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RELATIONSHIP BETWEEN YIELD AND FRUIT QUALITY OF PASSION FRUIT C_{03} PROGENIES UNDER DIFFERENT NUTRITIONAL LEVELS[1]

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ABSTRACT -The present study was conducted to evaluate different fertilization-management strategies in ten progenies of passion fruit from the third recurrent selection cycle and their effects on yield and fruit-quality traits. For this purpose, we adopted the strategy of correlations analysis, using the phenotypic and path correlations in different environmental conditions characterized by three levels of fertilization. The trial was set up as a randomized-block design in a split-plot arrangement with progenies representing the plots and three levels of potassium-nitrogen fertilization as the sub-plots, with three replicates. Path analysis showed that number of fruits was the variable of highest correlation with fruit diameter at fertilization I. Fruit weight and pulp weight were correlated with each other and with other traits like fruit length and fruit diameter at the three fertilization levels, except for number of fruits, which was correlated with nitrogen and potassium only at fertilization II. Path analysis also revealed that fruit diameter (3.125) showed the highest direct effect on yield at fertilization I. However, fruit weight and number of fruits showed, at fertilization II, the highest direct effects of 2.964 and 1.134 on yield, respectively, and number of fruits had a high phenotypic correlation and direct effect on yield at the three fertilization levels: 0.528 at fertilization I; 2.206 at fertilization II; and 0.928 at fertilization III. The results demonstrate the greater direct effect obtained with fertilization II, suggesting that the level adopted at fertilization II can provide satisfactory gains in yield and is thus recommended for the population in question.

Index terms: Pomology, nitrogen, potassium, *Passiflora edulis* Sims, path analysis.

RELAÇÃO ENTRE PRODUTIVIDADE E QUALIDADE DE FRUTOS DE PROGÊNIES C_{03} DE MARACUJÁ-AZEDO SOB DIFERENTES NÍVEIS NUTRICIONAIS

RESUMO-O presente trabalho foi desenvolvido com a finalidade de avaliar diferentes manejos de adubação em dez progênies de maracujazeiro-azedo do terceiro ciclo de seleção recorrente e seus efeitos sobre variáveis de produção e qualidade de frutos. Para isso lançou-se mão da estratégia da análise de correlações via correlações fenotípicas e de trilha, em diferentes condições de ambiente caracterizados por três níveis de adubação. O ensaio foi montado em delineamento de blocos ao acaso num esquema de parcelas subdivididas com as progênies nas parcelas e os três níveis de adubação potássica e nitrogenada nas subparcelas, com três repetições. Observou-se através da análise de trilha que a variável número de frutos foi a que apresentou a correlação de maior magnitude com o diâmetro do fruto na adubação I, entretanto o peso do fruto e o peso da polpa correlacionaram-se entre si e com outras variáveis como o comprimento e diâmetro dos frutos nos três níveis de adubação, exceto o número de frutos que correlacionou com a variável nitrogênio e potássio apenas na adubação II. A análise de trilha, também mostrou que a variável diâmetro do fruto (3,125) apresentou maior efeito direto sobre a produtividade na adubação I. Entretanto o peso de frutos e o número de frutos apresentaram na adubação II os maiores efeitos diretos de 2,964 e 1,134 sobre a produtividade, respectivamente, e o número de frutos apresentou alta correlação fenotípica e efeito direto com a produtividade nos três níveis de adubação, de (0,528) na adubação I, de (2,206) na adubação II e de (0,928) na adubação III, evidenciando o maior efeito direto com a adubação II, indicando que no nível da adubação II pode proporcionar ganhos satisfatórios na variável produtividade, sendo recomendada para a população em questão.

Termos para indexação: Fruticultura, nitrogênio, potássio, *Passiflora edulis* Sims, análise de trilha.

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INTRODUCTION

The *Passiflora edulis* Sims (passion fruit) is grown mainly in tropical countries, which account for approximately 90% of the world production. Fruit-bearing specie has become crop of great economic importance thanks to the full use of the fruit, wherein the pulp is destined for fresh and industrial consumption, the peel serves as animal feed or organic waste, and the seeds are used for oil extraction (COSTA et al., 2008).

