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THE AMAZING SWEET SORGHUM: PAMPANGA AGRICULTURAL COLLEGE'S INITIATIVES IN PROMOTING AND COMMERCIALIZING ITS UTILIZATION AS HUMAN FOOD, ANIMAL FEED AND BIO-FUEL

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ABSTRACT

Recognizing the potential of sweet sorghum, the Pampanga Agricultural College in Magalang, Pampanga, Philippines for the past three years has been conducting R&DE initiatives which include adaptability trials of different ICRISAT-bred varieties and processing of nutritious sweet sorghum food products, animal feed and as source of bio-fuel. Preliminary results were promising; hence, this paper describes the some strategies relative to its promotion and commercialization. From five varieties of sweet sorghum tested under Pampanga conditions, SPV422 showed the highest stripped stalk yield and percent sugar yield, which are very necessary in ethanol production. The expected income per hectare per year was computed at Php 125,000.00. Its grain was also found to have comparable performance as replacement for yellow corn in the diet of broiler chickens. About 486 persons benefited from the project from January 2006 to date. Promotional activities conducted included field days, exhibits, technology forum and demonstration. Participatory technology demonstrations at the farmers' field were also established to facilitate technology transfer among farmers in the countryside. Aside from various media exposures which include television, radio and print, a book was also developed and published containing various sweet sorghum-based food recipes. The book offers not only as a valuable guide for homemakers in the preparation and development of alternative food products for family consumption, but also to encourage stakeholders and entrepreneurs to develop a potentially viable cottage industry that could generate additional income for farming families. While its grains and stalk were also tested to evaluate its potential as alternative for corn in poultry feeds preparation and forage for ruminant animals, the juice can be processed into bio-ethanol for low-cost cooking fuel in the rural communities.

Key words: Commercialization, cottage industry, alternative food source.

INTRODUCTION

Sweet sorghum is versatile as a high value crop. The International Crop Research for Semi-Arid and Tropics International Crop Research for Semi-Arid and Tropics (ICRISAT) calls it a "smart crop". In the light of the oil and food crisis, several institutional partners agreed to push the program: the Philippine Commission on Higher Education (CHED), Department of Agriculture Bureau of Agricultural Research (DA-BAR), Philippine Council for Agriculture, Forestry and Natural Resources, Research and Development (PCARRD), and ICRISAT, among many others. The Pampanga Agricultural College (PAC), has been conducting R & D initiatives related to sweet sorghum since 2006 which consisted of (1) varietal trial (2) fertilizer trial (3) ethanol production (4) as animal feeds and (5) sweet sorghum-based food products. Among the five varieties (SPV- 422, NTJ-2, ICSV-93034, ICSV-700, and ICSV-93046) tested during the 2006 dry season at Pampanga Agricultural College, SPV-422 proved to be the best in terms of stalk production, grain yield and sugar content.

Sweet sorghum has an erect, solid stem and growth habit typical of any other grass species. Its stems vary in thickness because of cultivation techniques, competition from

surrounding plants, solar energy, availability of soil moisture, among many other factors. The basal stem diameter may reach one inch or more, and tapering towards its tip or inflorescence. Adventitious roots are found at each node and will develop if in contact with the soil. Prop (adventitious) roots may grow from lower nodes above the soil, especially in tall cultivars. A single bud is found at each node that may give rise to branches, called tillers or suckers, if these are from nodes at or near the soil surface. The Philippines is blessed with a climate in which sweet sorghum can be grown throughout the year or at least twice a year. Sweet sorghum is relatively easier to grow with minimal time and cost compared to other field crops. It is the only crop that both grains and juice can be processed into various food products that would substantially contribute to the food security program(ICRISAT, 2006). Moreover, the whole plant can be used as forage crop and the grain yield is also promoted to provide feed material for animals (De Jesus and Punzalan, 2007). Moreover, with the implementation of Bio-Fuels Act of 2006 (R.A.9367) that requires the blending of 5-10% ethanol to gasoline in order to minimize dependency on petroleum importation and attain 60% energy self-sufficiency by 2010, it is expected that the demand for sweet sorghum will expand, and must be met by local farmers to ensure the availability of supply in the future.

