academicJournals

Vol. 9(45), pp. 3305-3312, 6 November, 2014
DOI: 10.5897/AJAR2014.8573
Article Number: 5EC2A0848428
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Performance of segregating populations of feijoa cultivated under the agroforestry systems in southern Brazil

Joel Donazzolo[1]*, Thiago Sanches Ornellas[2], Juliano Garcia Bertoldo[3] and Rubens Onofre Nodari[4]

[1]Universidade Tecnológica Federal do Paraná – Campus Dois Vizinhos/PR - Brazil.
[2]Universidade Federal de Santa Catarina, Brazil.
[3]Fundação Estadual de Pesquisa Agropecuária -FEPAGRO-, Centro de Pesquisa do Litoral Norte, Brazil.
[4]Programa de Pós-Graduação em Recursos Genéticos Vegetais, Universidade Federal de Santa Catarina, Brazil.

Received 2 February, 2014; Accepted 10 October, 2014

In the south of Brazil, the development of agroforestry systems (AFS) lacks knowledge about the adaptation of species. Feijoa [*Acca sellowiana* (O. Berg) Burret] is a fruit species, listed as being capable to use for AFS. In order to evaluate the performance of segregating populations derived from two crosses between selected genotypes (C1 and C2), established experimental plots under AFS in five farms were evaluated with traits of indicative vegetative growth, earliness and yield. The average mortality was 46% influenced by the cultivation environment with no difference between progenies of the crosses C1 and C2. The cultivation environment here is defined by soil and climate conditions of each site, as well as the structure of the AFS and the management adopted by the farmer. Plants crossing C1 flourished and produced nearly as twice as many fruits as compared to C2. C1 in general, showed greater variability and better performance for evaluated traits at Paraí location, a place that best discriminate the segregating populations. Thus, selection can be made and should be prioritized for the progeny from crossing C1 at Paraí cultivation environment that presented the best contrasts.

Key words: *Acca sellowiana*, Goiabeira-serrana, genotype × environment interactions, pineapple guava.

INTRODUCTION

The agroforestry systems (AFS) are designed in a process of "co-domestication" of tree species in a typically human activity (Wiersum, 1997). The concept of AFS was developed around 1970 and was based in the inclusion of agricultural crops in the forests or the incorporation of trees in farming systems, (Wiersum, 2004). For Nair (1993), AFS is "the cultivating purpose or the deliberate retention of trees with crops and/or animals in interactive combinations to multiple production or benefits from the same management unit".

For AFS to succeed, it must choose the tree species according to local conditions of climate, soil and topography. However, with much relevance in relation to said priority species generating income, it is necessary to have access to quality genetic resources (Dubois, 2008). For altitude areas of southern Brazil, the development of

*Corresponding author. E-mail: joel@utfpr.edu.br. Tel: +55 46 3536-8900.

AFS is still dependent on knowledge of the arrangement and adaptation of species. Besides "mate" (*Ilex paraguariensis*), araucaria (*Araucaria angustifolia*) and bracatinga (*Mimosa scabrella*) (Ilany et al., 2010; Moreira et al., 2011) other few species of these regions were studied to be used in AFS.

Based in its attributes, the feijoa (*Acca sellowiana* (O. Berg) Burret) also called pineapple-guava has been reported as one of the most promising species (Della Mea et al., 2009). It is a perennial fruit belonging to the *Myrtaceae* family, from the Southern Brazilian plateau and northern Uruguay (Mattos, 1990) and found also in Argentina (Keller and Tressens, 2007). In its natural habitat in Brazil, feijoa occurs more often in woods type formations (capons) and araucaria forests at altitudes between 900 and 1100 m above the sea level; however, with good development at lower altitudes of 700 m above the sea level (Lorenzini et al., 2007). It presents distinctive flavor, sweet-acidic and aromatic fruits (Mattos, 1990) which along with adaptation to cold climates and altitudes are characteristics that makes it attractive for cultivation in these sites (Santos et al., 2005).