Commercial crops of this genus are almost entirely based on passion fruit, representing around 95% of commercial orchards. Brazil is the largest producer of passion fruit, having generated 823,284 t in a total area of 56,820ha harvested in 2014,with an average national production of 14.49 t ha^{-1} yr^{-1} (IBGE, 2014).

The Laboratory of Plant Breeding (*Laboratório de MelhoramentoGenético Vegetal* - LMGV) at the *Universidade Estadual do Norte Fluminense Darcy Ribeiro* - UENF has been developing a genetic breeding program for the crop aiming at the establishment of varieties adapted to the region (VIANA et al., 2003; GONÇALVES et al., 2007; SILVA et al., 2009; FERREIRA et al., 2016; SILVA et al., 2014). Research has recently been undertaken for the enhancement of plant production aspects and management of fertilization for the optimization of the yield and quality of this new cultivar. Such studies are of great relevance for the development of a more thorough technological package with specific indications for the aforementioned regions. In this regard, information about the fertilization and nutrition of passion fruit plants are extremely important, since this practice, coupled with others, is essential for obtaining greater productivity and fruit quality.

The management of fertilization in fruit species has been the object of study of many researchers. According to Aular and Natale (2013), the production increase at the expense of higher fertilization rates may cause a reduction in the quality of fruits, affecting their size, resistance to transport and storage, internal and external color, and total soluble solids content.

Brito Neto et al. (2011) evaluated the yield and fruit quality of 'Sunrise Solo' papaya as a function of N rates and found that N increased the yield, average fruit weight, and number of fruits per plant. Higher doses of N improved the diameter, fruit length, and total soluble solids (TSS) content. However, the pulp pH declined linearly as N rates were increased. Aular et al. (2014) observed that the response of 'Smooth Cayenne' pineapple to sources and levels of potassium on quality (fruit size, TSS, total titratable acidity [TTA], and TSS/TTA ratio) was positive to K and negative to N (fruit weight, TSS, and TTA). Total titratable acidity increased in response to K application, especially with the use of KCl. The use of K_2SO_4 resulted in a lower TSS/TTA ratio, especially at the highest K rates.

In plant breeding, the evaluation of fruit yield is an essential step. However, in fruit species, besides yield, fruit quality is also a parameter of great importance, as it determines the acceptance of the product and has a great impact on its price (NEGREIROS et al., 2007).

Knowing the association among traits is also a matter of great importance in breeding works associated with phenotypic evaluations under different environmental conditions, mainly in the case of traits of low heritability and/or difficult measurement (CRUZ et al., 2012). These relationships among traits can be modified by environmental changes; for this reason, investigating the association of traits in different environments is important for measuring these effects. Different environments are understood as the many planting seasons, irrigation depths, years, harvests, and fertilization-management strategies. Despite the usefulness of genotypic correlations in the understanding of a complex trait like yield, they only provide information on the association among traits (SOBREIRA et al., 2009). However, other types of research related to the estimated correlations can better discriminate the cause-effect relationships in the face of environmental changes, which can ultimately be credited if such environmental changes do occur. In this sense, path analysis is a noteworthy method for this type of study.

According to Cabral et al. (2011), path analysis has been used by several authors in many crops of economic importance, e.g., cotton (HOOGERHEIDE et al., 2007), wheat (VIEIRA et al., 2007), common bean (COIMBRA et al., 1999; FURTADO et al., 2002; KUREK et al., 2001), elephant grass (DAHER et al., 2004), exotic forest species (LORENTZ et al., 2006), 'bravo beans' (*Capparis flexuosa*) (SILVA et al., 2009), bell pepper (CARVALHO et al., 1999), and canola (COIMBRA et al., 2005).

Yield is a component of production that should be taken into account during the process of selection of new genotypes. However, when the explanatory traits are correlated with each other, the study should be focused on the decomposition of the existing correlations into their direct and indirect effects, in order to evaluate the degree of importance between each explanatory trait and the main trait (OLIVEIRA et al., 2010).

In view of the foregoing scenario, the present study was proposed to evaluate the relationship among passion fruit traits and their decomposition into direct and indirect effects, in ten progenies of passion fruit, aiming at the generation of heavier, better quality fruits, after fertilizing the plants with different levels of nitrogen-potassium.