Conceptual Framework

INPUT	PROCESS	OUTPUT
Sweet Sorghum Varieties from ICRISAT	Varietal trial and development of production technology	⇨ Appropriate variety identified and production technology
Sweet Sorghum Juice	Fermentation technique	⇨ Bio-ethanol for low-cost cooking stove ⇨ Liquid sugar/jaggery
Sweet Sorghum Grain	Processing techniques	⇨ Flour ⇨ Food products ⇨ Non-food products
Technology on sweet sorghum	Technology dissemination through demonstrations, trainings, fora, exhibits, etc.	⇨ Increased awareness and appreciation of potential stakeholders

Project Objectives

In general, the project aims to promote the production and utilization of sweet sorghum for human food, animal feed and bio-ethanol purposes in Region-3.

Specifically, the project has the following objectives:

1. to establish technology demonstration on sweet sorghum at the farmer's field level;
2. to develop and package production technologies on sweet sorghum for dissemination and transfer;
3. to generate technologies on the utilization of sweet sorghum as forage and feed for livestock;
4. to develop fermentation technology for ethanol production and utilization; and,
5. to develop and package technologies on sweet sorghum food products.

Project Implementation

The team is composed of researchers with different fields of specialization: horticulturist and agronomist to take care of the production technology, food technologist and chemist to

undertake food and non-food products development, an engineer to test the bio-ethanol on a low-cost cooking stove and an agricultural economist to evaluate the profitability aspect of the project.

A. In-Campus and Off-Campus Varietal Trials – Five sweet sorghum varieties sourced from ICRISAT, India were tested for adaptability both at Pampanga Agricultural College experimental areas and at the farmer's field.

B. Technology Generation - There were three groups of scientists who worked on the following aspects: production, food and non-food products development, animal feed, forage, and bio-ethanol production and utilization.

C. Technology Demonstration on the Production of Sweet Sorghum-Based Food Products – The PAC Department of Home Economics, which is manned by competent food processing experts, has established a show case of various sweet sorghum-based food products. Proper packaging and labeling of such products were done to encourage women, OSYs (Out-of-School-Youths), entrepreneurs, among others.

D. Packaging and Development of POT (Package of Technologies) – POTs from previously generated information by PAC and other agencies involved in sweet sorghum R&D were developed in various forms. Such materials developed are made available for distribution to increase awareness generate interest among potential users.

E. Conduct of Training – Potential technology takers/adopters were identified, organized and afforded with technical training on sweet sorghum production and processing of sweet sorghum-based food products.

F. Promotional and Media Mileage Activities – To enlarge the promotion of sweet sorghum, radio and print media were tapped. Slogans and other forms of articles were advertised.

G. Monitoring and Evaluation of the Project - A pool of expert-extensionists from PAC and partner-LGUs of the region were assigned to monitor and evaluate the progress/performance of the project based on its set of objectives.

RESULTS AND DISCUSSION

There were about 486 individuals who benefited from the project which composed of the following; 136 farmers, 108 mothers, 185 LGUs and professionals and 57 out of school youths and students. Of the 136 farmers, four were tapped as farmer-cooperators, who demonstrated the technology on sweet sorghum production. They also served as the venue for the conduct of field days (Fig. 1).

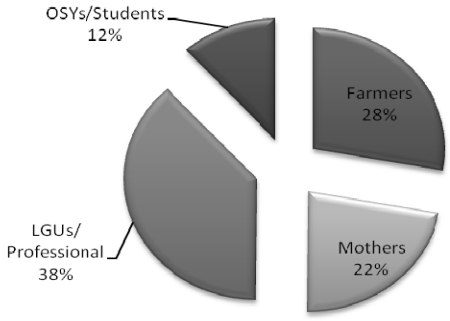

Fig. 1. Percent distribution of persons who benefited from this project.

Yield Performance

From the five varieties sourced from the International Crop Research Institute for Semi-Arid and Tropics (ICRISAT), India in 2006 and Mariano Marcos State University (MMSU) in 2007, SPV422 consistently gave the highest stripped stalk yield and percent sugar yield (Table 1). Although grain yield is also of economic importance in sweet sorghum production, for bio-ethanol purposes juice and sugar content are given emphasis in selecting the variety to grow. It is worthy to mention that sweet sorghum under Pampanga conditions can be ratooned up to three times, hence there would be four croppings including the seed crop.

Table 1. Comparative performance of five varieties of sweet sorghum under Pampanga conditions (Dry and wet season, 2007-2008).

