Analysis of Pineapple Production Systems in Benin

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Abstract

In Benin, pineapple is an important fruit crop, mainly grown in the Atlantic department. The overall quality of the two cultivars grown, 'Sugarloaf' and 'Smooth Cayenne', does not meet the requirements for some outlets and the heterogeneity in fruit quality within and between lots is high. This paper (1) describes and analyses the pineapple production systems of 'Sugarloaf' and 'Smooth Cayenne' and (2) identifies the main constraints reducing the quality of pineapple produced. First, semi-structured interviews were carried out with key informants including producers' organisations, input supplier and extension agents. Next, an in-depth questionnaire was carried out with 100 producers in the Atlantic department. Additionally, pedological and meteorological information was collected. Results indicated that pedo-climatic conditions in the Atlantic department were favourable for pineapple cultivation. The production practices were very diverse for both cultivars, especially regarding planting material used (slips, hapas and suckers), planting density, flowering induction time, and fertiliser application. The production systems of the two cultivars differed in type of planting material used, planting density, use of K_2SO_4, number of fertiliser applications and ethephon application. In 'Smooth Cayenne' cultivation, only hapas and suckers were used, planting density was lower, the number of fertiliser applications was higher, K_2SO_4 was generally used and maturity was more often synchronised than in 'Sugarloaf' cultivation. The main constraints were availability of appropriate planting material, heterogeneity in weight, age and leaf number of planting material, and availability and high costs of fertilisers. Tackling all these constraints would help producers improve the quality of produced pineapple in Benin.

INTRODUCTION

In Benin, the rural sector occupies 70% of the work force, contributes 39% to the Gross Domestic Product (GDP) and provides 90% of the export earnings (MAEP, 2005). In order to reduce poverty, the Benin government has decided to promote new export crops including pineapple [*Ananas comosus* (L.) Merrill]. Pineapple is the second most important tropical fruit in terms of production volume in West Africa, after banana (FAO, 2009). In Benin, it is the main crop in the southern part, mainly in the Atlantic department, where it is cultivated by about 70% of the producers. The Atlantic department realizes about 95% of the total Benin pineapple production (Helvetas-Bénin, 2008). Two varieties are cultivated: 'Smooth Cayenne' and 'Sugarloaf', with 'Sugarloaf' being the most cultivated one (Authors' own observations). The main problem of pineapple in Benin is the poor quality for local, regional and international outlets (Gbenou et al., 2006).

An analysis of the whole pineapple supply chain showed that the major constraints encountered by producers, wholesalers (when it comes to exporting the pineapple) and processors are the heterogeneity in pineapple quality produced or delivered, poor

compliance with quality criteria such as size and sugar concentration, and late delivery (Authors' own observations). These constraints may be linked to the way the pineapple is cultivated in the field, since the quality of agri-food is affected by cultural practices (e.g., Brown, 1986). Consequently, it is important to describe and analyse the pineapple production system(s) in Benin in order to identify the main factors that could reduce the quality of delivered pineapple and especially could increase the heterogeneity in quality. To date, no studies have been carried out on pineapple cultivation in Benin, despite its importance. Therefore, the objectives of this research are to describe and analyse 'Smooth Cayenne' and 'Sugarloaf' production systems in Benin and to identify the constraints that reduce the quality of pineapple produced. This was a baseline study useful for improving the production system and the quality of produced pineapple.

The research questions are: (1) What are the different ways of producing 'Smooth Cayenne' and 'Sugarloaf' in Benin? (2) What are the differences between the production systems of the two cultivars? (3) What are the different constraints that hamper the pineapple quality in Benin?