MATERIAL AND METHODS

Treatments and experimental design

We evaluated 10 progenies of full siblings originating from the third cycle of intrapopulation recurrent selection of the passion fruit breeding program at UENF. The genotypes were propagated via formation of semi-hardwood cuttings, composed of the following progenies: *Pe* 57 × *Pe* 15, *Pe* 144 × *Pe* 130, *Pe* 112 × *Pe* 42, *Pe* 117 × *Pe* 19, *Pe* 68 × *Pe* 135, *Pe* 81 × *Pe* 117, *Pe* 132 × *Pe* 15, *Pe* 144 × *Pe* 42, *Pe* 68 × *Pe* 15, and *Pe* 46 × *Pe* 14. Afterwards, these progenies were allocated in a split-plot arrangement, with the different progenies allocated in the plots and the fertilization levels in the sub-plots. Production nitrogen fertilization was based in the values recommended by Carvalho et al. (2000), while potassium was applied following the recommendations of Sousa et al. (2003), at the following levels: fertilization I (330.0 g N plant^{-1} yr^{-1}; 660.0 g KCl plant^{-1} yr^{-1}), fertilization II (660.0 g N plant^{-1} yr^{-1}; 1,320.0 g KCl plant^{-1} yr^{-1}), and fertilization III (990.0 g N plant^{-1} yr^{-1}; 1,980.0 g KCl plant^{-1} yr^{-1}), split into 12 months.

Phenotyping

Twenty-five ripe fruits were collected and standardized by size in each experimental plot over two harvests; discrepant fruits were discarded for the assessments of traits. The following traits were evaluated: average fruit weight (FW, g), by weighing the fruits on a digital scale and dividing the value by two collections in the harvest period; average fruit length (FL, mm), obtained by measuring the longitudinal dimensions of the fruits, using a digital caliper; average fruit diameter (FD, mm), determined by measuring the transverse dimensions of the fruits, using a digital caliper; average peel thickness (PT, mm), determined by measuring four points of the outer layer in the middle portion of the fruits (cut transversely in the direction of the largest diameter), using a digital caliper; pulp weight(PW, g)determined by weighing the pulp (seed with aril)on a digital scale; fruit acidity (pH),obtained by measuring the pH of the pulp of each fruit using an electronic pH meter; soluble solids content (SS, °Brix),measured in the pulp of each fruit, using a Brix saccharimeter; number of fruits (NF)(a component of yield),determined by harvesting and counting all fruits per experimental unit once weekly, upon reaching the stage of physiological maturity, identified by the change of color in the peel to yellow; and yield (YLD, t ha^{-1}), calculated based on the weight produced per plot.

The concentrations of N (nitrogen) and K (potassium) nutrients were determined by a chemical analysis of the leaf tissue, using the sixth leaf of the productive branch. Nitrogen was determined by the method of Nessler (JACKSON, 1965), while K was determined by flame photometry, following Freitas et al. (2011).

Correlations and path analyses

In the analysis of associations between pairs of yield and fruit-quality traits, in the different fertilization-management strategies, the simple correlation coefficients were obtained by the following estimators:

a) Phenotypic correlations

$$r_F = \frac{PMG_{XY}}{\sqrt{QMG_X \, QMG_Y}}$$

Where MPG_{xy} =mean product among the genotypes for the traits X and Y; MSG_x = mean square among the genotypes for trait X; MSG_y = mean square among the genotypes for trait Y. The correlation coefficients (r) were subjected to the t test at the 1% and 5% probability levels.

b) Path Analysis

The path analysis consisted of studying the direct and indirect effects of the explanatory traits (N, K, FW, FL, FD, PT, PW, pH, SS, and NF) in relation to yield. Because yield (y) is considered a complex trait resulting from the combined action of other traits, the following model can be established:

$Y = \beta_{1x1} + \beta_{2x2} + ...\beta_{nxn} + \varepsilon$, $X_1, X_2, ..., X_n$ where are the explanatory variables and Y is the main variable (or dependent variable).

