

FOUR-YEAR PERFORMANCE EVALUATION OF SASRI SUGARCANE VARIETIES AT NCHALO SUGAR ESTATE, MALAWI

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Abstract

The advent of globalisation has added a new dimension to maintaining a competitive advantage in sugar production. Continuous improvement is the key to achieve efficient and cost effective sugar production. At Nchalo Sugar Estate the production team uses new sugarcane varieties from SASRI's Plant Breeding Programme to add value, increase the competitive advantage of its sugar production enterprise and ultimately improve returns on investment. Ten varieties were evaluated in a randomised block design from plant to third ratoon, harvested Early, Mid and Late season. The 10 varieties evaluated were N38, N35, N36, 87F2719, 90F613, 90F2765, 90F3125, 91F0820, 91F2765, 90F3125 and 91F1161. The control variety was N14.

Overall, the top ranking varieties for tons sucrose per hectare (TSH) were N14 (23.28), N38 (22.08) and N35 (22.07). The lowest levels of smut were recorded in 91F0820 (1.08%), N36 (1.1%) and 87F2719 (1.34%) while the control variety, N14, had a smut level of 2.61%. From these trial results, varieties N38 and N35 have been identified as the varieties of choice to replace N14, which has succumbed to smut pressure.

Keywords: adding value, competitive advantage, superior sugarcane varieties

Introduction

Trial objective

The main objectives were to evaluate the performances of a range of new varieties under an overhead irrigated regime, and compare these with variety N14. The trial covered the plant crop and three ratoons harvested Early, Mid and Late season.

World sugar market

To complete the objective of sugar production the sugar must be marketed to satisfy or surpass consumer requirements and make returns on shareholders' investments. However, this is a serious challenge as world sugar prices are sometimes below production costs.

EU sugar policy changes

In September 2007, the European Union (EU) decided to end the Sugar Protocol with effect from 1 October 2009. Since 1975 the protocol has governed the sugar trade between the EU and 20 African, Caribbean and Pacific (ACP) countries by offering quotas and guaranteed prices. The ruling is part of a package of reforms for Europe's sugar sector and comes as the EU is preparing to complete Economic Partnership Agreements (EPAs) with the ACP regions. The EU is planning to provide ACP countries with tariff and quota free access to its sugar market. Although there will be a safeguard clause, the precise terms are still unknown. At present sugar prices are falling on the European market (-36% forecast between 2007 and 2010).

This trend does not bode well for increased export revenues. The planned reforms also threaten to increase competition between least developed countries (LDC) of the ACP group, such as Malawi, and others seeking to supply the European market, which appears likely to remain more attractive than the world market, at least until 2013. Between now and then, ACP countries will need to make the most of this price differential to earn as much revenue as possible, while at the same time taking advantage of support for restructuring of their sugar sector (Anon, 2007).

Importance of varieties in sustaining the Malawian sugar industry

Being part of the global economy, Malawi is also affected by movements in the world markets. The advent of globalisation has added a new dimension to maintaining a competitive advantage in sugar production, and from the above it is evident that non-sugar factors are exerting an influence on world market sugar prices, often in excess of and divorced from considerations of supply and demand. World sugar prices, that is, those quoted on international futures markets, are characterised by two basic features: (i) volatility and (ii) levels far below average costs of production (Isyagi, 2006). Against this background, one of the keys to achieve efficient, cost effective and self sustaining sugar production is by using the right mix of sugarcane varieties from sugarcane research and development efforts.

The South African Sugarcane Research Institute's role

The new varieties evaluated are products of the South African Sugarcane Research Institute (SASRI) research effort. The research outcomes are important to sustain and perpetuate the sugarcane industry. Sugarcane varieties are one of the many practical products which would be regarded as SASRI's 'delivering valuable project outcomes' (Anon, 2009).

Nchalo Sugar Estate

Nchalo Estate is located in Malawi and comprises 13 090 hectares of irrigated sugarcane. The average annual rainfall is 715 mm and occurs primarily from December to March. Soils are alluvial and range from vertisols to sandy lenses. There is a high potential for salinity problems because of the high evaporation rates and flat terrain. Drainage, especially subsurface, is difficult. The dominant varieties are MN1, N14, N25 and N32.

Despite the gradual reduction of N14 due to smut susceptibility, the variety has been performing well in good cane environments with good soils, adequate irrigation and drainage, correct timing of planting and harvest, matched with superior management. The high fibre content typically found in N14 is an advantage when considering the rising importance of biofuels. With the introduction of high sucrose varieties bagasse production has been constrained, hence opportunity exists to cultivate N14 to meet energy and sugar requirements simultaneously, due to its advantage of high plant population which gives it an inbuilt economy of scale.

Materials and Methods

Three variety trials were established, replicated three times by season, planted on 6 June 2003 for Early season, 6 August 2003 for Mid season and on 28 October 2003 for the Late season trial, all with overhead irrigation. The trial was a randomised block design with five replicates of 12 varieties: N38, N35, N36, 87F2719, 90F613, 90F2765, 90F3125, 91F0820, 91F2765, 90F3125 and 91F1161, with N14 as the control. The net plot size was 10 m by 4 rows, with the rows spaced at 1.65 m and surrounded by guard rows. Smut recordings were taken four times monthly, and began one month after planting. Flower scores were made a week before

harvest to establish flowering percentage. Direct analysis of cane (DAC) samples of each plot were taken a week before harvest to establish cane quality. Stalk counts of the middle two rows were made at harvest to establish plant population of millable stalks. Plots were burnt and weighed at harvest annually as follows to obtain the respective ratoon data:

- The plant crop was harvested from the Early season trial on 2 July 2004, from the Mid season trial on 10 August 2004 and the Late season on 18 November 2004.
- First ratoon harvest dates were: Early season trial 16 June 2005, Mid season 19 August 2005 and Late season 18 October 2005.
- Second ratoon harvest dates were: Early season trial 26 June 2006, Mid season 1 September 2006 and late season 28 October 2006.
- Third ratoon harvest dates for Early, Mid and Late season were 4 June 2007, 31 August 2007 and 27 October 2007, respectively.