MATERIALS AND METHODS

After a literature review on pineapple cultural practices across the world, first a semi-structured interview was carried out with key informants from two producers' organisations: RePAB (Réseau des Producteurs d'Ananas du Benin) and ARPA (Association Régionale des Producteurs d'Allada), one input supplier: PADFA (Projet d'Appui à la Filière Ananas au Benin) and the extension agents at the CeRPA (Centre Régionale de la Production Agricole) in the Atlantic department to increase our knowledge on existing cultural practices and constraints. Next, an in-depth pre-tested questionnaire was used to interview 100 producers in the Atlantic department. Five municipalities (Abomey-Calavi, Allada, Zè, Toffo and Tori) out of the 8 municipalities that constituted that department (INSAE, 2004) were selected based on their contribution to the total volume of pineapple produced in Benin. The number of producer respondents per municipality was proportional to the contribution of each municipality to the total volume of pineapple produced in Benin. A stratified sampling method based on the number of producers was used to determine the number of producer respondents per pineapple growing area within a municipality. These growing areas were: Glo Centre, Fanto, Wawata, Zinvié Zoumè, Kpaviédja, Kpé (in Abomey Calavi municipality); Agbondjédo, Tangbo, Houéta, Anagbo, Adjamè, Gandaho (in Zè municipality); Adimale, Dodji-Aliho, Loto-Denou, Lokoli (in Allada municipality); Agbame, Houegbo-Gare (in Toffo municipality); and Sogbe Hetin (in Tori municipality). The questionnaire was developed to gather information on production practices and constraints. To determine the constraints, a five-point Likert scale with the ratings "strongly disagree (1)", "disagree (2)", "neither agree nor disagree (3)", "agree (4)" and "strongly agree (5)" was used.

Data were analysed by SPSS, version 16.0. A chi-square test on numbers of producers was used to assess whether the constraints experienced by producers concerning planting material and fertilisers depended on the sources they were obtained from. Data are presented in percentages for clarity of presentation.

Cluster analysis was used to identify different production systems (Bernhardt et al., 1996). First, relevant production practices variables (Table 2) were submitted to hierarchical cluster analysis to select the number of different clusters from the distances coefficients in the scree diagram (elbow rule). Ward's method was used to calculate the distances. Next, the K-means algorithm (Hartigan, 1985) was used to partition the producers' production systems into the pre-determined cluster number, with the Euclidean distance being used as similarity measure (Bernhardt et al., 1996). The final cluster centres per variable, i.e. the averages, were used to describe the clusters. To identify the production practices variables that separated the production systems of the two cultivars, discriminant analysis was performed. All data were standardised before analysis.

RESULTS

Description of the Atlantic Department

The Atlantic department has a subequatorial climate with two rainy seasons (the first from March to July and the second from September to October) alternating with two dry seasons (the first from November to March and the second in August). The mean monthly temperatures range from 27 to 31°C and the mean annual rainfall is about 1200 mm from which 700-800 mm is recorded in the first rainy season and 400-500 mm in the second (INSAE, 2004). The main crops grown are pineapple, maize, cassava, groundnut, tomato and pepper (INSAE, 2004). The pedological map of Benin revealed that the Atlantic department is covered by one major group of soils which is the ferrallitic soil (Willaine and Volkoff, 1967). This type of soil is characterised by good physical conditions (very deep soil and good drainage, i.e. permeable soil and high water-holding capacity) and relatively good chemical conditions (good cation exchange capacity). The pH ranges from 5.5 to 6.0 (Agossou, 1983).

Description of Pineapple Cultural Practices

The cultural practices of 'Smooth Cayenne' and 'Sugarloaf' are shown in Table 1. Planting starts with land preparation and producers preferred the start of the first rainy season as planting time. Planting materials used included all traditional propagule types: slips (produced on the peduncle at the base of the fruit), hapas or side shoots (produced above ground from the stem at the junction of the stem and the peduncle) and suckers (side shoots originating below ground from the stem). Crowns (produced at the top of the fruit) were not used. Slips, hapas and suckers were used by 'Sugarloaf' producers whereas only hapas and suckers were used by 'Smooth Cayenne' producers. These planting materials were obtained from plants kept in the field after the previous harvest, or other producers or both (Table 1). No producers obtained their planting material from PADFA, an institution aiming at providing producers with planting material. The main reason stated by producers was they did not know that such an institution existed. Figure 1 shows the percentage of producers using each of these sources that agreed with pre-formulated constraints for each source. The results of the Chi-square test show that the constraints depended significantly on the source for both pineapple cultivars. The main constraints were the non availability of planting material from other producers when needed, the heterogeneity of the planting material (mainly when sourced from other producers), and the variation in planting material age (mainly when the planting material was derived from plants kept after the previous harvest).

