AGRONOMIC BIOGRAPHY OF NIA-2012, A NEW HIGH YIELDING AND EARLY MATURING VARIETY OF NUCLEAR INSTITUTE OF AGRICULTURE (NIA), TANDOJAM

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ABSTRACT

Sugarcane (*Saccharum officinarum* × *S. spontaneum* hybrid) is a major cash crop of Pakistan. However, breeding elite cane varieties has been slow for this commodity because of the inapt agroclimatic conditions of the country. This study presents comparative trials of NIA-2012, a high yielding and early maturing variety against commercial checks (Thatta-10 and SPF-234), and three other promising clones. Fields trials were conducted at Nuclear Institute of Agriculture (NIA), Tandojam for two consecutive years. NIA-2012 recorded superior two years' average cane yield of 132.78 t/ha whereas SPF-234 exhibited lowest average cane yield of 82.38 t/ha. Thatta-10 was also seen to yield poorer than most of the clones evaluated in the experiment. Moreover, NIA-2012 maintained its superiority over all the entries regarding sucrose contents as well, which is the most important parameter of sugarcane crop for sugar industry. It produced highest sucrose contents of 20.04, and 19.66 % for the two seasons. Likewise, NIA-2012 out-yielded all entries regarding sugar yield, recording sugar yield of 20.08 and 19.21 t/ha for two years. Thatta-10, on the other hand, showed 12.58 and 11.92 t/ha of sugar yield. NIA-2012 can result in excellent economic returns to the farming community as well as sugar mills because of its exceptionally high cane yield and sugar contents. Additionally, it maintains its high sucrose contents from November until February which would be another edge to the farming community in prevailing sugar sector's trends of the country. This variety, with its tremendous combination of sucrose contents and cane yield, can play vital role to serve the agricultural sector and sugar industry.

Keywords: Cane Yield, Commercial Cane Sugar, Sucrose, Sugarcane Breeding, Sugar Yield

INTRODUCTION

Agriculture has paramount importance in Pakistan's economy. It has 19.5 percent share towards Gross Domestic Product (GDP) of the country, and is biggest source of employment for labor force in Pakistan by contributing up to 42.3%. Moreover, this sector is a begetter of raw material for many of the industries for value-added products (Azam and Shafique, 2017; MoF, 2017). Being a semi-industrialized economy and having a well integrated agriculture sector, Pakistan's industrial commodities like cotton and sugarcane are exceptionally significant for economic development. Sugarcane is one of the most important agricultural commodities of Pakistan. It contributes by 3.4% towards agricultural value addition while 0.7% for overall GDP of the country. Pakistan is largest per-capita consumer of sugar in the South-Asian region having a consumption rate of 25.83 kg per year, against 14, 10 and 11 kg of India, Bangladesh, and China, respectively (Azam and Khan, 2010). Sugarcane produces 99% of the sugar engendered in the country, moreover, sugarcane sector has second largest industrial base in the country after textile industry (Azam and Khan, 2010; Khan et al., 2016, 2018). Thus, this crop is also a source of

employment for thousands of skilled and non-skilled workers involved in the sugar industry. Additionally, sugarcane is a source of various value-added products for other industries as well (Khan et al., 2017). Among cane producers, Pakistan ranks at 5th position (FAOSTAT, 2015). In 2016-17, Pakistan cultivated sugarcane on an area of 1.2 million hectares and produced 73 million tons of sugarcane. Sugarcane yield of Pakistan is 60.31 t/ha against 142, 130, and 126.8 t/ha of Guatemala, Senegal, and Egypt, respectively. A huge yield gap is evident from the figures which depict the need for improvement to cash maximum economic returns from this commodity (FAOSTAT, 2017). Moreover, sugar recovery of Pakistan is also low against other cane growing countries (PSMA, 2017).

