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PERFORMANCE EVALUATION OF SWEET SORGHUM LINES FOR BIO-ETHANOL AND GRAINS UNDER PANGASINAN CONDITION (3 TRIALS)

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ABSTRACT

The general objective of the study is to conduct evaluation trial of five (5) sweet sorghum lines under Pangasinan condition. Specifically, it aims to determine their agronomic characteristics and identify and recommend varieties that are suitable for ethanol production. This paper highlighted the results of the three (3) trials conducted from October 2007 to February 2009. All data gathered were analyzed using Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD) and mean differences were determined by Least Significant Differences (LSD) test at 1% and 5% levels of significance. Analysis of variance in the 1st and 2nd trials showed that there were significant differences among varieties observed for plant height, stalk yield, stripped stalk yield, stalk juice volume, stalk juice yield, Brix, stillage yield, grain yield and seed size. In the 3rd trial, however, stalk yield and stripped stalk yield parameters showed that there were no significant differences among the varieties tested. The mean agronomic characteristics of the 5 varieties evaluated showed that ICSV 700 performed better in terms of plant height. Consequently, ICSV 700 and ICSV 93046 were the top performers in terms of stalk yield, stripped stalk yield, stalk juice volume, stalk juice yield, and *Brix. The varieties SPV422 and NTJ2 performed better in terms of stillage yield in the 1st trial while SPV 422 obtained the best performance in the 2nd trial. However, for the 3rd trial, ICSV 93046 performed better as compared to the other varieties. On grain yield parameter for 1st and third trials, SPV422, ICSR93034 and NTJ2 were among the top yielders. Data on grain yield was not taken in the second trial due since it was attacked by the birds. Whereas, in terms of seed weight, ICSR 93034, performed better in the 1st and 2nd trials, while SPV 422 performed better in the 3rd trial.

INTRODUCTION

Sweet sorghum (*Sorghum bicolor (L.*) Moench) has been successfully grown in many parts of the world, especially in semi-arid tropics. It is special purpose sorghum with sugar-rich stalk and sugar content of 16-23% (Brix value). It has a very wide adaptability and is relatively tolerant to drought, water logging, and soil salinity and acidity stresses, requiring low inputs to attain good yields (ICRISAT, 2006). Sweet sorghum is one of the many varieties of sorghum, a cane-like plant with a high sugar content. It is native to Africa and Asia, where they have been cultivated since ancient times. Up to 3 m (10 ft) tall, they bear seeds on terminal heads, or panicles. Sweet sorghum will thrive under drier and warmer conditions than many other crops and is grown primarily for forage, silage, and sugar production. It differs from grain sorghum mainly in that its grain yields are low and its stalks are taller and juicier and have high sugar content. It reproduces by seed and produces tillers (ratooning). Traditional uses of sweet sorghum includes: 1) syrup production – has historically been the main use; 2) grain is used for food (as flour & pop grain) & feeds; 3) juice for production of vinegar & wine; 4) stalk for production of silage or fodder; 5) the fiber of the stalk is one of the best materials for making high quality paper. In terms of its agronomical characteristics, sweet sorghum has wider adaptability, more rapid growth, and higher sugar accumulation and biomass production potential than sugarcane. It is also tolerant of drought, water-logging, soil salinity, and acidity toxicities. In dry land, seeds can be sown like corn at a rate of 5-8 kg/ha. A higher seed rate (8-10 kg/ha.) is used for more humid soils. Seeding in the tropics is nearly anytime. Drill seeding method is also recommended. Seeds are planted at a spacing of 100 cm between rows and 15 cm within rows at a depth of 1.5 to 3 cm depending on soil structure and moisture. For drilled seeds, thinning follows after emergence. The advantages of sweet sorghum includes: shorter growth period of 3-4 months (100-110 days after

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emergence for seed crop; 85-95 days after ratooning for ratoon crop) compared to about 11-14 months for sugarcane. While it is sensitive to low temperatures, it can withstand temperature fluctuations better than sugarcane. Two crops can therefore be produced per year, depending on the climatic conditions, without replacing the main crop such as rice. It has low water requirements (175 m3/ha.), 1/4 less than sugarcane (700 m3/ha.) and 1/2 less than corn (400 m3/ha).Has high water use efficiency and is drought tolerant. Tolerates some degree of salinity, alkalinity and poor drainage. It can be successfully grown on a wide range of soils. It requires 35% less fertilizer input than sugarcane & 50% less than corn.