Variety	Stripped Stalk Yield (t/ha)		Grain Yield (t/ha)		Percent Sugar yield, °Brix Meter
	Seed Crop	1st Ratoon	Seed Crop	1st Ratoon	
NSIC	47.5	55.1	3.62	4.40	18.5
SPV422	57.5	61.0	3.28	3.92	19.0
ICSV700	45.5	47.5	3.46	4.11	18.0
ICSV93034	52.0	51.5	3.40	4.08	15.0
ICSV93034	49.0	50.0	3.46	4.25	18.0

Note: Mean of two cropping seasons/year

Profitability of Sweet Sorghum Production

In growing sweet sorghum, farmers have several options for additional income such as selling of harvested grains, cane stalks with leaves as forage for animals, stripped cane stalks to produce juice extracts, boiled sweet sorghum juice (jaggery) to produce liquid sugar and distilled jaggery to produce ethanol. The farmers, therefore, could earn more by selling sweet sorghum cane stalks in addition to the income from grain harvest. Sweet sorghum cane stalks are main raw materials for the production of ethanol. A cost and return analysis of sweet sorghum production per hectare is presented in Table 2 to indicate the profitability. As sweet sorghum is not a plant intended to replace other crops grown by target farmers, it can be planted during the dry season in irrigated areas and during wet season in idle rain fed areas where it can survive and thrive well. Net income from a rain fed area during the wet season (P127,129.40) is estimated to be higher by P8,669.80 per hectare than that generated from an irrigated area during the dry season (P118,458.60). Gross revenue derived from irrigated area during the dry season (P174,250) is higher by P5,500 than that realized from rainfed areas during the wet season (P168,750). However, this profit advantage is not enough to compensate for the higher production cost incurred during the dry season in the irrigated area brought about by the need for labor, fuel and oil for irrigating the crop. Pesticides and the labor cost is doubled in the irrigated area during the dry season.

Harvesting, threshing and drying costs are also relatively bigger during the dry season in an irrigated area due to its greater production (especially grains) as these expense items are largely dependent on the volume of harvests. Total cost of sweet sorghum production per hectare, therefore, is much higher (by P14,169.80) in the irrigated area during the dry season (P55,790.40) than in the rainfed area during the wet season (P36,620.60).

Table 2. Cost and return analysis for one hectare (dry and wet seasons).

Items	Dry Season Production from Seed and Ratoon Crops (Irrigated)	Wet Season Production from Seed and Ratoon Crops (Rainfed)
Grain	93,750.00	81,250.00
Fresh cane	80,500.00	87,500.00
Variable costs		
Material cost	14,110.00	9,400.00
Seeds	800.00	800.00
Fertilizer	8,100.00	8,100.00
Pesticides	1,000.00	500.00
Fuel and oil	4,210.00	
II. Labor cost	28,250.00	22,723.33
Tractor plowing	2,500.00	2,500.00
Tractor harrowing	2,500.00	2,500.00
Furrowing	1,200.00	1,200.00
Planting	1,000.00	1,000.00
Basal Fertilizer Application	600.00	600.00
Side dressing fertilizer application	800.00	800.00
Hilling-up	2,100.00	2,100.00
Irrigation	3,000.00	
Pesticide application	1,600.00	800.00
Harvesting	8,000.00	6,933.33
Threshing	3,750.00	3,250.00
Drying	1,200.00	1,040.00
III. Interest on operating capital	5,930.40	4,497.27
Total Variable Cost	48,290.40	36,620.60
Total Fixed Cost (land rental)	7,500.00	5,000.00
Total Cost (B+C)	55,790.40	41,620.60
Total Net Income (A-D)	118,459.60	127,129.40
Returns above variable cost	125,959.60	132,129.40
Return on Investment	212.33%	305.45%

The returns above variable cost for the two farms planted at different production periods are more than P125,000 per hectare which show a high level of profitability as compared with those derived from rice and corn farming. In the short run, the farmer must at least cover total variable costs or production should be discontinued. The returns on investment (ROIs) in all

production seasons (dry and wet) and ecosystems (irrigated and rainfed) have positive values from 212.33% to 305.45%. This means that a farmer would earn more than twice or even thrice for every peso invested in sweet sorghum production, depending on the type of production ecosystem and cropping season. ROI is a performance measure used to evaluate the efficiency of an investment. It is a very popular measure of profitability because of its versatility and simplicity. That is, if an investment does not have a positive ROI, then such investment should not be undertaken.