The direct and indirect effects of the explanatory traits are estimated over the main variable. In this way, $r_{iy} = p_i + \sum_{j=1}^{n} p_{ij} \, r_{ij}$, where r_{iy}: the correlation between the main variable (Y) and the i-th explanatory variable; p_i direct effect of variable i on the main variable; and $p_j r_{ij}$: indirect effect of variable *i*, via variable *j*, on the main variable. Analyses were run using GENES software (Cruz, 2013).

RESULTS AND DISCUSSION

The analysis of the matrix of phenotypic correlations among the measured traits at the dose applied in fertilization I showed that some traits were strongly interrelated, displaying values equal to or greater than 0.500. This strong interrelationship was detected between FW and FD: 0.935; FW and PW: 0.905; FD and PW:0.847; and FL and FW: 0.589 (Table 1). Fruit diameter had a higher correlation with FW than with FL and PW, even though the difference was small (Table 1). These results corroborate Negreiros et al. (2007), who found a higher correlation between fruit diameter and fruit weight than between fruit length and weight.

Recognizing the heaviest fruits in the field using simpler instruments is of great importance, since it benefits works aimed at the selection of more promising genotypes, as verified by the fruit 'equatorial diameter' trait (NEGREIROS et al., 2007).

As shown in Table 2, there were high correlations among some of the passion fruit traits at fertilization II, e.g., FW with PW, FD and FL: 0.866, 0.744,and 0.650, respectively. Pulp weight, in turn, showed a correlation of 0.581 with FD and of 0.546 with FL. There were correlations between NF with N and K of the respective orders of 0.539 and 0.495, and the highest correlation found between K and N was 0.623, suggesting a strong interrelationship between them at fertilization II.

At fertilization III, however, there were high correlations between FW with FD, FL and PW: 0.934, 0.759,and 0.652, respectively. The same was also true between PW and NF: 0.522. Fruit length had a correlation of 0.794 with FD and of 0.619 with PW. Fruit diameter had a positive, but less expressive correlation with PW, of 0.484, as well as with NF, of 0.422. Other correlations were observed between N with pH and SS: 0.334 and 0.586, respectively. Potassium showed correlations with FW, FL, and FD of the respective orders of 0.529, 0.517, and 0.448 (Table 3).

The negative correlations between PT with FW and PW at fertilizations I and III (Tables 1 and 3) are important for breeding programs, inasmuch as the industry of concentrated juice and the fresh fruit market value a finer peel in the classification of the fruit because it is inversely proportional to the amount of pulp and consequently to the juice yield (FORTALEZA et al., 2005). At fertilization II, the correlation was positive but low (Table 2).

The other selected traits showed correlation coefficients of low magnitude. In the case of these correlations, one can anticipate the possibility of indicating fertilization II as the fertilization-management strategy for the progenies in question.

In the choice for fruit yield and quality traits in passion fruit, we took into consideration agronomic criteria and trends of the consumer market for larger fruits with a heavier pulp. Another possibility is the selection of responsive genotypes with lower nutritional availability that nevertheless meet these market requirements, which can also be exploited in recurrent selection programs.

Identifying the correlation among easily measured traits and those related to fruit yield and quality is one of the goals of breeding programs to facilitate and accelerate the selection of superior plants (OLIVEIRA et al., 2010). Silva et al. (2007) suggest that the selection of papaya plants with a thicker stem may result in higher-producing plants, given the high genetic correlation between these traits (0.84).

Path analysis revealed that FD, PW, PT, NF and FL have correlations with the basic trait YLD, whereas PT has a low correlation, in the opposite direction, and a direct effect (0.678) with this trait. However, FD had a higher direct effect (3.215) PW (2.217), NF (0.528), and FL (0.498) at fertilization I (Table 4).This high direct effect indicates the cause-effect relationship, wherein FD, PW, NF, and FL were determinants of alterations in the basic trait YLD. However, these four traits contribute to production and consequently increase the yield of the crop. Similar results were reported by Negreiros et al. (2007). Path analysis revealed a determination coefficient (R^2) of 1.00, which, associated with the null residual effect, indicates that the effects of these traits is explain the totality of effects shown in the causal diagram adopted for the basic trait yield.