Sweet sorghum can be planted during the lean months of rice production especially in rainfed areas. Requires less cultural practices (minimal tilling) and lower cost due to ratooning characteristic. Sweet sorghum is therefore expected to be well adapted for growth. Sweet Sorghum can thus be planted (in rotation) or processed during palay off-season or "tiempos muertos". This will allow rice farmers to economically extend their cropping season, and allow for year-round (240 days) ethanol production as well as address social concerns of lack of income during palay off-season. According to Layaoen (2006), dual-type sorghum varieties have the advantage over sugarcane. Normally, it has a maturity of 100 days in the Philippines and can be grown after rice. Compared to sugarcane, which matures at 300-330 days and produces only sugar cane, sorghum can have syrup, grains and fodder. The juice produced from sorghum is lower than that from sugarcane per cutting, but it can be compensated by shorter maturity of the sweet sorghum plant. Thus, juice yield in sweet sorghum is higher per unit time/area than in sugarcane. Sorghum can also be rationed so that multi-harvest is done for one single planting. Introduction of proper soil and fertilizer management can result to comparable, if not better, grain and juice output. Its growth characteristic fits to a multi-cropping system to maximize unit farm output. The stalks and leaves can also be used as animal feeds and for energy. Varietal testing has been conducted in various locations all over the Philippines with positive results. The most suitable variety under local conditions is SPV 422 (from ICRISAT-India). In Region I, successful trials had been conducted and are still being conducted in Mariano Marcos State University (MMSU) in Batac, Ilocos Norte. Multi-location field trials had been conducted in the region including Sta. Maria and Alaminos City, Pangasinan.

It does not compete, albeit, it complements rice production in dry and marginal areas. Grains from the crop can be used as wheat flour substitute or animal feed. There is a worldwide race in the production of biofuel especially ethanol. Its production is a bioconversion process aided by microorganisms. Billions of gallons of ethanol are produced in the US and Brazil using corn and sugarcane as fermentable substrates, respectively. Ethanol is primarily used for the production of gasohol, a sulfur and lead-free fuel containing a certain percentage of ethanol in gasoline which leads to a lower amount of carbon monoxide and nitrogen oxides compared to pure gasoline. Thus, gasoline with a certain percentage of ethanol is an environmentally friendly fuel. Its use is encouraged worldwide to reduce pollution, combat the oil price hikes, lessen dependence to oil-producing countries, and to prepare for the projected depletion of fossil fuel in the near future. Currently, the Department of Energy (DOE) is pursuing a program promoting the use of bio-ethanol as blend for gasoline. DOE's Fuel Ethanol Program aims to replace 10% of imported gasoline with domestically produced fuel ethanol. A 10% ethanol blend to gasoline would result to savings of Php 10.4 billion within the next three years. Based on the estimates of the Philippines, the estimated bio-ethanol requirement for motor fuel over the next ten years of 3.7 billion liters (L) is equivalent to 51.71 million metric tons (MT) of sugarcane.

Reasons for the growing market for ethanol (Environmental Benefits) includes:1)ethanol has nearly-complete combustion, wherein very little carbon monoxide is produced; 2) ethanol does not contain contaminants commonly found in gasoline such as sulfur, benzene and other aromatics; 3) when blended with gasoline, ethanol contributes to a reduction in most emissions according to its percentage in the blend; 4) in general, ethanol use in transport industry reduces "greenhouse" gases that cause climate change and global warming. Other driving forces in the Philippines (In the Agriculture Sector) includes: 1) product diversification and integration of local agriculture industries (multi-product industry); 2) hedging on the competitive advantages, i.e., agricultural products as efficient energy crops and expertise and technological advancements; 3) increased and stable farm incomes; 4) with the National Bioethanol Program in place, agricultural products will be used for food and fuel. This means that farmers' products will be in demand. High demand translates to increased incomes for the farmers. National interest and global issues such as issues on air pollution and global warming, in compliance with the Philippine Clean Air Act. Energy security initiatives aimed at addressing high dependence on imported fuel. Country is 46% dependent(2003) on imported fuel, hence, massive drain in foreign reserves ($3.5 billion in 2003).New investments, employment, increased farm incomes, increased economic activity, avoided urban migration. Finally, GMA's 10-point agenda and in line with the MTDP. Economic and social benefits such as increased investments in agriculture and the countryside. Generation of jobs and income in host communities; creation of support services; multiplier effect on business in countryside; energy security and reduction in imported oil dependence; positive effect on balance of payments/currency reserves of the country. Changing environmental regulations such as reduction in toxic emissions and greenhouse gases; with potential benefits from Kyoto Protocol/CDM (1997). Clean Air Act (2000) that favors cleaner fuel. Clean Water Act which promotes the reuse of effluents for useful purposes (e.g. distillery effluents as fertilizer or irrigation water). Biofuels Act of February 2007 and Renewable Energy Act (RA 9513-Dec. 2008).