Sweet sorghum grain yield from seed crop is the same at 3,500 kilograms per hectare, regardless of cropping season and production ecosystem. Ratoon crop grain yield is 4,000 kilograms from irrigated area during dry season and 3,000 kilograms from rainfed area during the wet season. Fresh cane yield from seed crop is 55,000 kilograms per hectare from irrigated area during dry season and 60,000 kilograms from rainfed area during the wet season (De Jesus and Punzalan, 2007). Sweet sorghum ratoon crop yield of fresh cane is 60,000 kilograms from irrigated area during dry season and 65,000 kilograms from rainfed area during the wet season. Quantities or volume of production inputs and outputs from sweet sorghum growing were based from the recommendations of the International Center for Research in the Semi-Arid Tropics (ICRISAT) located in India where the crop originated. Data on land rental, loan interest and prices of outputs and inputs were based on prevailing market rate in the project area taken through personal interviews. The prices of outputs (grains and fresh canes) are the same across cropping seasons and production ecosystems. The cropping period from land preparation to marketing of harvest or output is three and a half (3.5) months for all three (3) crops. The production period for two (2) croppings is 7 months while the interest rate is 24% per annum

As Animal Feed

It was generally observed that the performance of broilers fed with sweet sorghum grain in terms of growth, was comparable in all the treatment groups (Table 3). The weight gain of broilers is almost the same since the birds consumed nearly equal amount of feeds. The gain in weight conforms to the principle that growth rate of the birds is correlated with the level of feed intake (Ackar and Cunningham, 1991).

Table 3. Performance of birds fed with corn and sweet sorghum based diet.

	Dietary Treatments				
Item	**Corn**	**Sorghum**	**Corn + Sorghum**	**SEM**	**P - value**
Initial weight (g/bird)	279.17	268.76	263.20	5.63	.567
Final weight (g/bird)	1,568.33	1,575.00	1,566.67	8.45	.934
Gain in weight (g/ bird)	1,289.17	1,306.25	1,303.47	6.70	.601
Average Daily Gain (g/bird)	37.74	38.28	38.14	0.24	.835
Feed consumption (g/bird)	2848.33	2756.67	2773.33	21.12	.170
Feed Conversion Ratio	2.23	2.14	2.15	0.02	.135

Pooled SEM, n=36

Palatability and acceptability of the diets, regardless of the based ingredient, was the same as manifested by similar feed consumption rate. It was noted that broilers fed with corn-based

diet consumed more feeds. However, the difference was not enough to elicit remarkable improvement in weight gain and accordingly in feed efficiency. The result would imply that sweet sorghum can replace corn without causing adverse effects on performance and this is in agreement with previous studies conducted comparing low tannin sorghum with maize (Ackar and Cunningham, 1991). Analysis showed that the net income per kilogram liveweight was highest in sorghum-fed diets regardless of the levels of inclusion (Table 4). The rate of feed consumption and the cost of diet (Php21.86/kg) contributed to the highest cost of feed/kg live weight which was calculated to be Php2.00 to 3.00 higher in corn-based diet that eventually reduces the return of income from this group. Also, it is worth mentioning that the cost of diet in treatments 2 (sweet sorghum) and 3 (sorghum + corn) were almost the same (Treatment 2 = Php20.49, Treatment 3 = Php20.70). However, it should be pointed out that this was Php1.00 cheaper than the corn-based diet. The protein contribution coming from sweet sorghum reduces the inclusion rate of other protein-rich ingredients like soya and fish meal, which ultimately lessens the cost of diet per kilogram (Richert, et al., 1991). Considering that the supply of sweet sorghum will become more available in the future and the price as estimated to be Php13.00/kg will remain or even decrease, it is therefore highly beneficial to replace corn with sweet sorghum in the broiler diet (Pineda and Pineda, 2008).