Pakistan harvested 9.87% sugar recovery in 2017 (PSMA, 2017). Sugar recovery is the primary parameter which determines the economic returns of the sugarcane crop. Major reason of low yield and recovery is the unavailability of high cane yielding sugarcane varieties (Heinz, 2015). It is evident from the situation that there is an urgent need to focus on sugarcane breeding in Pakistan. This dismal state of affairs necessitates evolution of new sugarcane varieties endowed with high yield, better sugar recovery and resistance to biotic and abiotic stresses. Pakistan's sugarcane breeding program faces many hurdles complicating the varietal development program. Most importantly, Pakistan's climate is subtropical. Although sugarcane can be grown in this climate, its growth is affected in harsh conditions i.e. low temperatures in winter, and very high temperature in summers (Malik, 2010; Azam and Shafique, 2017). Natural viable fertile seed production has ever been a problem in Pakistan because of none or sporadic flowering (Moore and Nuss, 1987). Moreover, arrangements for hybridization under artificial conditions are scare and meager. On the other hand, deterioration in the yield potential and resistance to biotic and abiotic stresses of sugarcane cultivars demand their continuous replacement with new and improved ones. Therefore, sugarcane breeding is extremely complex compared to other crops in the country (Mendoza, 2000). Keeping in view the situation evaluating exotic germplasm and obtaining crosses from there is an excellent approach in limiting conditions of Pakistan (Mendoza, 2000). Elite sugarcane variety NIA-2012 (CPNIA86-328) with high yield potential and other desired characters was selected from exotic material. The clone is early maturing and has high yield potential coupled with excellent commercial cane sugar (CCS) and recovery. The variety is tolerant to lodging, insect pests and diseases, apart from being a good ratooner. Present study was conducted to evaluate the performance of NIA-2012 over a period of two years against other potential clones of sugarcane.

MATERIALS AND METHODS

NIA-2012 was evaluated in advanced yield trials along with other entries in autumn planting at Nuclear Institute of Agriculture (NIA), Tandojam for two consecutive years i.e. 2011-12 and 2012-13. The experimental layout was randomized complete block design (RCBD) with 4 replications. The plot size was 8 x 10 m, with one-meter row spacing. Sowing was done in the month of September. Recommended agronomic practices for earthing up, weeding, and disease and insect control were followed throughout the growth period (Malik, 2010). N: P_2O_5: K_2O fertilizers were applied at a rate of 230:115:125 kg ha^{-1} using Urea, TSP and SOP. Potassium and phosphorous were given as a basal dose at sowing along with 1/3 nitrogen. Whereas, the remaining nitrogen was applied to the crop as two split doses. Three stools were randomly taken from each plot to determine their sugar contents according to Sugarcane Laboratory Manual for Queensland Sugar Mills, while three rows from each plot were harvested to record yield data (Anonymous, 1970). The recorded data were analyzed statistically using windows operated program Statistix 8.1 through DMR test.

Sucrose % was compared for four months *viz*. November, December, January, and February as it dictates the proper harvesting time as well as the next cropping patterns in the farmer's field.

RESULTS AND DISCUSSION

The data regarding evaluation of the genotypes in this study is presented in Table 1, and 2. Mean squares comparison showed highly significant differences among the genotypes studied against the clone of interest (NIA-2012) for cane yield, CCS%, sucrose %, and sugar yield—four most important parameters of sugarcane crop. NIA-2012 showed highly promising performance regarding all traits under consideration. Highest cane yield of 135.64 and 129.92 t/ha was recorded for NIA-2012 in the cropping seasons of 2011-12, and 2012-13, respectively. AEC86-341 was also seen to excel in cane yield recording second highest yields both years. The cane yield of 105.15, and 105.61 t/ha was observed for the two years' period for mentioned clone. CP80-1557 was observed to have a yield of 103.25 t/ha during second year of evaluation which was at par with that of AEC86-341.Two checks were used in the study viz. Thatta-10 and SPF-234, both of which have been popular varieties in Sindh. However, SPF-234 exhibited lowest cane yield for both years (79.45 and 85.32 t/ha) whereas Thatta-10 also revealed cane yield lower than most of the clones evaluated in this experiment.