Most producers arranged the plants in beds of two rows at planting (Table 1) in association with maize. The planting densities were highly variable, ranging from 4-17 plants/m^2 for 'Sugarloaf' and from 4-11 plants/m^2 for 'Smooth Cayenne'. Also the fertilisation practices were diverse in number of applications and type of fertiliser used (Table 1). Fertilisers were collected from CeRPA or shops where sellers are pineapple producers or other people. Figure 2 summarises the percentage of producers using each of these sources that agreed with pre-formulated constraints for each source. The results of the Chi-square test show that the constraints related to fertilisers were not source- dependent. The main constraints were the non availability and the high costs of the fertilisers.

During crop development, producers induced flowering 9-13 months after planting by means of CaC_2, using the months after planting as the main criterion. Forty-two percent of the 'Sugarloaf' producers induced flowering 12 months after planting and 34% of 'Smooth Cayenne' producers induced flowering 10 months after planting (Table 1). Before harvest, some producers applied 2-chloroethyl phosphonic acid ($ClCH_2CH_2PO(OH)_2$; ethephon), which enhances the skin colour change from green to yellow (Audinay, 1970; Crochon et al., 1981). The criteria used by producers to apply ethephon were the number of months after flowering induction (4-5, generally 5 months), the fruit size (when the fruit reached the optimum size), or the delivering/selling time (2 weeks before delivering/selling). Few producers practiced crown gouging, i.e. mechanical

removal of the shoot apex of the crown. After harvest of the fruits, the ratoon-crop was kept only for planting material production.

Cluster analysis on the production practices variables revealed four clusters, but from the cluster centres per variable, these clusters could not be realistically distinguished into different pineapple production systems.

Differences in Production System between 'Sugarloaf' and 'Smooth Cayenne'

Table 2 shows which practices differentiated the ways in which the two cultivars were produced. There was a significant difference between the cultivars' production systems in type of planting material used, planting density, use of K_2SO_4, number of fertiliser applications and ethephon application. For 'Smooth Cayenne', all producers used hapas and suckers as planting material whereas for 'Sugarloaf' all producers used slips and most additionally hapas and suckers. Planting density was higher in 'Sugarloaf' cultivation (4-17 plants/m^2) than in 'Smooth Cayenne' cultivation (4-11 plants/m^2). For 'Smooth Cayenne', the number of fertiliser applications was higher than for 'Sugarloaf', K_2SO_4 was generally used and ethephon was more often applied.

DISCUSSION

Temperature is one the most important factors that determine pineapple growth. In the Atlantic department, the temperature range (between 27 and 31°C) is favourable for pineapple growth since it has been found that pineapple growth decreases rapidly at mean temperatures below 15°C and above 32°C (Neild and Boshell, 1976) or below 10°C and above 35°C (Bartholomew and Criley, 1983; Py et al., 1987; Malézieux et al., 1994). Also the mean annual rainfall of 1200 mm is favourable for pineapple growth and development because optimum rainfall for good commercial pineapple cultivation ranges from 1000 mm to 1500 mm (Bartholomew et al., 2003b). Also the soil characteristics (good drainage and pH ranging from 5.5-6.0) are favourable because the best soils for pineapple culture have a neutral to acid pH (Morton, 1987; Hepton, 2003) with good drainage (Collins, 1960; Hepton, 2003) in order to prevent water logging and root diseases. This means that the pedo-climatic conditions for pineapple production are satisfied and that the main constraints that reduce the production of high quality pineapples for different outlets have to be linked to the production system.

The possibility of PADFA supplying producers with planting material was unknown and producers obtained planting material only from other sources and own production (Table 1). The planting material was heterogeneous in weight, age and number of leaves (Fig. 1) and this could contribute to the heterogeneity in pineapple quality observed since there is a relation between the size and type of planting material and fruit size (e.g. Linford et al., 1934; Malézieux, 1993). Singh (2002) argued that the availability of best planting material is important to assure successful crop production. In addition, it is important for producers to get their planting material on time so as to meet the delivering time set by their customers. The great diversity in planting density observed could also contribute to the quality and heterogeneity in quality of pineapple. High planting densities reduce growth (Zhang, 1992) and consequently average plant weight, decrease fruit diameter (Treto et al., 1974; Zhang, 1992) and fruit length (Norman, 1978), increase the total acids concentration and reduce the total soluble solids (Chada et al., 1974; Mustaffa, 1988; Bartholomew et al., 2003a). Another source of heterogeneity in quality could be the different fertilisation practices since the nutritional status of the pineapple influences its growth and consequently its yield and quality (Malézieux and Bartholomew, 2003). It is important to note that there was no specific fertiliser formulation for pineapple in Benin; and due to the fertilisers' availability and cost problem some producers may apply what they have at hand or not apply at all. This is one of the critical points of high quality pineapple production since the moment of fertiliser application greatly influences the quality. For instance, N application after flowering synchronisation decreases total soluble solids and total acidity (Spironello et al., 2004) and increases fruit size (de Paula et al., 1991).