Table 4. Cost and return analysis of broiler birds fed with sweet sorghum and corn**.**

Particulars	**Corn**	**Sweet Sorghum**	**Corn+ Sorghum**
Expenses			
Stocks	1944	1944	1944
Feeds			
CBM	971.26	971.26	971.26
Experimental Feeds[1]	4299.80	4097.13	4117.68
MVE	80	80	80
Vaccine ($NCDB_1B_1$)	80	80	80
Miscellaneous	200	200	200
Total Expenses	7575	7372	7392
Return			
Total LW produce, kg	100.9	103.1	101.7
Selling Price/kg LW	90	90	90
Gross Income	9081	9279	9153
Net Income	1505	1906	1760
Cost to produce kg LW	75.07	71.51	72.69
Feed Cost/kg LW	52.24	49.16	50.04
Net Income/kg LW	14.93	18.49	17.31

[1]Diet cost per kilogram: Corn-based = PhP21.86, Sweet Sorghum-based = PhP20.49, Corn + Sweet sorghum 3 = PhP20.70 and Traditional Sorghum-based = PhP20.51.

Food and Non-Food Products Developed

The general preparation of the sweet sorghum grains for processing is shown in Figure 2. Sweet sorghum grains ready for processing were tested with the different processing techniques such as: toasting, boiling, milling and some other techniques that were used in combination, such as boiling and addition of sugar, milling and drying.

PREPARATION OF THE SWEET SORGHUM GRAIN AND JUICE

⇩

TESTING WITH FOOD PROCESSING TECHNIQUES

⇩

IDENTIFY THE RECIPE/PROCEDURE

⇩

SWEET SORGHUM FOOD PRODUCTS AND DELICACIES

Fig. 2. Framework of the study on the utilization of the sweet sorghum plant for human food (Zabala et al., 2009).

Food Products

Various food and non-food products were developed from sweet sorghum-derived flour and grains. To enhance technology adoption, said food products were packaged into a compendium book and published through the funding assistance of Bureau of Agricultural Research of the Department of Agriculture of the Philippines.

Food and non-products developed are the following:

1. Several sorghum–based food products developed, include: burger, pastilles, porridge in various flavors like chicken or chocolate, native rice cakes with squash , soup with mushroom or various vegetables,

2. Non-food products included hair remover, soap, spa salt, hair remover, body scrub, and liniment oil.

Bio-Ethanol Production and Utilization

Ethanol derived from crops other than corn would increase farm diversity and sustainability. Sweet sorghum, which is biologically competitive to corn, has a more beneficial energy balance than corn. To produce comparable ethanol yields, 190, 140, and 90 kilograms N per hectare, respectively, are required for corn, grain sorghum, and sweet sorghum production.

Sweet sorghum extract contains about 8 to 10 percent sugar (w/w). Fermentable sugars present are mainly fructose, sucrose and glucose. Not all sugars in the sweet sorghum extract were fermentable. Every liter of sweet sorghum extract yields 40 to 50 ml (4-5%) of ethanol upon distillation (about 100 ml of 50% ethanol solution) after three days of fermentation. Fermentation efficiency ranges from 40 to 45 percent after three days of fermentation using yeast. Varietal study on the type of yeast used in the fermentation has not yet to be done.

Unmodified commercially available kerosene stove was tested and was able to produce a steady blue flame while utilizing a low grade ethanol (50% ethanol) made out of sweet sorghum extract. Modifications will be done to further increase the efficacy and safety of the stove while using ethanol as fuel.

Promotional Activities

Aside from proper coordination with various stakeholders and partners, different promotional activities were also undertaken to ensure technology diffusion among target end-users. These activities include: video shooting and TV telecasts, radio broadcasts, posters and primers production, training, technology fora, trade fair and exhibits, among others.

SUMMARY AND CONCLUSIONS

Sweet sorghum variety from ICRISAT, India, particularly SPV422, was found productively growing under Central Luzon, Philippines conditions. It requires lesser inputs like fertilizer and irrigation vis-a-vis corn and rice. Its grains were tested and found effective as alternative to corn in the diets of broiler chicken, hence higher net returns not only for grain growers but also for broiler producers. Juice extracted from sweet sorghum, which contains about 8 to 10 percent sugar (w/w), was found highly feasible to ferment and produce blue-colored flame ethanol when used in a modified low-cost cooking stove. A very interesting array of low cost and nutritious food developed from sweet sorghum grains and stalks were packaged into a book, in a manner people in the countryside can easy to follow, to hasten its utilization.

There were about 486 persons who benefited from the project from January 2006 to December 2009 from activities such as; farmer's field days, exhibits and technology fora. Technology demonstrations at the farmers' field level were also undertaken.

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