Since the species is in the early stage of domestication in its naturally occurring area (Santos et al., 2005), one of the needs for its use is the availability of adapted genotypes to farmers cultivation site, in addition to presenting desirable fruit features. Thus, for commercial purpose, it is important that the selected varieties meet superior characteristics to the plants in their natural state with regard to productivity, stability in production and fruit quality (Degenhardt et al., 2005). Among the fruit species, the results of the breeding programs have been advanced in several species, especially peaches, grapes, citrus, apples, figs, pears and some that are not so common, like acerola, guava, cherimoyas and passion fruit (Pommer and Barbosa, 2009).

Although, feijoa cultivars has been launched in Brazil (Ducroquet et al., 2007, 2008), little is known about its cultivation in AFS. Also, under orchard conditions distant from biodiverse reality of the ecosystem of origin, often presents biotic disturbances with insects such as fruit flies and weevils (Hickel and Ducroquet, 1992) and fungi such as anthracnose (Ducroquet and Ribeiro, 1996), these problems could be alleviated by cultivation in AFS.

Thus, the objective of this study was to evaluate the performance of segregating populations from two crosses between feijoa superior genotypes, through the establishment of experimental plots under AFS in farmers' fields to enable the selection.

MATERIALS AND METHODS

Progenies of two crosses made by the Agricultural Research and Rural Extension Agency of Santa Catarina (Epagri – SC) were used. The three parental were chosen among the elite genotypes of feijoas from the Active Germplasm Bank of São Joaquim; SC for fruit size, pulp yield, total soluble solids content and tolerance to biotic agents). The first cross (C1) involved the genotypes ≠101 (female) and ≠458 (male) and the second cross (C2) was performed between the genotypes ≠125 (female) and ≠458 (male). The crosses were made in 2007 and the seedlings obtained in 2008, and thereafter transplanted to the field experiments in November of the same year. At that time, the seedlings presented 10 leaves between 8 and 13 cm in height for C1 and 8 leaves between 6 and 11 cm in height for the C2 without branching.

The experiments were established in five farmers' fields under different AFS design (see description below), in five countries of Rio Grande do Sul, Brazil. The seedlings, distributed according to available area were planted by farmers. Seedling pruning or foliar spray during the evaluation period was not done to allow the full expression of the traits under AFS conditions. The handling of ruderal herbs and fertilizers were particular to each of the four AFS.

The cultivation environments were:

i. Antônio Prado – (28° 50'42.2" S; 51° 15'10.9" W; Altitude: 690 m) - Located in permanent protection area on the edge of a stream which exits the bed with some frequency, previously an annual cropping area. The soil is of low fertility. AFS has the goal of restoring riparian vegetation and fruit production to marketing. Fruit species (native and exotic) were also planted. From planting until 2010, when each plant was fertilized with 3 to 4 kg of organic compost, the management practices consisted only of weeding. AFS is exposed to the west, and the plants have direct light from the sun only in the afternoon.

ii. Nova Bassano – (28° 42' 23" S; 51° 41' 21" W; Altitude: 640 m) - Area intended diversified crops was ecologically transformed into AFS, taking the quince as a species of principal interest. The transplant took place in a period of severe drought. Despite several watering after planting in the second evaluation, it was verified that no seedling survived and the site was withdrawn from further evaluations.

iii. São Domingos do Sul – (28° 31'16.3" S; 51° 52'47.9" W; Altitude: 685 m) - Area with steep slope, formerly cultivated with sugar cane and abandoned. It is of low fertility, northern exposure, and it is in the initial phase of regeneration of native vegetation. Onsite lime seedlings were planted in 2007 and 2008 as species of economic interest inset to native vegetation. Regeneration of natural species is managed with mowing them so as to maintain a suitable level of shading in the view of the farmer. No fertilizer were added other than nutrient cycling. The planting was done with good soil moisture conditions. Although, there was a period of severe drought after planting, watering was not performed. The shade level estimated in the fifth evaluation was approximately 40%.

iv. Paraí – (28° 34'47.2" S; 51° 47'27.4" W; Altitude: 645 m) – A flat terrain area was used to organically crop annual species (peanuts, beans and corn, among others) for several years. In 2007 and 2008, AFS was implemented with several tree species (native and exotic) for various purposes from fruit to lumbering. The management consisted only of weeding. In the winter of 2009 a severe frost decimated much of the tree species, except feijoa, which were replaced in the next year, or held the regrowth when present. The area is lush natural fertility. The level of shading was assessed on the fifth review of full sun.