It is in this premise that integrated program on sweet sorghum as feedstock for bioethanol and grains should be pursued vigorously. The general objective of the study is to conduct evaluation trial of five sweet sorghum lines in Pangasinan. Specifically, it aims to: (1) Conduct performance tests of the different sweet sorghum lines/varieties; (2) Determine their agronomic characteristics under Pangasinan rainfed condition; (3) Identify and recommend varieties that are suitable for ethanol production under Pangasinan condition;

Methodology

This study used Randomized Complete Block Design (RCBD) Experimental Design. The plot size is 5m x 5m x 5 rows or equivalent to 25 sq m. Spacing is 1 m between furrows, 1 m between plots and 1.5 m between blocks/replications and the number of block/replication is 4.The experimental area was thoroughly prepared by 2 times plowing and harrowing once and furrows were made at a distance of 90 cm. The land where the sweet sorghum planted is slightly sloping with an area of 1,200 sq.m. and with good internal drainage. The pH ranges from 5.5-6.5 and accessible to a source of irrigation water and the experimental area is enclosed with concrete fence. The land was cultivated manually for 21 days after planting (DAP) to kill the weeds that would compete with the sweet sorghum. The planting was done by hand at a rate of 25 seeds per meter of row. The seeds were covered with approximately 2-3 cm thick fine soil. While, thinning was done 10-14 days after emergence leaving 15 plants per linear meter row which is equivalent to 75 plants.Hilling-up was done 30 days after planting to avoid serious root and physical damages to the plants. Complete fertilizer (14-14-14) at 0.71 kg/plot was applied basal and 0.25 kg/plot 0-20-0 and 0.05 kg/plot of 0-0-60. Fertilizer was drilled in the furrow 2 cm deep and covered with soil before planting. The 1st sidedress, 0.21 kg per plot of urea (46-0-0) was applied and 0.2 kg per plot muriate of potash (0-0-60). In the 2nd sidedress, 0.21 kg per plot of urea (46-0-0) was applied. To control shoot fly attack and in leaf whorls a pinch of Carbofuran 3G was applied during planting in furrow at 1½ kg for the whole experimental area. Harvesting was done when they reached physiological maturity, specifically, at 96-100 days after planting for the early maturing lines (ICSR 93034, NTJ2 and SPV 422) and 121 days for the late maturing lines (ICSV 93046 and ICSV 700). Immediately after harvesting the SS plants, data on plant height, stalk yield, strip stalk yield were obtained, stalks were milled using SS juicer to gather data on stalk juice volume, stalk juice yield and stillage yield and *Brix values using refractometer. All data gathered were analyzed using ANOVA for RCBD and mean differences were determined by Least Significant Difference (LSD) test at 1% and 5% levels of significance.

RESULTS AND DISCUSSION

Plant height at harvest of sweet sorghum lines are shown in Table 1. First trial (WS 2007-2008) revealed that ICSV 700 had the tallest height of 297.76 cm but not significantly taller to ICSV 93046 with 277.78 cm. This was followed by ICSR 93034 with 259.12 cm but not significantly different to SPV 422 with 255.08 cm and NTJ 2 with 251.78 cm. Similar findings were observed for the next two trials, indicating that the ICSV lines (700 and 93046) have consisttaller plant height than the three entries (ICSR 93034, NTJ2 and SPV 422). Data on the stalk yield is presented in Table 1. For the 1st Trial, ICSV 700 and ICSV 93046 obtained higher stalk yields of 34.34 and 30.87 t/ha, respectively, over other entries of SPV 422, ICSR 93034 and NTJ2 with 24.82, 24.15 and 21.0 t/ha, respectively. Trial 2 also showed significant differences among entries, however, succeeding trial showed no significant differences on stalk yield among entries. Data on stripped stalk yield is presented in Table 1. For the 1st trial, ICSV 700 and 93046 obtained higher stalk yields of 30.38 and 26.18 t/ha, respectively. Lowest yielder was NTJ2 with 18.04 t/ha. On trial 2, ICSR and ICSV 93046 registered higher stripped stalk yields of 29.50 and 27.64 t/ha, respectively. Similar with the first trial, NTJ2 obtained the lowest yield of 23.43 t/ha. No marked variation on stripped stalk yield among entries for 3rd trial was observed.