Another plausible cause of the heterogeneity in pineapple quality will be linked to flowering induction. Firstly, because pineapple plants with their initial variability at planting time in terms of size and type of planting material will not all have reached the same developmental stage when flowering is induced by the grower. In addition, there was a large variation in the number of months after planting at which flowering was induced.

The number of hand weeding over the crop cycle was high (Table 1) and constitutes another constraint because hand weeding is a time consuming activity. Weeds are a serious constraint in crop production in Benin (Vissoh et al., 2004). In pineapple cultivation, they reduce the mean fruit length, diameter and weight (Tadesse et al., 2007).

Some practices like pruning of developing slips and side shoots before harvest time were not applied by producers. As slip formation overlaps with the period of fruit development and maturation, slips may act as sinks competing directly with the fruit for assimilates. Therefore, removing slips could be an option to increase pineapple fruit size and perhaps also its quality.

CONCLUSIONS

Although the Atlantic department is favourable for pineapple cultivation there were some constraints in the production system that reduced the quality of pineapple. These constraints included availability of appropriate planting material, heterogeneity in planting material weight and age, availability of fertilisers, and cost of the fertilisers. All these constraints made it difficult to control the heterogeneity in quality in the field. The production practices were very diverse for both cultivars grown. Tackling the constraints would help producers improve the quality of produced pineapple in Benin.

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Tables

Table 1. Pineapple production system practices in Benin.

Production practices	Cultivar	Description	Remarks
Area under pineapple	Sugarloaf	Area ranged from 0.08-15 ha	On average Sugarloaf producers had 1.92 ha
	Smooth Cayenne	Area ranged from 0.08-4 ha	On average Smooth Cayenne producers had 1.33 ha
Land preparation			
Preparation tool	Both cultivars	Hoe	
Type of labour	Both cultivars	Family, labour sharing and hire labour	All producers hired labour
Planting			
Type of planting material	Sugarloaf	Slips, suckers and hapas	64% of Sugarloaf producers used slips, hapas and suckers 28% of Sugarloaf producers used only slips 8% of Sugarloaf producers used only slips and hapas
	Smooth Cayenne	Hapas plus suckers	All Smooth Cayenne producers used hapas and suckers
Source of planting material	Sugarloaf	Producers obtained their planting material from either previous harvested field, other producers or both previous harvested field and other producers	38% of Sugarloaf producers obtained their planting material from previous harvested field only 4% of Sugarloaf producers obtained their planting material from other producers 58% of Sugarloaf producers obtained their planting material from both previous harvested field and other producers
	Smooth Cayenne	Producers obtained their planting material from either previous harvested field, or other producers or both previous harvested field and other producers	20% of Smooth Cayenne producers obtained their planting material from previous harvested field 3% of Smooth Cayenne producers obtained their planting material from other producers 77% of Smooth Cayenne producers obtained their planting from both sources
Preferred planting time	Both cultivars	March-April-May-June	Rainfall season
Treatment before planting	Both cultivars	No treatment	
Plant arrangement	Sugarloaf	Plants arranged in beds of two alternating rows: Row width: 35.9 ± 1.95 cm (range 20- 50 cm); between plants: 27.4 ± 1.71 cm (range 20-40 cm); between double rows: 57.3 ± 3.58 cm (range 30-80 cm)	Used by 65% of Sugarloaf producers

Table 1. Continued.