v. Sananduva – (27° 56'59" S; 51° 48'24" W; Altitude: 636 m) - Crop area with good natural fertility, clay soil and flat terrain. Native and exotic species (fruit, timber and fertilizer plants) were planted in 2007 in line to form an AFS in alleys. In the following summer and winter the area received green manure formed by a mixture of species (sunflower, corn, sun hemp, oats, vetch and radish, among others). Also, vegetable products and annual crops (cassava, sweet potatoes, beans, and cucurbits) were cultivated. The feijoa plants were inserted between the other species in the rows and received between 1 and 2 kg/seedling of organic compost and 300 g of powder of crushed rock (basalt). However, there was a period of drought after three weeks of planting, when the plants were

Table 1. Percentage of mortality of progeny plants of two crosses of Feijoa evaluated in five different locations in Rio Grande do Sul, under AFS from 3 to 39 months of transplantation.

Cross	Location	n	Age of evaluation (months)				
			3	9	17	28	39
	Paraí	09	0	0	0	0	0
	Antônio Prado	08	0	0	0	0	0
C1	Nova Bassano	08	38	100	100	100	100
	Sananduva	13	46	-	62	62	62
	São Domingos	12	58	75	75	75	75
	Paraí	08	0	0	0	0	0
	Antônio Prado	08	0	0	0	0	0
C2	Nova Bassano	09	33	100	100	100	100
	Sananduva	13	39	-	69	69	69
	São Domingos	12	0	25	25	25	25
	Paraí	17	0	0	0	0	0*
	Antônio Prado	16	0	0	0	0	0
C1 + C2 (n=100)	Nova Bassano	17	35	100	100	100	100
	Sananduva	26	42	-	65	65	65
	São Domingos	24	29	50	50	50	50
C1		50	32	-	50	50	50^{ns}
C2		50	16	-	42	42	42
Grand Total		100	24	-	46	46	46

Only data of C1+C2 from 39 months after transplantation were submitted to the χ^2 test; *, ^{ns} = Significant (P<0.05) and not significant (P<0.05) deviation by the χ^2 test in the column, only at 39 months.

irrigated three times. In 2009, each native tree received 2 kg of poultry manure as fertilizer. The estimated level of shading in the fifth review was full sun.

The feijoa plants were evaluated for: height in centimeters, measured from the ground level to the apex of the plant; crown diameter in centimeters, obtained by averaging the diameter in the longitudinal and transverse to the line of cultivation; basal area of the stem of the plant in square centimeters, obtained from the diameter of the stem of the plant at five centimeters of soil, considering the ramifications when present; death rate; number of side branches at the stem of the plant; number of plants that flowered; number of plants showing fruiting and fruit yield, according to these categories, (Degenhardt et al., 2005) (Class 1 < 10, Class 2 = 11 - 40, Class 3 = 41 - 80, Class 4 = 81 - 120, Class 5 = 121 -160 and Class 6 > 160) the last three variables were taken only on season 2010/2011 and 2011/2012.

Assessments occurred five times: 3, 9, 17, 28 and 39 months after transplanting which occurred in November, 2008 being the last assessment conducted in February, 2012 when the analysis of soil fertility was performed. The assessments at 9 months in Sananduva and at 17 months in São Domingos do Sul were not conducted.

Data were subjected to descriptive statistics and the coefficient of phenotypic correlations were estimated by the PROC CORR procedure, using the statistical package SAS® 9.1.3 (2007). Non-orthogonal contrasts were estimated between crosses and location, and pair-to-pair for the other variables. For this evaluation, all data were analyzed by the GLM procedure of the statistical system SAS® 9.1.3 (2007). The variables mortality, fruiting and flowering were assessed qualitatively and tested with χ^2 in contingency table to determine the association between the effect of location and crosses.

RESULTS AND DISCUSSION

The final rate of mortality was not affected by crossing with C1 50 % and C2 42%, and an overall average for the experiment of 46% (Table 1). However, there was an association between seedling mortality and cultivation environments defined here as the soil and climate conditions of each site, the structure of AFS and the management adopted by the farmer. In the environments of Antônio Prado and Paraí, no plants died while in Nova Bassano all died but at Sananduva and in São Domingos do Sul the mortality were up to half of the planted seedlings (Table 1). The planting in November and the severe drought that occurred in that year (2008/2009) were probably the factors that most contributed to the high mortality, while from the nine months of transplantation there was no trend in the mortality rate.