ICSV 700 obtained the highest juice volume of 17.40 kl/ha followed by ICSV 93046 with 15.60kl/ha. Lowest juice volume was recorded on plots planted with SPV 422, ICSR 93034 and NTJ2 with 6.87, 6.29 and 3.55 kl/ha, respectively. It can be gleaned from table 2 that ICSV 93046 and ICSV 700 performed better with 17.51 and 17.33 Kl/ha. lowest juice volume of 8.68Kl/ha. Results of succeeding trial revealed that ICSV 93046 and 700 consistently obtained the highest juice volume with 10.50 and 8.38 kl/ha but differences among each other were not significant. Lowest juice volume was recorded on plots planted with NTJ2, ICSR 93034 and SPV 422 with 6.39, 5.14 and 4.88 kl/ha, respectively. Table 2 shows the data of sweet sorghum lines on juice yield. ICSV 700 obtained the highest juice yield with 17.63 t/ha, followed by ICSV 93046 with 15.37 t/ha in the 1sttrial. Lowest juice yield were obtained by SPV 422, ICSR 93034 and NTJ2 with 6.87, 6.56 and 3.86 t/ha, respectively. In the second trial, ICSV 700 and 93046 attained the highest juice yield with 18.33 and 17.49 t/ha, respectively. However, NTJ 2 obtained the lowest juice volume among the lines tested with 4.88 t/ha. In the 3rd trial, ICSV 93046 and ICSV 700 outperformed the other tested lines with 18.33 and 17.49, respectively. SPV 422 obtained the lowest juice output of 4.88 t/ha. On total fermentable sugar, ICSV 93046 obtained the highest *Brix value in the first trial with 22.27 followed by ICSV 700 with 22.05, ICSR 93034 with 15.60, SPV 422 and NTJ2 with identical values of 12.61. In the second trial, ICSV 93046 and ICSV 700 obtained the highest with Brix of 21.56 and 20.30, respectively. SPV 422 obtained the lowest Brix of 12.86. However, in the succeeding trial SPV 422 obtained the highest Brix of 17.13 followed by ICSV 700 and 93046 with an identical Brix values of 13 and ICSR 93034 with 12.63. Lowest Brix value was obtained by ICSR NTJ2 with 11.8.

For the first trial, SPV 422 and NTJ2 obtained an identical yields of 14.28t/ha while ICSV 93046 obtained the lowest yield of 10.81t/ha. In the second trial, SPV 422 obtained the highest stillage yield of 27.74 t/ha followed by ICSR 93034 with 15.30 t/ha while the lowest was obtained by ICSV 93046 with 9.99 t/ha. In the 3rd trial, ICSV 93046 and ICSV 700 obtained the highest yield with 11.46 and 9.42 t/ha, respectively. NTJ 2 obtained the lowest stillage yield of 7.74 t/ha. In the first trial, results indicated that SPV 422 and NTJ2 obtained an identical grain yield of 12.95 t/ha each while the lowest yielder was ICSV 93046 with 8.34t/ha. On the 2nd trial, there were no data available since the grains were attacked by birds and devastated by typhoon Cosme. In the succeeding trial (third), ICSR 93034 obtained the highest grain yield of 8.54 t/ha while the lowest was ICSV 93046 with 4.30t/ha. On seed weight, data revealed that ICSR 93034 obtained the highest weight of 100 seeds with 9.68 g while the lowest was ICSV 700 with 4.13 as weight. On the second trial, ICSR 93034 obtained the highest weight of 9.11g followed by SPV 422 with a seed weight of 9.3g.However, for the next cropping season, SPV 422 obtained the heaviest seeds with 8.7g followed by ICSV 93046while the lightest was ICSR 93034 with 4.2 g.

Rating for Shootfly and Stemborer Damage

Except for the 2nd trial, no marked variations were noted on shootfly damage among sweet sorghum lines grown during the 1st trial and 3rd trial. For the 2nd trial, ICSV 700 got the lowest rating of 1.0 (free from dead hearts) but not significantly different to ICSR 93034 rating of 1.40.

