIP308497.212, CIP308498.191, CIP308498.280, CIP308513.404, CIP308517.91 and CIP308519.433, were also

phenotypically stable but with average tuber yields less than 20 th^{-1}. The clones CIP308478.59, CIP3078487.157 and CIP308487.197 are phenotypically unstable and are adapted under HYO conditions with an average yield of 22.43 to 40.68 th^{-1}, clones CIP308474.153, CIP308479.56 and CIP308480.292 with 25.89, 26.06 y 23.80 th^{-1}, are also unstable but they are adapted to SRA.

Results

For the total tuber yield, the biplot for principal components PC1 and PC2 explain 50.4% and 32.5% of the interaction clones x environments. (Figure 3). 18 clones showed phenotypic stability for this character with tuber yields from 25.71 to 31.14 th^{-1} (Table 3, Figure 3).

13 clones combine stability for commercial and total tuber yield and late blight resistance, these clones can be used for release of new varieties or as parental in crossing plans in the NARS (Table 3).

Annexes

Table 1.- Clones B3C3 with resistance to late blight in studio for Phenotypic Stability for resistance to late blight and tuber yield.

#	Clone	Female	Male	Skin Color	Flesh Color	Tuber Shape	Eyes Deep	TTY th^{-1}	MTY th^{-1}	AUDC	SAUDPC
1	CIP308427.194	CIP395017.229	CIP395011.2	pink	cream	oblong	superficial	32.57	28.32	192.50	1.34
2	CIP308436.173	CIP395111.13	CIP395011.2	cream	cream	elliptical	superficial	30.68	28.30	220.28	1.53
3	CIP308436.245	CIP395111.13	CIP395011.2	cream	cream	elliptical	superficial	31.12	26.37	293.06	2.16
4	CIP308441.201	CIP395114.5	CIP396240.2	cream	cream	elliptical	superficial	28.82	24.93	405.28	3.07
5	CIP308452.167	CIP396026.101	CIP395011.2	cream	cream	elliptical	superficial	25.66	24.04	117.50	0.94
6	CIP308474.153	CIP395037.107	CIP395096.7	Red/Cream	cream	oval	Superficial	28.33	25.89	464.17	4.46
7	CIP308478.123	CIP395096.2	CIP396264.14	cream/pink	cream	oval	superficial	25.71	23.73	355.56	2.68
8	CIP308478.59	CIP395096.2	CIP396264.14	cream	cream	oblong	superficial	43.50	40.68	315.28	2.17
9	CIP308479.56	CIP395096.5	CIP395017.242	cream	cream	rounded	superficial	29.01	26.06	453.33	3.42
10	CIP308480.287	CIP395109.29	CIP395017.242	cream	cream	elliptical	superficial	20.02	17.73	78.33	0.50
11	CIP308480.292	CIP395109.29	CIP395017.242	cream	cream	elliptical	superficial	26.00	23.80	320.56	2.53
12	CIP308482.163	CIP395109.34	CIP396038.107	pink	cream	Oblong	superficial	29.80	27.13	330.28	2.52
13	CIP308486.187	CIP395112.32	CIP396012.288	Cream	Cream	Round	Superficial	27.40	24.39	319.72	2.37
14	CIP308486.355	CIP395112.32	CIP396012.288	Purple	Cream	Round	Superficial	31.14	27.62	510.56	3.91
15	CIP308487.157	CIP395112.32	CIP396264.14	Red	Cream	Oval	Superficial	24.72	22.43	211.39	1.47
16	CIP308487.197	CIP395112.32	CIP396264.14	red	cream	oblong	superficial	29.74	26.79	387.78	2.80
17	CIP308490.332	CIP395112.36	CIP396263.8	cream/pink	cream	oblong	superficial	22.04	19.57	376.11	2.47
18	CIP308490.407	CIP395112.36	CIP396263.8	cream/pink	cream	oval	superficial	30.12	27.04	633.06	4.51
19	CIP308493.22	CIP395117.3	CIP395096.3	cream	cream	oval	superficial	27.90	22.57	366.11	2.48
20	CIP308497.212	CIP396004.225	CIP396041.102	red	yellow	oval	superficial	24.37	20.50	428.06	2.59
21	CIP308498.191	CIP396004.263	CIP395017.229	cream	yellow	oval	superficial	17.41	15.48	338.61	3.57
22	CIP308498.280	CIP396004.263	CIP395017.229	Cream	Cream	Oval	Superficial	20.71	18.46	366.11	2.63
23	CIP308505.377	CIP396009.239	CIP396004.337	cream/pink	cream	oblong	superficial	22.40	20.39	535.69	5.80
24	CIP308510.80	CIP396031.118	CIP395077.12	pink	yellow	oval	superficial	27.56	24.15	256.39	1.82
25	CIP308513.318	CIP396033.102	CIP395152.16	Purple	Cream	Oval	Superficial	29.13	26.95	224.44	2.53
26	CIP308513.404	CIP396033.102	CIP395152.16	purple	cream	oblong	superficial	19.24	17.59	336.94	2.39
27	CIP308517.91	CIP396034.103	CIP396038.107	red	cream	Oblong	superficial	22.64	19.94	70.83	0.50
28	CIP308518.201	CIP396034.103	CIP396041.102	pink	cream	oblong	superficial	30.25	25.55	71.39	0.46
29	CIP308518.7	CIP396034.103	CIP396041.102	red	cream	oblong	superficial	26.70	23.74	151.11	1.07
30	CIP308519.433	CIP396046.105	CIP396017.227	cream/pink	cream	oblong	superficial	21.38	19.71	411.94	2.88
31	Kory - INIA	Control								587.19	3.76
32	Amarilis - INIA	Control								1076.26	5.69
33	Yungay	Control								1095.49	6.00