The results showed that there were significant (P<0.05) differences between the values of means, variances and amplitudes among the progeny of crosses evaluated in four cultivation environments in Rio Grande do Sul

Table 2. Means, standard deviations, maximum and minimum values, variances and amplitudes of the traits of the plant height in cm (PHE), crown diameter (DIA), number of branches (NB), basal area (BA) and fruit yield (FY) for two crosses (C1 and C2) of Feijoa at 39 months after transplantation.

Genotype	Parameters	Characteristics				
		PHE (cm)	DIA (cm)	NB (un)	BA (cm^2)	FY (un)
C1	Mean	188	164	2.1	14.9	3.4
	Standard deviation	31	51	1.5	7.3	2.0
	Minimum	140	65	1.0	4.5	1.0
	Maximum	230	290	6.0	29.1	6.0
	Variance	971	2615	2.4	52.8	3.8
	Amplitude	90.00	225	5.0	24.6	5.0
C2	Mean	179	129	1.0	10.2	1.2
	Standard deviation	51	50	0.0	7.4	0.4
	Minimum	70	20	1.0	0.6	1.0
	Maximum	280	200	1.0	32.2	2.0
	Variance	2641	2482	0.0	54.4	0.2
	Amplitude	210	180	0.0	31.5	1.0
General	Mean	183	145	1.5	12.4	2.2
	Standard deviation	43	53	1.2	7.6	1.8
	Minimum	70	20	1.0	0.6	1.0
	Maximum	280	290	6.0	32.2	6.0
	Variance	1855	2797	1.4	58.3	3.1
	Amplitude	210	270	5.0	31.5	5.0

(Table 2). The means of the progenies of the cross C1 were higher for all traits compared to the average of the progenies of the cross C2 considering the genotypes *per se*. Regarding the amplitude and variance of the data, it can be verified that both values were higher in the C1 progeny for traits crown diameter (DIA), number of branches (NB) and fruit yield (FY). However, for the other traits, they were lower than in C2. In the C2 progenies, variance values were low for the traits NB, since their plants showed no branching and FY (Table 2).

Thus, there are presence of variability among crosses, although it cannot be completely isolated from the interaction between genotype x environment. In addition, the selection within the progeny of C1 can be more effective because, in general, there is greater variation between plants in comparison with C2 cross. However, depending on the breeder or a farm demands, gains from selection on the plant height (PHE) may be bigger when selection is practiced within the progeny of C2. This will depend on the type of plant being targeted and the fining evaluation of fruit and productivity characteristics. In addition to the higher values of the variances, the data amplitude in the segregating populations of both crosses reveals that the selection of promising individuals in segregating families is possible, since there are differences between individuals within the families. Analyzing amplitude values for the trait plant height, as an example, individuals were observed between 140 and 230 cm (C1) and between 70 and 280 cm (C2), which may provide the breeder an opportunity of selection for greater or lesser stature. It is worth noting that the differences between and within the progeny may have two origins, genetics and environmental, and the plants considered as the best can be propagated vegetatively, allowing to set the desired trait by fixing the genetic gain towards clonal propagation.

In order to verify the differences between the average of the crosses and growing environments, orthogonal contrasts were estimated (Tables 3 and 4). The progenies of C1 showed statistical differences ($P<0.05$) for all characters except plant height (Table 3). This result may be showing the superiority of progenies from this cross, considering the evaluated variables. Regarding four cultivation environments, significant differences were observed for almost all characters. It may be noted that, the Antônio Prado and Sananduva environments were differentiated from each other, and Paraí and São Domingos do Sul presented the greatest discrepancy. It is also important to highlight that the plants from Paraí environment had the highest averages for all evaluated traits with significant contrasts in relation to other cultivation environments, except for height (PHE) with the Sananduva environment. This result indicated that the cultivation environment is critical to the superiority or

Table 3. Contrasts pair-to-pair between two crossings and four environments for the characters plant height in cm (PHE), crown diameter (DIA), number of branches (NB), basal area (BA) and fruit yield (FY) for two crossings of Feijoa at 39 months after transplantation.