Table 1. Mean and results of analysis of variance (ANOVA) for agronomic characteristics of the 5 varieties evaluated, CY 2007-2009

Entry	Plant Height (cm)			Stalk Yield (t ha^1)			Stripped Stalk Yield(t ha^1)		
	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial)	WS 2008-2009 (3rd Trial)	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial	WS 2008-2009 (3rd Trial)	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial	WS 2008-2009 (3rd Trial)
SPV 422	255.08	277.34	183.63	24.82	35.50	12.40	21.06	31.59	10.56
ICSR 93034	259.12	269.05	200.45	24.15	35.33	14.24	20.49	29.50	12.27
ICSV 700	297.76	338..96	215.20	34.34	32.21	13.73	30.38	26.33	10.70
ICSV 93046	277.78	346.58	209.43	30.87	31.76	12.35	26.18	27.64	10.65
NTJ 2	251.78	258.006	189.77	21.0	29.20	12.55	18.04	23.43	12.37
F-test	**	**	**	**	*	ns	**	**	ns
CV(%)	2.9	3.6	4.2	12.3	8.6	22.5	12.6	9.7	23.8

Table 2. Mean and results of analysis of variance (ANOVA) for agronomic characteristics of the 5 varieties evaluated, CY 2007-2009

Entry	Stalk Juice Volume(Kl ha^1)			Stalk Juice Yield (t ha^1)			*Brix values		
	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial)	WS 2008-2009 (3rd Trial)	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial)	WS 2008-2009 (3rd Trial)	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial)	WS 2008-2009 (3rd Trial)
SPV 422	6.87	10.34	4.88	7.08	10.37	4.88	12.61	12.86	17.13
ICSR 93034	6.29	9.66	5.14	6.56	9.81	5.14	15.60	13.69	12.63
ICSV 700	17.40	17.33	8.38	17.63	17.49	8.38	22.05	20.30	13
ICSV 93046	15.60	17.51	10.50	15.37	18.33	10.50	22.27	21.56	13
NTJ 2	3.55	8.68	6.39	3.86	9.11	6.39	12.61	12.98	11.8
F-test	**	**	**	**	**	**	**	**	**
CV(%)	21.3	5.0	21.3	21.3	4.8	21.1	11.3	5.0	11.3

Table 3. Mean and results of analysis of variance (ANOVA) for agronomic characteristics of the 5 varieties evaluated, CY 2007-2009

Entry	Stillage Yield (t ha^1)			Grain Yield (t ha^1)			Seed Weight (t ha^1)		
	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial	WS 2008-2009 (3rd Trial)	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial	WS 2008-2009 (3rd Trial)	WS 2007-2008 (1st Trial)	DS 2008-2009 (2nd Trial	WS 2008-2009 (3rd Trial)
SPV 422	14.28	27.74	8.15	12.95		7.54	4.2	9.3	8.7
ICSR 93034	14.01	15.30	8.66	11.9		8.54	9.68	9.11	4.2
ICSV 700	12.76	10.35	9.42	10.9		5.06	4.13	8.65	8.2
ICSV 93046	10.81	9.99	11.46	8.34		4.30	4.16	8.56	8.3
NTJ 2	14.28	12.68	7.74	12.95		6.8	4.2	5	4.6
F-test	**	**	**	**		**	**	**	**
CV(%)	8.7	25.5	13.70	12.2		8	12.3	9.6	8.7

Table 5. Ratings for shoot fly and stemborer damage of five sweet sorghum lines, PSU Sta. Maria, Pangasinan

Entry	Ratings for shoot fly damage		Ratings for stemborer damage	
	2007-2008 (1st Trial)	2008 (2nd Trial)	2007-2008 (1st Trial)	2008 (2nd Trial)
ICSR 93034	1.60	1.40^{bc}	1.80^{ab}	1.00
ICSV 700	1.40	1.00^{c}	1.40^{bc}	1.00
ICSV 93046	1.20	1.60^{ab}	1.00^{c}	1.00
NTJ 2	1.60	2.00^{a}	2.00^{a}	1.00
SPV 422	1.20	2.00^{a}	1.40^{bc}	1.00
F-test	ns	**	*	ns
CV(%)	33.88	19.26	26.32	0.00

Table 6. Leaf disease, plant appearance and lodging scores of five sweet sorghum lines, PSU Sta. Maria, Pangasinan