Table 2.- Analysis of variance AMMI for resistance to late blight (AUDPC y SAUDPC) and total and marketable tuber yield over environments 2016-2018.

Source of variation	Mean Square					
	df	TTY	MTY	df	AUDPC	SAUDPC
Environment	4	12989.50**	11688.20**	2	10671116.00**	618.70**
Replicactions/Environment	10	64.10	54.40	6	13681.00**	1.07**
Clones	29	390.20**	335.60**	32	483011.00**	18.78**
clones x environment	116	223.80**	211.40**	64	126878.00**	10.30**
PC1	32	379.07**	372.04**	33	149154.40**	16.60**
PC2	30	190.36**	282.13**	31	103163.50**	3.61**
PC3	28	87.39**	85.58**			
PC4	26	33.75**	67.60**			
Pooled error	290	35.70	34.00	192	3163.00	0.22
CV (%)		25.41	24.30		15.09	17.25

Table 3.- Phenotypic Stability AMMI for Commercial and total tuber yield and resistance to late blight (AUDPC)

#	Clone	TTY	MTY	AUDC
1	CIP308427.194	Unstable	Stable	Stable
2	CIP308436.173	Stable	Stable	Stable
3	CIP308436.245	Stable	Stable	Stable
4	CIP308441.201	Stable	Stable	Stable
5	CIP308452.167	Stable	Stable	Unstable
6	CIP308474.153	Unstable	Unstable	Stable
7	CIP308478.123	Unstable	Unstable	Unstable
8	CIP308478.59	Unstable	Unstable	Stable
9	CIP308479.56	Unstable	Unstable	Stable
10	CIP308480.287	Stable	Stable	Stable
11	CIP308480.292	Unstable	Unstable	Stable
12	CIP308482.163	Stable	Stable	Stable
13	CIP308486.187	Unstable	Stable	Stable
14	CIP308486.355	Stable	Stable	Stable
15	CIP308487.157	Unstable	Unstable	Stable
16	CIP308487.197	Unstable	Unstable	Stable
17	CIP308490.332	Stable	Unstable	Stable
18	CIP308490.407	Stable	Stable	Unstable
19	CIP308493.22	Stable	Stable	Stable
20	CIP308497.212	Stable	Stable	Unstable
21	CIP308498.191	Stable	Stable	Stable
22	CIP308498.280	Stable	Stable	Stable
23	CIP308505.377	Unstable	Unstable	Stable
24	CIP308510.80	Unstable	Stable	Stable
25	CIP308513.318	Stable	Stable	Stable
26	CIP308513.404	Stable	Stable	Stable
27	CIP308517.91	Stable	Stable	Unstable
28	CIP308518.201	Unstable	Stable	Unstable
29	CIP308518.7	Stable	Stable	Stable
30	CIP308519.433	Stable	Stable	Stable

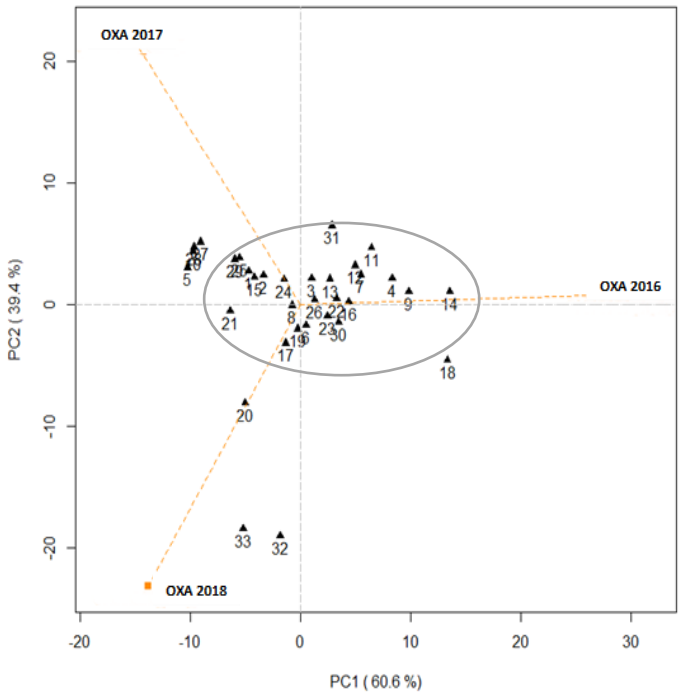

Figure 1.- Biplot from AMMI ANALYSIS for Late Blight resistance showing first and second principal components (PC1 and PC2) for three locations and 30 genotypes 2016-2018