Crosses × Locals	Means				
	PHE (cm)	DIA (cm)	NB (un)	BA (cm^2)	FY (un)
Cross. 1	188	164	2.1	14.9	3.4
Cross. 2	179	129	1.0	10.2	1.2
Antônio Prado	162	136	1.4	10.3	1.7
Paraí	221	199	2.2	19.6	3.7
São Domingos	138	79	1.0	3.9	1.0
Sananduva	210	148	1.1	13.6	2.1
Contrasts			Pr>F*		
C1: Cross. 1 x Cross.2	ns	0.0154	0.0003	0.0226	<000.1
C2: A.Prado x Paraí	<000.1	<000.1	0.0282	<000.1	0.0004
C3: A.Prado x S.Domingos	0.0204	<000.1	ns	0.0016	ns
C4: A.Prado x Sananduva	<000.1	ns	ns	ns	ns
C5: Paraí x S.Domingos	<000.1	<000.1	0.0042	<000.1	<000.1
C6: Paraí x Sananduva	ns	0.0001	0.0159	0.0047	0.0145
C7: S.Domingos x Sananduva	<000.1	<000.1	ns	<000.1	ns

*Significant at the level of 5% by F test; ns = not significant (P<0.05).

Table 4. Pairwise contrasts between two crossings in four environments for the characters plant height in cm (ALT), crown diameter (DIA), number of branches (NB), basal area (BA) and fruit yield (FY) for two crossings of Feijoa at 39 months after transplantation.

Crosses x Locations	Means				
	PHE (cm)	DIA (cm)	NB (un)	BA (cm^2)	FY (un)
Cross.1 Antônio Prado	164	138	1.2	11.2	2.3
Cross.2 Antônio Prado	160	135	1.0	9.3	1.1
Cross.1 Paraí	210	218	3.3	20.8	5.6
Cross.2 Paraí	233	179	1.0	18.4	1.5
Cross.1 São Domingos	148	88	1.0	4.8	1.0
Cross.2 São Domingos	134	76	1.0	3.6	1.0
Cross.1 Sananduva	210	154	1.2	16.1	3.0
Cross.2 Sananduva	210	140	1.0	10.3	1.0
Contrasts			Pr>F*		
C1: Cross.1 x Cross.2 A. Prado	ns	ns	ns	ns	0.0035
C2: Cross.1 x Cross.2 Paraí	ns	0.0066	<0.0001	ns	<0.0001
C3: Cross.1 x Cross.2 S. Domingos	ns	ns	ns	ns	ns
C4: Cross.1 x Cross.2 Sananduva	ns	ns	ns	ns	0.0002

*Significant at the level of 5% by F test; ns = not significant (P>0.05).

otherwise of a given genotype, and it is necessary to evaluate the progenies in different cultivation environments before any recommendation. Since the effect in years is prominent in the species (Degenhardt et al., 2003, 2002), it is also prudent to monitor over time.

Additionally, the progenies of all crosses were

Table 5. Pearson's coefficients of phenotypic correlations (above the diagonal) and respective probability values (below the diagonal) for the traits plant height (PHE), crown diameter (DIA), number of branches (NB), basal area (BA) and fruit yield (FY) for two crossings of Feijoa.

Trait	PHE (cm)	DIA (cm)	NB (un)	BA (cm^2)	FY (un)
PHE (cm)	1.00	0.73	0.13	0.72	0.36
DIA (cm)	<0.0001	1.00	0.49	0.83	0.66
NB (un)	0.3203	0.0001	1.00	0.45	0.64
BA (cm^2)	<0.0001	<0.0001	0.0005	1.00	0.58
FY (un)	0.0074	<0.0001	<0.0001	<0.0001	1.00

compared pairwise within a cultivation environment in order to provide an understanding of the effect of the environment on their average behavior (Table 4). It can be seen that the Crosses C1 and C2 in general were not disparate in the Antônio Prado, São Domingos and Sananduva cultivation environments, where plants were statistically different for only one character (fruit yield). In turn, the Paraí environment allowed the largest number of statistical differences between the crosses, since the average values of the progenies of the crosses were distinct in this environment for crown diameter (DIA), number of branches (NB) and fruit yield (FY) (Table 4).