Production practices	Cultivar	Description	Remarks
Plant arrangement	Sugarloaf	Plants arranged in single rows: Rows width: 71.3 ± 3.87 cm (range 50-80 cm); between plants: 32.2 ± 1.23 cm (range 30-40 cm)	Used by 28% of Sugarloaf producers
		Plants arranged in quincunxes: Row width: 29.7 ± 0.51 cm (range 28-30 cm); between plants: 44.3 ± 1.42 cm (range 40-45 cm)	Used by 7% of Sugarloaf producers
	Smooth Cayenne	Plants arranged in beds of two alternating rows: Rows width: 45.5 ± 4.45 cm (range 30-75 cm) ; between plants: 34.2 ± 3.17 cm (range 20-50 cm); between double rows: 75.0 ± 5.01 cm (range 50-100 cm)	Used by 63% of Smooth Cayenne producers
		Plants arranged in single rows: Row width: 62.5 ± 5.97 cm (range 50-75 cm); between plants: 31.9 ± 2.63 cm (range 30-40 cm)	Used by 27% of Smooth Cayenne producers
		Plants arranged in quincunxes: Row width: 32.7 ± 5.33 cm (range 30-38 cm); between plants: 50.0 ± 10 cm (range 45-60 cm)	Used by 10% of Smooth Cayenne producers
Planting density	Sugarloaf	8.6 ± 0.35 plants/m² for those arranging the plants in beds of two alternating rows	The number of plants ranged from 4-17 plants/m^2
		4.6 ± 0.14 plants/m² for those arranging the plants in single rows	The number of plants ranged from 4-6 plants/m^2
		7.3 ± 0.28 plants/m² for those arranging the plants in quincunxes	The number of plants ranged from 7-9 plants/m^2
	Smooth Cayenne	5.2 ± 0.40 plants/m² for those arranging the plants in beds of two alternating rows	The number of plants ranged from 4-11 plants/m^2
		5.3 ± 0.36 plants/m² for those arranging the plants in single rows	The number of plants ranged from 4-7 plants/m^2
		7.3 ± 0.33 plants/m² for those arranging the plants in quincunxes	The number of plants ranged from 7-8 plants/m^2
Fertilisation practices			
Type of fertilisers used	Both cultivars	NPK 15-20-15; NPK 16-16-16; Urea 46%N; K_2SO_4 50% K_2O and 18% S	

Table 1. Continued.

Production practices	Cultivar	Description	Remarks
Number of applications	Sugarloaf	1-4 applications	98% of Sugarloaf producers fertilised at least 2 times Of those (24%) who fertilised 2 times, most applied Urea + NPK 3.2 ± 0.21 and 7.7 ± 0.59 months after planting Of those (34%) who fertilised 3 times, most applied Urea 2.3 ± 0.22 or NPK 2.0 months after planting the first time; NPK 2.5 ± 0.34 or NPK+Urea 5.1 ± 0.46 or Urea 4.3 ± 0.25 months after planting the second time and K_2SO_4 9.7 ± 0.66 or NPK 7.1 ± 0.54 months after planting the third time Of those (4%) who fertilised 4 times, most applied Urea at 2 months after planting, NPK+Urea two times at 4 and 6 months after planting and NPK at 8-9 months after planting
	Smooth Cayenne	2-4 applications	All Smooth Cayenne producers fertilised at least 2 times Of those (40%) who fertilised 2 times, most applied Urea+NPK at 3.1 ± 0.28 and 7.4 ± 0.60 months after planting Of those (54%) who fertilised 3 times most applied Urea at 2.6 ± 1.01 months after planting, NPK at 5.2 ± 1.32 months after planting and K_2SO_4 at 8.4 ± 0.48 months after planting Those (6%) who fertilised four times applied Urea at 2, 4 and 6 months after planting and K_2SO_4 or K_2SO_4+NPK at 9 or 14 months after planting
Source of the fertilisers	Both cultivars	Producers obtained the fertilisers from CeRPA, shops or both	57% and 59% of Sugarloaf producers and 67% and 53% of Smooth Cayenne producers obtained the fertilisers from CeRPA and shops respectively
Flowering synchronisation (FS)			
Chemical product used	Both cultivars	Carbide of Calcium (CaC_2)	
Application time and number	Sugarloaf	One application at 9-13 months after planting	42% of the Sugarloaf producers applied CaC_2 at 12 months after planting, 28% at 10 months after planting
	Smooth Cayenne	One application at 9-13 months after planting	34% of the Smooth Cayenne producers applied CaC_2 at 10 months after planting
Criterion used	Both cultivars	Number of months after planting	
Maturity synchronisation			
Chemical product used	Both cultivars	Ethephon	

Table 1. Continued.