The indirect effects were relatively high. Fruit length, FD and PW had indirect effects on N of 0.859, 0.873, and 0.691, respectively (Table 4). This result is indicative of the high indirect correlation, via the N trait, of these explanatory traits with the basic trait (YLD).

In the fruit qualitative traits, pH was negatively correlated with YLD (−0.212) and had a high contrary direct effect (−0.934), which may indicate an effect of competition among fruits for photoassimilates and thus a dilution effect brought about by the increased yield. Soluble solids content displayed a negative correlation (−0.359) and evidenced a correlation coefficient of low relevance (0.023) with YLD. However, this fact was not observed for the positive indirect effect via the N trait (0.470) with the basic trait YLD, demonstrating the importance of evaluating the morpho-agronomic criteria of fruit quality as a function of different fertilization levels on the yield of passion fruit progenies. As stated by Silva et al. (2005), acidity is important for the industry in that it increases the difficulty of deterioration by microorganisms and allows for greater flexibility in sugar addition, an important step in the preparation of ready-to-drink beverages.

Number of fruits showed a high phenotypic correlation (0.661) and a direct effect (1.133) with the basic traitYLD (Table 5). Fruit weight presented a low phenotypic correlation (0.261) and a high direct effect (2.964) with YLD. There was a low phenotypic correlation of FL(0.270), FD(0.305), PW (0.363), and PT (−0.511) with YLD; however, they showed high-magnitude indirect effects via FW on YLD: 1.928, 2.206, 2.567,and 1.128, respectively (Table 5). Therefore, YLD can be directly influenced by the FW and NF and indirectly by the FL and FD, PW, and PT, whose correlation with YLD was high and negative, suggesting that a finer peel may provide greater yields. According to Negreiros (2007), pulp yield can also be selected indirectly, based on the lower peel thickness.

Table 6 describes the estimates of direct and indirect effects on the primary components of fruit yield and quality in passion fruit (N, K, FW, FL, FD, PT, PW, pH, SS, and NF) on the basic trait YLD. Number of fruits had a high phenotypic correlation (0.893) and direct effect (0.928) on YLD. Pulp weight also had a high phenotypic correlation (0.729) and direct effect (0.12) on YLD. However, FW, FL, FD, and PT showed respective correlations of 0.479, 0.331, 0.371, and −0.436 with YLD. Fruit weight and PT showed a high correlation with YLD, but of negative sign in the case of PT, and also negative direct effects, indicating that these traits may not provide satisfactory gains in yield for fertilization III.

TABLE 1- Estimate of phenotypic correlation coefficients among 11 agronomic fruit yield and quality traits of passion fruit (*Passiflora edulis* Sims) at fertilization I.

	K	FW	FL	FD	PT	PW	pH	SS	NF
N	0.559	-0.761	-0.612	-0.596	0.218	-0.492	0.552	-0.334	0.307
K		-0.640	-0.543	-0.498	0.308	-0.620	0.432	-0.036	-0.099
FW			0.589	0.935	-0.162	0.905	-0.662	0.299	0.023
FL				0.490	0.228	0.441	-0.109	0.108	-0.071
FD					-0.286	0.847	-0.643	0.098	0.189
PT						-0.108	0.388	0.398	0.054
PW							-0.499	0.329	0.079
pH								0.001	-0.069
SS									-0.190

Nitrogen = N, potassium = K, fruit weight = FW (g), fruit length = FL (mm), fruit diameter = FD (mm), peel thickness = PT (mm), pulp weight = PW(g), fruit acidity = pH, total soluble solids = SS (°Brix) and number of fruits = NF.

TABLE 2- Estimate of phenotypic correlation coefficients among 11 agronomic fruit yield and quality traits of passion fruit (*Passiflora edulis* Sims) at fertilization II.

	K	FW	FL	FD	PT	PW	pH	SS	NF
N	0.623	-0.115	0.173	-0.103	-0.129	-0.216	0.321	0.217	0.539
K		0.149	0.408	-0.139	0.205	0.008	-0.163	0.060	0.495
FW			0.650	0.744	0.380	0.866	0.067	-0.231	0.092
FL				0.184	0.433	0.546	0.169	0.236	0.327
FD					-0.159	0.581	0.206	-0.196	0.019
PT						0.177	-0.186	-0.004	-0.105
PW							-0.071	-0.280	-0.014
pH								0.275	0.647
SS									0.454

Nitrogen = N, potassium = K, fruit weight = FW (g), fruit length = FL (mm), fruit diameter = FD (mm), peel thickness = PT (mm), pulp weight = PW (g), fruit acidity = pH, total soluble solids = SS (°Brix) and number of fruits = NF.