Thus, we can say that C1 was precocious for all environments, except for São Domingos where plants did not go into the reproductive phase for both crossings. Taking into account the vegetative growth, plants of C2 do not exhibit ramifications. The opposite occurred with C1 in the three cultivation environments which also resulted in plants with larger diameter at C1 in Paraí. Thus, the overall results indicated that the selection of individuals should be prioritized in the Paraí cultivation environment because selection is more pronounced in the environment that best discriminate the variables of the evaluated genotypes. Due to the similarity of the results, it is not necessary that one can be eliminated in the simultaneous selection in the Antônio Prado and São Domingos environments.

An important evaluation for the improvement of any species is the correlation between the characters. The existence of the positive and significant phenotypic correlation coefficients between all characters can be verified, except PHE × NB (Table 5). This demonstrates that the increase in height is accompanied with an increase in DIA, BA and FY (Table 5). However, the highest values of correlation coefficients were observed between the characters DIA × BA (0.83), PHE × DIA (0.73) and PHE × BA (0.72) and, consequently, those which have practical use. However, this will depend on the desired architecture of plant. Since feijoa shortest plants are most suitable for fruit harvesting, the correlation between PHE and FY may hamper genetic progress for higher productivity.

The onset and intensity (proportion of plants) of flowering and fruiting were dependent on both the crossing and the cultivation environment (Table 6). In the season of 2010/2011, two years after transplantation, 40% of the C1 plants flowered and 36% fructified, while only 3.4% of the C2 plants fructified (Table 6). In the following season, (2011/2012) three years after transplantation, approximately 90% of the C1 plants flowered and fructified. This performance reflects the genetic effect and may be related to a greater average diameter of the crown and higher average basal area of the stem (Table 3). This indicates that this family of siblings has a higher initial rate of growth and more earliness at the same time. Because it is segregating, progeny allows selection that can be done by the farmer themselves. Overall, the earliness was affected by genotype and by environment.

Importantly, the effect of cultivation environment was prominent for the beginning and intensity of flowering and fruiting (Table 6). In Paraí, in the season of 2010/2011, all plants of the C1 crossing flowered and fructified compared with 12.5% of C2 crossing, which amounted to almost 60% of plants for this environment. In addition, except for 6.3% of the plants of Antônio Prado (all of C1), no other plant bloomed or fructified this season (Table 6). For this cultivation environment, as shown above, except for plant height in relation to Sananduva, all other evaluated variables for growth were significantly higher, possibly by better fertility condition, especially phosphorus, presented by the soil from Paraí (Table 7). In the following season, (2011/2012) in Paraí and Antônio Prado, all plants flowered and most of them fructified, and in Sananduva 100% of the plants from the C1 and 25% of the C2 flowered and fructified (Table 6). In São Domingos do Sul, no plant bloomed until the 39 months of the transplant. In this cultivation environment, all evaluated parameters for growth were significantly lower in comparison to other environments, especially crown diameter and basal area of the stem, which may have influenced or not on the early reproductive stage. The lower levels of phosphorus in the soil, considered very low by soil analysis, coupled with the fact that this environment has not received any fertilizer, which may partly explain the delay in flowering. Besides soil fertility, the highest level of shading in São Domingos do Sul (40%) may have contributed to this behavior as well,

Table 6. Percentage of plants that flowered and fructified on seasons 2010/2011 and 2011/2012 derived from progeny of two crosses of Feijoa established in 2008 under AFS in four different places in Rio Grande do Sul.

Crosses/Locations	Flowering 2010/2011	Fructification 2010/2011	Flowering 2011/2012	Fructification 2011/2012
C1	40.0**	36.0**	88.0*	84.0**
C2	3.4	3.4	58.6	37.9
Paraí	58.8**	58.8**	100.0**	94.1**
Antônio Prado	6.3	0.0	100.0	68.8
Sananduva	0.0	0.0	66.7	55.6
São Domingos	0.0	0.0	0.0	0.0
C1/Paraí	100.0**	100.0**	100.0**	100.0**
C1/Antônio Prado	12.5	0.0	100.0	100.0
C1/Sananduva	0.0	0.0	100.0	80.0
C1/São Domingos	0.0	0.0	0.0	0.0
C2/Paraí	12.5ns	12.5ns	100.0**	87.5**
C2/Antônio Prado	0.0	0.0	100.0	37.5
C2/Sananduva	0.0	0.0	25.0	25.0
C2/São Domingos	0.0	0.0	0.0	0.0

* and ** = P<0.05 e P<0.01, respectively, of the adhesion to the χ^2 test in the column; ns = not significant (P>0.05).