Production practices	Cultivar	Description	Remarks
Application time and number	Sugarloaf	No or one application at 16-17 months after planting	Only 10% of Sugarloaf producers applied ethephon
	Smooth Cayenne	No or one application at 14-19 months after planting	60% of Smooth Cayenne producers applied ethephon
Criteria used	Both cultivars	Number of months after flowering synchronisation (4-5 months after FS)	Generally 5 months after FS for growers using this criterion
		Fruit size	When the fruit size optimum (based on their experience)
		Delivering time to consumers	Generally 2 weeks before the delivering time
Crown gouging	Both cultivars	No or gouged crown at 1.5-2 weeks before harvest	10% of Sugarloaf producers and 20% of Smooth Cayenne producers gouged the crown. Gouging was done at 1.5-2 weeks before harvest time
Shoot pruning	Both cultivars	No pruning	Producers did not even know such technique exists
Fruit protection on field against sunburn	Both cultivars	No protection or use of palm leaves, maize leaves or dry weeds loosely distributed on top of the crop	24% and 20% of respectively Sugarloaf and Smooth Cayenne producers protected their fruit against sunburn
Weeding practice	Both cultivars	Hand weeding (10-15 per crop cycle) or herbicides	Only few producers used herbicides
Disease and insect control	Both cultivars	None	The occurrence of diseases and pest was very low. The only case we noticed was the Wilt disease affecting the planting material
Intercropping system	Both cultivars	Pineapple associated with maize, cassava, tomato and chili pepper, or no intercropping	89% of the producers used intercropping system. From that 89% associated pineapple with maize
Harvest			
Harvest number	Both cultivars	One harvest	The ratoon crop was only used for planting material production
Harvest time	Sugarloaf	16.2 ± 0.25 months (range 14-19 months) after planting	
	Smooth Cayenne	15.8 ± 0.52 months (range 14-19 months) after planting	
Yield	Sugarloaf	Evaluated in terms of number of trucks, the number of trucks was: 17.0 ± 0.52 trucks/ha	The truck capacity is 1440-2160 pineapples for ‘Sugarloaf’
	Smooth Cayenne	Evaluated in terms of number of trucks; the number of trucks was 19.0 ± 1.02 trucks/ha	The truck capacity is 1200-1400 pineapples for ‘Smooth Cayenne’

Table 2. Differences in production practices of 'Smooth Cayenne' and 'Sugarloaf" pineapple cultivars in Benin.

Production practices	p-value[x]
Field size (ha)	NS[y]
Planting material from previous harvest field	NS
Planting material from other producers	NS
Planting material from both previous sources	NS
Use of slips at planting	–[z]
Use of hapas at planting	0.001
Use of suckers	0.000
Plants arranged in beds of two alternating rows	NS
Plants arranged in single rows	NS
Plants arranged in quincunxes	NS
Planting density (plants/m^2)	0.000
Use of NPK	NS
Use of Urea	NS
Use of K_2SO_4	0.000
Number of fertiliser applications	0.032
Fertilisers from CeRPA	NS
Fertilisers from shops	NS
Fertilisers from both CeRPA and shops	NS
Time between planting and flowering induction (months)	NS
Use of ethephon for maturity synchronisation	0.000
Crown gouging practice	NS
Fruit protection against sunburn	NS
Use of herbicide	NS
Inter-cropping	NS
Time between flowering induction and harvest (months)	NS

[x]Probability of obtaining the Fisher test statistic for determining production practices that discriminate 'Smooth Cayenne' and 'Sugarloaf".

[y]NS: Not significant ($p>0.05$).

[z]No p-value was computed since this variable did not vary within a cultivar. Slips were only used for Sugarloaf.