TABLE 3- Estimate of phenotypic correlation coefficients among 11 agronomic fruit yield and quality traits of passion fruit (*Passiflora edulis* Sims) at fertilization III.

	K	FW	FL	FD	PT	PW	pH	SS	NF
N	0.280	0.224	-0.066	0.273	-0.194	-0.210	0.334	0.586	-0.063
K		0.529	0.517	0.448	-0.317	0.149	-0.274	0.213	-0.144
FW			0.759	0.934	-0.679	0.652	-0.475	0.393	0.439
FL				0.794	-0.187	0.619	-0.617	0.061	0.190
FD					-0.495	0.484	-0.361	0.250	0.422
PT						-0.420	0.255	-0.457	-0.368
PW							-0.586	0.381	0.522
pH								0.099	-0.090
SS									0.530

Nitrogen = N, potassium = K, fruit weight = FW (g), fruit length = FL (mm), fruit diameter = FD (mm), peel thickness = PT (mm), pulp weight = PW (g), fruit acidity = pH, total soluble solids = SS (°Brix) and number of fruits = NF.

TABLE 4 - Estimate of direct and indirect effects of explanatory traits on the basic trait yield (YLD) in passion fruit (*Passiflora edulis* Sims) at fertilization I.

Traits		N	K	FW	FL	FD	PT	PW	pH	SS	NF
Direct effects on YLD		-1.404	-0.514	-7.131	0.498	3.215	0.678	2.217	-0.934	0.023	0.528
Indirect effects	N		-0.786	1.068	0.859	0.837	-0.306	0.691	-0.775	0.470	-0.431
	K	-0.288		0.329	0.279	0.256	-0.158	0.319	-0.222	0.018	0.051
	FW	5.429	4.569		-4.205	-6.674	1.155	-6.457	4.723	-2.139	-0.165
	FL	-0.305	-0.271	0.293		0.245	0.114	0.220	-0.054	0.053	-0.035
	FD	-1.917	-1.603	3.009	1.577		-0.922	2.724	-2.068	0.315	0.609
	PT	0.148	0.209	-0.110	0.155	-0.194		-0.073	0.263	0.270	0.036
	PW	-1.092	-1.376	2.008	0.979	1.879	-0.240		-1.108	0.729	0.176
	Ph	-0.516	-0.405	0.619	0.102	0.600	-0.363	0.466		-0.001	0.065
	SS	-0.007	-0.000	0.007	0.002	0.002	0.009	0.008	0.000		-0.004
	NF	0.162	-0.053	0.012	-0.037	0.100	0.028	0.042	-0.037	-0.101	
	Total	0.210	-0.230	0.106	0.209	0.266	-0.005	0.157	-0.212	-0.359	0.830
	R^2	1.00045713									
	Residual effect	0.00									

Nitrogen = N. potassium = K, fruit weight = FW (g), fruit length = FL (mm), fruit diameter = FD (mm), peel thickness = PT (mm), pulp weight = PW (g), fruit acidity = pH, total soluble solids = SS (°Brix) and number of fruits = NF.

TABLE 5 - Estimate of direct and indirect effects of explanatory traits on the basic trait yield (YLD) in passion fruit (*Passiflora edulis* Sims) at fertilization II.