Table 7. Soil analysis and interpretation criteria of the soils from the AFSs in the four locations studied.

Parameter	Locations			
	Paraí	Antônio Prado	Sananduva	São Domingos do Sul
Texture (% clay)	25 (Class 3)	35 (Class 3)	67 (Class 1)	19 (Class 4)
pH	5.7 (Medium)	5.8 (Medium)	5.9 (Medium)	5.6 (Medium)
SMP	6-	6.4	6.1	6.1
P (ppm)	>50 (Very High)	13.4 (High)	23.2 (Very High)	4.1 (Very low)
K (ppm)	250	133	192	226
MO (%(m/v))	5 (Medium)	2.1 (Low)	3.5 (Medium)	3.7 (Medium)
Al (cmolc/l)	0	0	0	0
Ca (cmolc/l)	10 (High)	4.1 (High)	6.7 (High)	8.4 (High)
Mg (cmolc/l)	1.6 (High)	1.6 (High)	3.2 (High)	1.7 (High)
Na (ppm)	39	24	29	31
H + Al (cmolc/l)	4.36	2.75	3.89	3.89
Sum Base (cmolc/l)	12.42 (High)	6.15 (High)	10.52 (High)	10.82 (High)
CTC (cmolc/l)	16.789 (High)	8.9 (Medium)	14.41 (Medium)	14.71 (Medium)
Saturation Bases (%)	74.02 (Medium)	69.1 (Medium)	73 (Medium)	73.56 (Medium)

Source: Physical Chemical and Biological Laboratory of the Integrated Company of Agricultural Development of Santa Catarina.

since the plants had lower growth and did not enter into the reproductive phase, while in other places, the plants have thrived practically at full sun. It is not yet scientifically enlightened about the adaptation of the plant with shading, although rarely they do occur in areas with very high levels of shading and the plants adapt preferably in open areas or on the edge of forests.

Thus, one can postulate that the entry in the reproductive period has the influence of genotype; however the conditions of feijoa plant development, that is, the soil and climatic characteristics of the site and the structure and management of AFS (environment), are also factors preponderant in this process. Whereas the main goal of using feijoa is for fruit production, which is necessary to continue the evaluations to meet with the robustness of the reproductive phase of this perennial plant, since the AFS are long-term experiments.

Conclusion

The progenies of the cross C1 (≠101 x ≠458) showed higher variation and better performance for the analyzed growth and reproductive traits. The site (soil and climate conditions, the AFS' structure and the management practices adopted) influenced the survival, growth and precocity of the plants. Paraí is the environment that best discriminated the segregating populations. Overall, feijoa can be used in distinct AFS systems.

Conflict of Interest

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

We sincerely thank the families of Alceu Tedesco, Anésio Foschiera, Cleomar Zoccolin, Fernanda Torrezan, and Diógenes Fracasso, for providing us with the area to work with; also we are grateful to the Centre of Alternative and Popular Technology and Ecological Center; to Karine L. dos Santos, researcher from Epagri-SC, by providing us with the supply of seedlings and also the Coordination for the Improvement of Higher Education Personnel (CAPES) for the scholarship awarded to J.D., and the The National Council for Scientific and Technological Development (CNPq) for the scholarships to other authors.

REFERENCES

Degenhardt J, Ducroquet JPHJ, Guerra MP, Nodari RO (2003). Variação fenotípica de características de frutos em duas famílias de meios-irmãos de Goiabeira Serrana (*Acca sellowiana* Berg.) de um pomar comercial em São Joaquim, SC. Rev. Bras. Frutic. 25:475-479. http://dx.doi.org/10.1590/S0100-29452003000300029

Degenhardt J, Ducroquet JPHJ, Guerra MP, Nodari RO (2005). Variação fenotípica em plantas de duas famílias de meios-irmãos de goiabeira-serrana (*Acca sellowiana* Berg.) em um pomar comercial em São Joaquim-SC. Rev. Bras. Frutic. 27:462-466. http://dx.doi.org/10.1590/S0100-29452005000300029