The data regarding commercial cane sugar (CCS %) of the genotypes also showed superiority of the of elite clone NIA-2012 against other genotypes. Promising CCS% values of 14.81 and 14.79 % were observed for NIA-2012, which surpassed all the remaining clones. However, again, AEC86-341 followed NIA-2012 in CCS% showing the commercial cane sugar of 14.43 and 14.27 % for the study period. Whereas, SPF-234 showed lowest CCS% for the consecutive years. NIA-2012 also maintained its superiority over all the entries regarding sucrose contents, which is the most important parameter of sugarcane crop for sugar industry. It produced highest sucrose contents (20.04, and 19.66 % for seasons 2011-12 and 2012-13, respectively). However, for year 2012-13, AEC86-341 showed sucrose content of 19.59 % which was at par with that of NIA-2012. All of the remaining entries had lower sucrose % values (Table 1, and 2). Apart from determining the economical returns of the mills, sucrose % also dictates the purity of the crop before it can be harvested. Thus, high sucrose values are a prerequisite for early maturing varieties (Khan et al., 2004). Therefore, sucrose contents were analyzed for four consecutive months for the clones under study.

Sugar contents as well as cane yield, both are important parameters regarding sugarcane's commercial outcomes (Panhwar et al., 2017). A novel elite sugarcane variety must have a good amalgam of both of the characteristics as in Pakistan, farmers are paid on the basis of cane weight whereas sugar mills' profitability rely on sugar contents of the crop (Tabassum, 2018). New genotypes must fulfill the requirements of both of the stakeholders or they will not be acceptable to one or the other stakeholder. Cane yield is a quantitative trait dependent upon several other parameters (Okaz et al., 2011). In general, higher tillers, taller plants, and thicker cane results in higher cane yields (Khan et al., 2018). In our study, NIA-2012 surpassed all of the remaining genotypes in cane yield, proving it to be a clone of interest for the farmers. The September sown crop was analyzed for sucrose contents in the months of November, December, January and February. NIA-2012 maintained its dominance against rest of the genotypes during all four months. Average sucrose % of NIA-2012 was 19.4 % in the month of November against 17.64 and 18.25 % of Thatta-10 and SPF-234, respectively (Table 3). A general trend of increase in sucrose contents over the months was observed for the genotypes under consideration. In the month of February, NIA-2012 showed average sucrose contents of 20.10 % whereas Thatta-10 and SPF-234 showed sucrose contents of 17.73

and 19.14 %, respectively. AEC86-341 was seen to have second highest sucrose contents following NIA-2012 with sucrose contents of 19.12, 19.18, 19.62, and 20.03, for the months of November, December, January, and February, respectively. The sucrose contents of NIA-2012 kept increasing over time for the mentioned period, while on the other hand for Thatta-10, the sucrose contents were observed to decline after a continuous increase for first three months. NIA-2012 outperformed AEC86-341—the genotype with second highest sucrose contents—over all four months of evaluation (Figure 1).

NIA-2012 out-yielded all entries in terms of sugar yield as well. Huge differences were observed among this elite clone vs. other clones evaluated in the study. Currently grown popular controls from the province recorded the least sugar yields. Thatta-10 exhibited 12.58 and 11.92 t/ha for the year 2011-12 and 2012-13, while SPF-234 produced sugar yield of 8.79 and 11.13 t/ha for the two years. Thus, NIA-2012 showed as high as more than four times sugar yield than the variety Thatta-10. Similar observations were recorded against SPF-234 as well. The genotypes in this study revealed highly significant variations regarding their characteristics including cane yield, CCS%, sucrose %, and sugar yield. The difference in crop performance roots from its genetic make-up (Brewbacker, 1964). However, epigenetic factors and environmental variations contribute towards dictating the performance of the genotypes; stress response and tolerance play a major role in such mechanisms (Okaz et al., 2011; Basnayake et al., 2012). A commercially successful variety must perform good in varying environmental conditions and in presence of stress conditions (Mari et al., 2011). It has already been established that crop maintenance and provision of excellent agronomic practices like manuring, fertilizers application, and proper irrigations can only result in higher yields when the genetic capabilities of the variety are high (Keerio et al., 2003).