Traits		N	K	FW	FL	FD	PT	PW	pH	SS	NF
Direct effects on YLD		-0.038	-0.733	2.964	-0.022	-1.511	-1.535	-1.112	-0.676	-0.139	1.133
Indirect effects	N		-0.024	0.004	-0.007	0.004	0.004	0.008	-0.012	-0.008	-0.020
	K	-0.457		-0.109	-0.299	0.102	-0.150	-0.006	0.120	-0.044	-0.363
	FW	-0.343	0.442		1.928	2.206	1.128	2.567	0.199	-0.685	0.273
	FL	-0.003	-0.009	-0.015		-0.004	-0.009	-0.013	-0.004	-0.005	-0.007
	FD	0.157	0.211	-1.125	-0.279		0.241	-0.879	-0.312	0.296	-0.029
	PT	0.199	-0.315	-0.585	-0.665	0.245		-0.273	0.287	0.006	0.161
	PW	0.240	-0.009	-0.964	-0.609	-0.647	-0.197		0.079	0.311	0.015
	Ph	-0.218	0.110	-0.045	-0.115	-0.139	0.126	0.048		-0.174	-0.438
	SS	-0.030	-0.008	0.032	-0.033	0.027	0.000	0.039	-0.036		-0.064
	NF	0.611	0.561	0.104	0.371	0.022	-0.119	-0.016	0.733	0.515	
	Total	0.118	0.226	0.261	0.270	0.305	-0.511		0.378	0.073	0.661
	R^2	1.00045713									
	Residual effect	0.00									

Nitrogen = N, potassium = K, fruit weight = FW (g), fruit length = FL (mm), fruit diameter = FD (mm), peel thickness = PT (mm), pulp weight = PW (g), fruit acidity = pH, total soluble solids = SS (°Brix) and number of fruits = NF.

TABLE 6- Estimate of direct and indirect effects of explanatory traits on the basic trait yield (YLD) in passion fruit (*Passiflora edulis* Sims) at fertilization II.

Traits		N	K	FW	FL	FD	PT	PW	pH	SS	NF
Directeffectson YLD		0.086	0.203	-0.645	0.068	0.038	-0.216	0.312	-0.346	-0.036	0.928
Indirect effects	N		0.024	0.019	-0.005	0.024	-0.016	-0.018	0.029	0.050	-0.005
	K	0.057		0.108	0.105	0.091	-0.064	0.030	-0.056	0.043	-0.029
	FW	-0.144	-0.341		-0.490	-0.602	0.438	-0.421	0.306	-0.253	-0.284
	FL	-0.004	0.035	0.052		0.054	-0.013	0.042	-0.042	0.004	0.013
	FD	0.010	0.017	0.036	0.030		-0.019	0.019	-0.014	0.009	0.016
	PT	0.042	0.068	0.147	0.040	0.107		0.091	-0.055	0.099	0.079
	PW	-0.065	0.046	0.203	0.194	0.151	-0.131		-0.183	0.119	0.163
	Ph	-0.116	0.095	0.165	0.214	0.125	-0.089	0.203		-0.034	0.031
	SS	-0.022	-0.007	-0.014	-0.002	-0.009	0.016	-0.013	-0.004		-0.019
	NF	-0.059	-0.134	0.408	0.177	0.392	-0.342	0.484	-0.084	0.492	
	Total	-0.215	0.006	0.479	0.331	0.371	-0.436	0.729	-0.449	0.493	0.893
	R^2	1.00011538									
	Residual effect	0.00									

Nitrogen = N, potassium = K, fruit weight = FW (g), fruit length = FL (mm), fruit diameter = FD (mm), peel thickness = PT (mm), pulp weight = PW (g), fruit acidity = pH, total soluble solids = SS (°Brix) and number of fruits = NF.

CONCLUSIONS

The correlation of greatest magnitude was observed between fruit diameter and fruit weight, at fertilization I. Fruit weight and pulp weight were correlated with each other and with other traits like fruit length and diameter at the three fertilization levels, except number of fruits, which was correlated with the traits nitrogen and potassium only at fertilization II.

There were high correlations between the explanatory traits fruit diameter, pulp weight, number of fruits, and fruit length with direct effects on the yield of passion fruit progenies. Indirect effects on yield were also obtained by traits fruit weight, fruit length, fruit diameter, and pulp weight by the nitrogen trait.

Only number of fruits showed a high phenotypic correlation and direct effect on yield at the tree fertilization levels — 0.528 at fertilization I; 2.206 at fertilization II; and 0.928 at fertilization III —, indicating that fertilization II can provide satisfactory gains in yield and also highlighting the possibility of selecting more efficient genotypes in nutrient utilization.

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