Degenhardt J, Ducroquet JPHJ, Reis MS, Guerra MP, Nodari RO (2002). Efeito de anos e determinação do coeficiente de repetibilidade de características de frutos de goiabeira-serrana. Pesq. Agropecu. Bras. 37:1285-1293. http://dx.doi.org/10.1590/S0100-204X2002000900012

Della Mea LG, Lorenzini AR, Luckman A, Boff P (2009). Goiabeira-Serrana em sistemas agroflorestais como forma de harmonização de pomares comerciais e das áreas de preservação permanente. *In*: I Workshop Sul Americano sobre Acca sellowiana. CCA/UFSC. São Joaquim, Brasil. 2009. CD-ROM.

Dubois JCL (2008). Classificação e Breve Caracterização de SAFs e Práticas Agroflorestais. *In*: Deitenbach A, Floriani GS, Dubois JCL, Vivan JL. Manual Agroflorestal para a Mata Atlântica. Ministério do Desenvolvimento Agrário, Brasil. pp. 15-64.

Ducroquet JPHJ, Nunes EC, Guerra MP, Nodari RO (2008). Novas cultivares brasileiras de goiabeira serrana: SCS 414-Mattos e SCS 415-Nonante. Agropec. Catarinense 21:79-82.

Ducroquet JPHJ, Ribeiro PA (1996). Goiabeira serrana: fatores climáticos trazem a pesquisa de volta ao centro de origem da espécie. Agropec. Catarinense 3:13-15.

Ducroquet JPHJ, Santos KL, Andrade ER, Boneti JI, Bonin V, Nodari RO (2007). As primeiras cultivares brasileiras de goiabeira serrana: SCS 411 Alcântara e SCS 412 Helena. Agropec. Catarinense 20:77-80.

Hickel ER, Ducroquet JPHJ (1992). Entomofauna associada à goiabeira serrana. Rev. Bras. Frutic. 14:101-107.

Ilany T, Ashton MS, Montagnini F, Martinez C (2010). Using agroforestry to improve soil fertility: effects of intercropping on *Ilex paraguariensis* (yerba-mate) plantations with *Araucaria angustifolia*. Agroforest Syst. 80:399-409. http://dx.doi.org/10.1007/s10457-010-9317-8

Keller HA, Tressens SG (2007). Presencia en argentina de dos especies de uso multiple: Acca sellowiana (Myrtaceae) y Casearia lasiophylla (Flacourtiaceae). Darwiniana 45:204-212.

Lorenzini AR, Boff MIC, Rech TD, Boff P (2007). Fitogeografia da goiabeira serrana no Planalto Serrano Catarinense. Agropec. Catarinense 20:86-89.

Mattos JR (1990). Goiabeira-serrana- Fruteiras nativas do Brasil. 2º ed. Ceue. Porto Alegre, Brasil.

Moreira PA, Steenbock W, Peroni N, Reis MS (2011). Genetic diversity and mating system of bracatinga (*Mimosa scabrella*) in a re-emergent agroforestry system in southern Brazil. Agroforest Syst. 83:245-256. http://dx.doi.org/10.1007/s10457-011-9428-x

Nair PKR (1993). An Introduction to Agroforestry. Kluwer Academic Publishers. The Netherlands, Dordrecht. http://dx.doi.org/10.1007/978-94-011-1608-4

Pommer CV, Barbosa W (2009). The impact of breeding on fruit production in warm climates of Brazil. Rev. Bras. Frutic. 31:612-634. http://dx.doi.org/10.1590/S0100-29452009000200043

Santos KL, Steirner N, Ducroquet JPHJ, Guerra MP, Nodari RO (2005). Domesticação da Goiabeira-Serrana (*Acca sellowiana*) no Sul do Brasil. Agrociência 9:29-33.

SAS Institute Inc. (2007). SAS® 9.1.3 (TS1M3) for Windows Microsoft. SAS Institute Inc: Cary.

Wiersum KF (1997). From natural forest to tree crops, co-domestication of forests and tree species, an overview. Neth. J. Agric. Sci. 15:425-438.

Wiersum KF (2004). Forest gardens as an 'intermediate' land-use system in the nature–culture continuum: Characteristics and future potential. Agroforestry Syst. 61:123-134. http://dx.doi.org/10.1023/B:AGFO.0000028994.54710.44