Sucrose analysis over time dissected this commercially imperative trait of concern, and revealed the exceptional performance of NIA-2012 in this regard. On average, NIA-2012 depicted highest sucrose contents. This characteristic of the clone is vital keeping in view that acceptability of a crop at the sugar mills depend on its sucrose contents at the time of harvest. Highest sucrose contents in the month of November depict that NIA-2012 is an early maturing variety and it can be harvested in the start of November, when the sugar mills start operating in Pakistan (Hamilton, 2014). Thus, the farmer can harvest the crop earlier for planning next utilization of available land which has significant importance for economical returns of the farmers (Singh et al., 2016). Moreover, NIA-2012 did not show any decline in sucrose contents for four months viz. November until February. This capability of the genotype is highly advantageous as it ensures that the clone can be harvested during any month of operation of sugar mills in Pakistan and will not result in economic losses to the mills (Zhu et al., 1997; Gilbert et al., 2006; Khushk and Memon, 2008).

NIA-2012 proved to be an extremely promising clone as it performed exceptionally well against traditional check varieties of the Sindh province. The clone also was a top performer among other elite genotypes under evaluation. Moreover, maintenance of its superiority over a period of two years increases the confidence in this clone. It was evident from the data that the field and climatic conditions were harsher for the first year of the study however, in both years' environmental conditions this clone maintained its superiority which indicates that the clone is not only high yielding but stress tolerant as well (Sohu et al., 2008). The data depicted that this clone have inherent genetic potential and capability to tolerate stress, and utilize the provided agronomic resources in varying environmental conditions ensuring highly economic production.

CONCLUSIONS

It is concluded that NIA-2012 can result in excellent economic returns to the farming community as well as sugar mills because of its exceptionally high cane yields and sugar contents. Moreover, this clone maintains its high sucrose contents from November until February which would be another edge to the farming community in prevailing sugar sector's trends of the country. Hence, NIA-2012 is recommended for planting in agro-climatic zones of Sindh.

Table-1 Performance of different sugarcane clones for cane yield, sugar contents and sugar yield in advanced yield trial at NIA, Tandojam during 2011-12

Genotypes	Cane Yield (t/ha)	CCS %	Average Sucrose % (Nov. – Feb.)	Sugar Yield (t/ha)
CP80-1557	96.23c	13.56bc	19.22b	13.04c
AEC86-341	105.15b	14.43ab	19.37b	15.17b
NIA-2012	**135.64a**	**14.81a**	**20.04a**	**20.08a**
CP71-2086	92.77c	14.07b	19.65b	13.05c
Thatta-10	94.89c	13.26c	17.80c	12.58c
SPF-234	79.45d	11.06d	18.27c	8.79d

NIA-2012 was evaluated against two checks and three other potential genotypes. Values are means of four replications. Means followed by same letters are not significantly different from each other ($p \leq 0.05$).