Figures

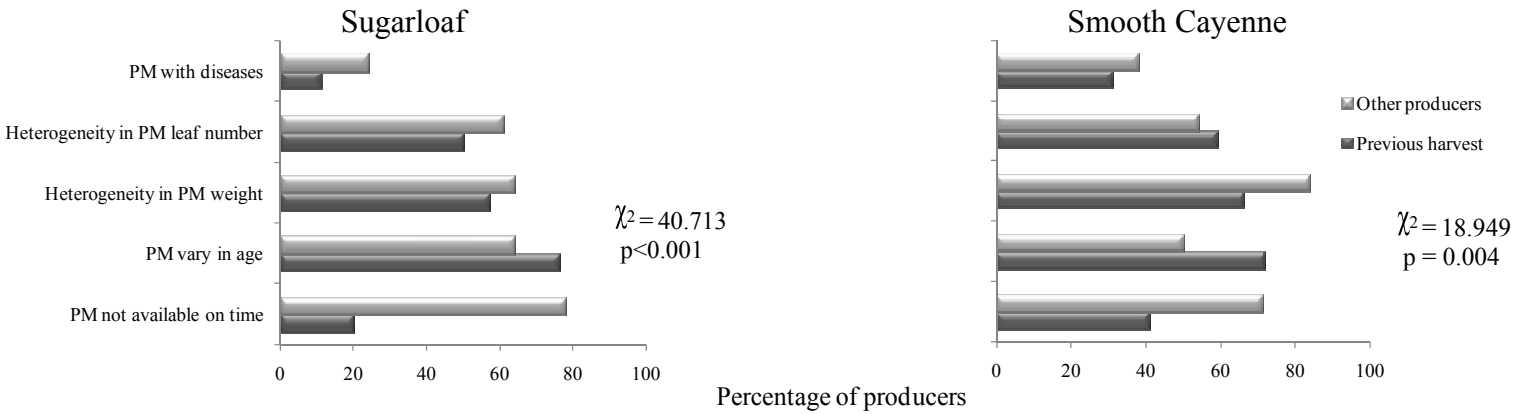

Fig. 1. Percentage of producers growing 'Sugarloaf' and 'Smooth Cayenne' and obtaining the planting material from other producers and previous harvest field that agreed (combining the responses "agree" and "strongly agree") with constraints linked to those sources. PM=planting material.

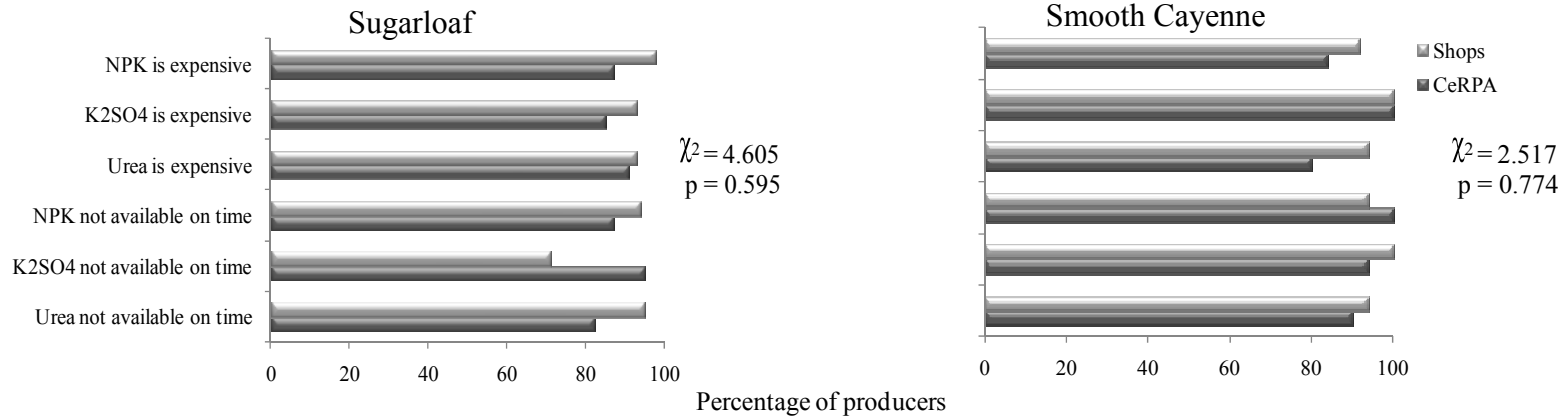

Fig. 2. Percentage of producers growing 'Sugarloaf' and 'Smooth Cayenne' using the indicated fertilisers and obtaining them from CeRPA and shops, that agreed (combining the responses "agree" and "strongly agree") with constraints linked to those sources.