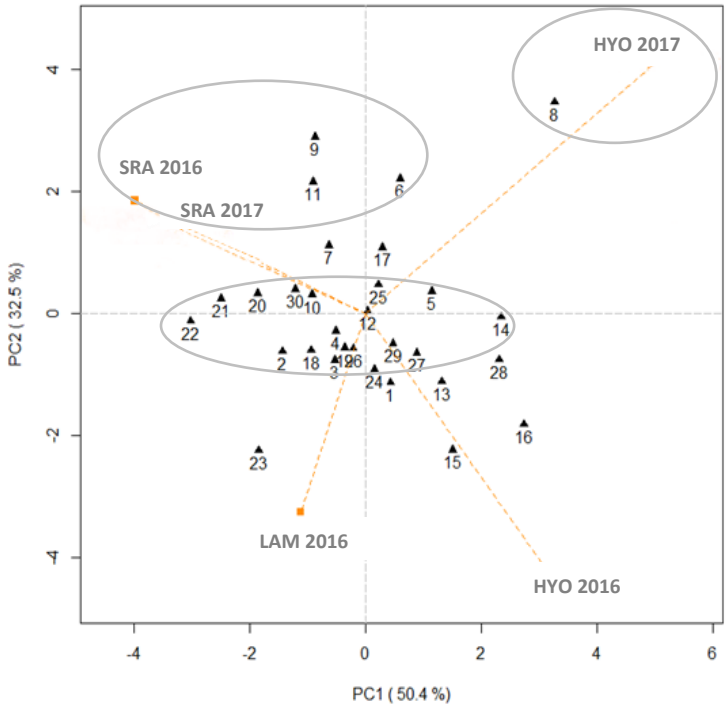

Figure 2.- Biplot from AMMI ANALYSIS for total tuber yield showing first and second principal components (PC1 and PC2) at five locations and 30 genotypes 2016-2018

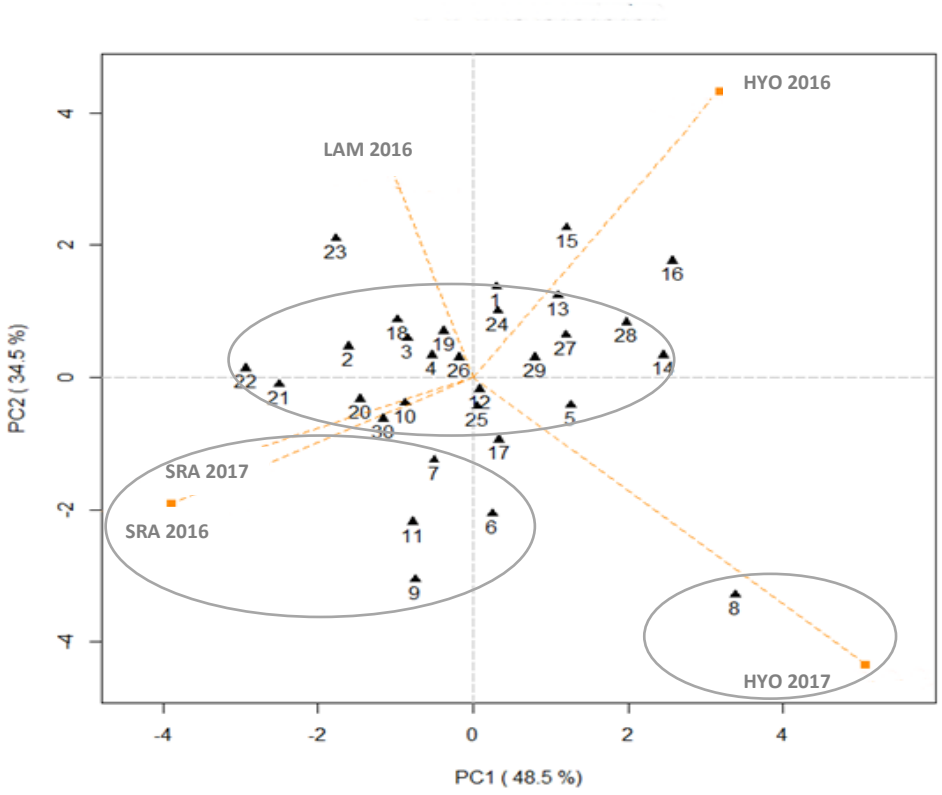

Figure 3.- Biplot from AMMI ANALYSIS for Commercial tuber yield showing first and second principal components (PC1 and PC2) at five locations and 30 genotypes 2016-2018