Table-2 Performance of different sugarcane clones for cane yield, sugar contents and sugar yield (CCS t/ha) in advanced yield trial at NIA, Tandojam during 2012-13

Genotypes	Cane Yield (t/ha)	CCS %	Average Sucrose % (Nov. – Feb.)	Sugar Yield (t/ha)
CP80-1557	103.25b	13.40bc	17.84c	13.83c
AEC86-341	105.61b	14.27ab	19.59ab	15.07b
NIA-2012	**129.92a**	**14.79a**	**19.66a**	**19.21a**
CP71-2086	94.82c	13.99b	18.70bc	13.27c
Thatta-10	91.36c	13.05c	17.96c	11.92d
SPF-234	85.32d	13.04c	19.13b	11.13d

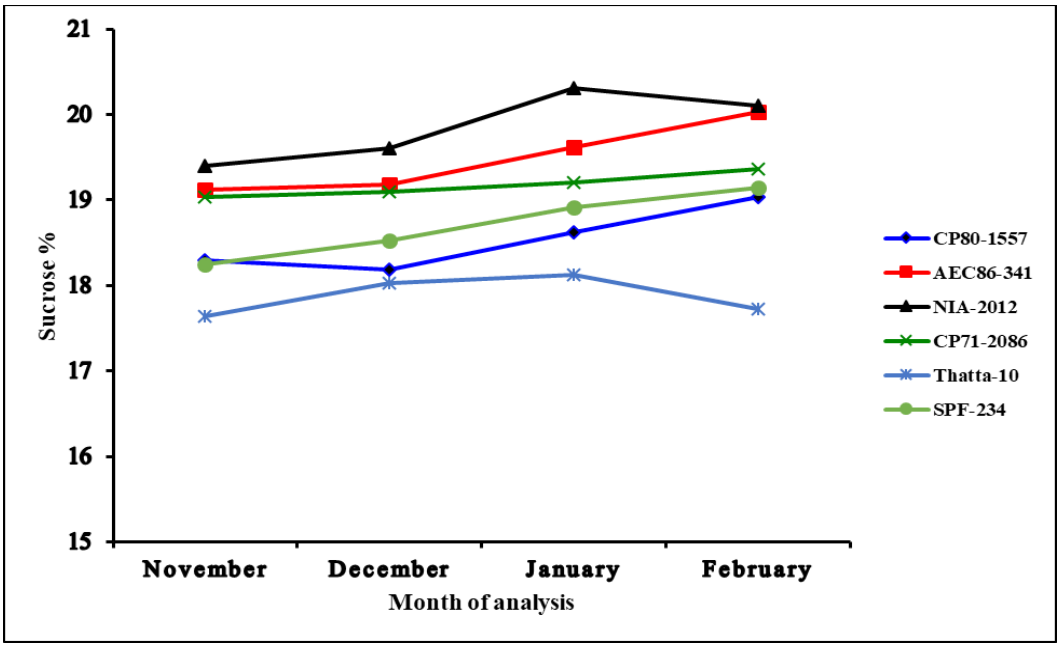
NIA-2012 was evaluated against two checks and three other potential genotypes. Values are means of four replications. Means followed by same letters are not significantly different from each other ($p \leq 0.05$).

Table-3 Sucrose changes over different months of harvesting (Two years pooled data)

	November	December	January	February
CP80-1557	18.30 ± 1.68	18.18 ± 0.96	18.62 ± 0.93	19.03 ± 0.33
AEC86-341	19.12 ± 0.73	19.18 ± 0.62	19.62 ± 0.39	20.03 ± 1.74
NIA-2012	19.40 ± 0.40	19.61 ± 0.52	20.31 ± 0.39	20.10 ± 0.32
CP71-2086	19.04 ± 1.00	19.09 ± 0.99	19.21 ± 0.68	19.36 ± 0.27
Thatta-10	17.64 ± 0.35	18.03 ± 0.28	18.13 ± 0.33	17.73 ± 0.71
SPF-234	18.25 ± 0.28	18.52 ± 0.50	18.91 ± 1.06	19.14 ± 0.71

Table presents two years' pooled data of sucrose% quantified in cane juice of different genotypes analyzed over a period of four months. Values are followed by their standard deviations.

Fig. 1 Comparison of sucrose % among different genotypes over a period of four months



Sucrose% changes in evaluated genotypes over a period of four months. The graphed values are average of figures for two consecutive years. NIA-2012 maintained its superiority for all four months.

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