Entry	Leaf disease score		Plant appearance score		Lodging score	
	2007-08 (1st Trial)	2008 (2nd Trial)	2007-08 (1st Trial)	2008 (2nd Trial)	2007-08 (1st Trial)	2008 (2nd Trial)
ICSR 93034	2.00	3.00	2.40^{ab}	1.20^{b}	2.60^{b}	2.00^{b}
ICSV 700	2.20	3.20	2.80^{a}	3.20^{a}	3.60^{a}	2.80^{a}
ICSV 93046	2.40	3.00	2.00^{b}	2.40^{a}	2.00^{b}	2.20^{ab}
NTJ 2	2.00	3.60	2.20^{b}	3.20^{a}	2.40^{b}	1.60^{b}
SPV 422	2.00	3.40	1.00^{c}	2.20^{ab}	2.00^{b}	1.60^{b}
F-test	ns	ns	**	**	**	*
CV(%)	13.75	24.69	19.23	34.65	22.97	28.58

Further, NTJ2 and SPV 422 obtained the highest rating of 2.0 (1-25% deadhearts) but not significantly higher to ICSV 93046 rating of 1.60. For the stemborer damage, considerable differences were observed among sweet sorghum lines for the 1st trial. ICSV 93046 got the lowest rating of 1.0 (free from deadhearts) but not considerably lower to other lines, ICSV 700 and SPV 422 with the same rating of 1.40 each. However, the succeeding planting (2nd trial) showed no marked variations on stemborer damage among entries. Means in a column followed by the same letter are not significantly different at 5% level of probability, LSD.

No marked differences were seen on leaf disease score among entries for the last two trials. Different responses among lines were recorded for the different cropping seasons. For the 1st trial, SPV 422 had the lowest rating of 1.0 (very good) followed by ICSV 93046 with a rating of 2.0 (good) but not significantly different to NTJ2 (2.20) and ICSR 93034 (2.40). ICSV 700 got the highest rating of 2.80 which is significantly higher to ICSR 93034 rating. For the 2nd trial, again marked variations were noted among entries. ICSR 93034 had the lowest rating of 1.20 but not considerably higher to SPV 422 rating of 2.20. Further, ICSV 700 and NTJ2 got the highest score of 3.20 each but not significantly higher to two other entries, ICSV 93046 (2.40) and SPV 422 (2.20), respectively. Lodging scores entries responded differently in three cropping seasons. For the 1st trial, SPV 422 and ICSV 93046 got the lowest rating of 2.0 (1.25% plants lodged), followed by NTJ2 with 2.40, ICSR 93034 with 2.60. Highest rating of 3.60 was recorded on ICSV 700 which means that this line is more prone to lodging. Similar observations were noted on succeeding planting with ICSV 700 having the most number of lodged plants.

Summary and Conclusion

Based from the results of the study, the following conclusions were formulated: ICSV 700, one of the late maturing varieties evaluated, was the top performer in terms of plant height, stalk yield, stripped stalk yield, stalk diameter, stalk juice volume, stalk juice yield, seed size and *Brix values, however, performed inferior in stillage yield and grain yield parameters. ICSV 93046, the other late maturing varieties evaluated, was also one of the top performers in terms of stalk yield, stripped stalk yield, stalk diameter, stalk juice volume, stalk juice yield, *Brix values and seed size, however, performed inferior in stillage yield and grain parameters. SPV 422 outperformed all other varieties in stillage yield, grain yield and second best in seed size parameter but inferior in other agronomic parameters. ICSR 93034, performed better also in terms of stillage yield, grain yield and seed size. NTJ 2 performed better only in terms of the grain yield parameter. For 1st trial, significant differences among the varieties were observed for plant height, stripped yield, stalk diameter, stalk juice volume, stalk juice, stillage yield, grain yield and seed size. However, there were no significant differences among the varieties in terms of the plant stand. Shoot fly and stem borer damage, infestations range from 1.0 to 2.0 among the lines for the 2 cropping seasons. For leaf diseases, score ranges from 2.0 to 2.40 during the 1st trial and 3.0 during the 2nd trial. Plant appearance on the other hand, score ranges from 1.0 to 2.80 during the trials.

Recommendations

Special projects like this should be given flexibility in fiscal management for as long as it is within the bounds of the "*usual accounting and auditing procedures"* policy. Planting time for WS trials should be in July to avoid intense winds during soft dough stage of the SS plant. Bagging with perforated polyethylene bags of the SS panicles and grains to protect against birds.

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