Trial data analysis was done using Genstat Version 10 General analysis of variance for single factor, variety.

Results

Analysis of variance was conducted on all the trial data and is presented below by parameter by season by ratoon.

Smut

Table 1. Varietal smut infection by ratoon by season.

Variety	% SMUT																Crop cycle average
	2004 Plant crop				2005 Ratoon 1				2006 Ratoon 2				2007 Ratoon 3				
	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	
86F0504	0.00	0.00	0.000	0.0	0.5	0.0	0.1	0.2	0.5	8.7	0.9	3.3	1.6	2.8	1.6	2.0	1.4
87F2719	0.00	0.00	0.000	0.0	0.2	0.0	0.0	0.1	0.3	7.9	3.3	3.8	1.1	1.7	1.8	1.5	1.3
90F0613	0.00	0.00	0.000	0.0	0.5	0.0	0.1	0.2	2.4	8.6	7.5	6.2	5.5	13.5	8.1	9.0	3.8
90F2765	0.00	0.00	0.000	0.0	0.7	0.0	0.0	0.2	2.2	10.0	6.9	6.4	4.1	6.0	3.0	4.4	2.7
90F3125	0.00	0.00	0.000	0.0	0.9	0.0	0.1	0.3	2.3	10.5	6.1	6.3	2.1	8.2	2.2	4.2	2.7
91F0820	0.00	0.00	0.000	0.0	0.0	0.0	0.0	0.0	0.5	5.5	1.7	2.6	2.7	1.5	1.1	1.7	1.1
91F1161	0.00	0.00	0.040	0.0	0.3	0.0	0.0	0.1	0.5	8.3	1.6	3.4	2.3	4.4	2.3	3.0	1.6
N14	0.00	0.00	0.000	0.0	0.4	0.0	0.0	0.1	1.0	7.7	5.6	4.7	3.7	8.7	4.5	5.6	2.6
N35	0.00	0.00	0.000	0.0	0.5	0.0	0.0	0.2	0.9	9.1	1.7	3.9	2.5	4.2	1.9	2.9	1.7
N36	0.00	0.00	0.000	0.0	0.4	0.0	0.0	0.1	0.1	6.2	1.6	2.6	1.5	2.8	0.7	1.7	1.1
N38	0.00	0.04	0.000	0.0	0.4	0.1	0.0	0.2	0.8	7.3	2.3	3.5	1.7	1.8	2.4	1.9	1.4
Mean	0.00	0.0	0.0	0.0	0.4	0.0	0.0	0.1	1.0	8.1	3.5	4.2	2.6	5.0	2.7	3.4	2.0
LSD 5%	0.00	0.0	0.0	0.0	0.7	0.0	0.1	0.3	1.4	4.9	3.5	3.2	1.9	2.1	1.3	1.7	1.3
CV	*	741.6	741.6	741.6	123.2	741.6	346.9	403.9	102.6	47.6	76.5	75.6	55.6	32.9	36.8	41.8	315.7

Plant cane

In Early, Mid and Late season the smut level was not greater than 0.05%. In Mid season N38 registered 0.04% smut, and in Late season 91F1161 registered 0.04% smut. The control N14, which under commercial conditions at Nchalo is highly susceptible, did not register any smut infection in Early, Mid or Late season.

Ratoon 1

Early season the highest smut ranking variety was 90F3125 at 0.9%, followed by 90F2765 at 0.7%. The lowest infected variety was 87F2719 at 0.2% smut. The control variety N14 had 0.4% smut, as did N36 and N38. Mid season N38 registered 0.1% infection. Late season the only varieties that registered any infection were 86F504, 90F0613, 90F3125, all at 0.1%. On average the most susceptible variety was 90F3125 at 0.3% and least susceptible was 91F0820 at 0%. The control variety N14 registered 0.1% smut. However, at the 5% level there was no significant difference between all the varieties by season.

Ratoon 2

Early season the top ranking smut infected varieties were 90F613 (2.4%), followed by 90F3125 (2.3%) and 90F2765 (2.2%). The lowest ranking smut variety was N36 (0.1%). The control variety N14 registered 1% smut infection. At the 5% level of significance N14, 90F0613, 90F3125 and 90F2765 were the same in terms of smut susceptibility, but different when compared to N36. Mid season the two top ranking smut varieties were 90F3125 (10.5%) and 90F2765 (10.0%). The lowest ranking smut variety was 91F0820 (5.5%). The Mid season infection results are single digit due to subjective scoring, but within the season the coefficient of variation was the lowest. Late season the two top ranking smut infected varieties were 90F0613 (7.5%) and 90F2765 (6.9%). The lowest ranking smut variety was 86F0504 (0.9%). N14 registered 5.6% smut. On average the highest smut infected variety was 90F2765 (6.4%) and the lowest were 91F0820 and N36, both at 2.6%.

Ratoon 3

Early season, variety 90F0613 had the highest smut level at 5.5%, followed by 90F2765 at 4.1% smut. The lowest infection of 1.1% was in 87F2719. The control N14 was the fourth highest at 3.7% infection. The varietal mean smut level was 2.6%. Mid season, 91F0820 had the lowest smut level of the varieties under observation at 1.5%. Variety 90F0613 had the heaviest infestation at 13.5%, followed by N14 at 8.7%. The midseason trial mean was 5.0% smut. Late season N36 registered the lowest infection at 0.7%, the highest being 90F0613 at 8.1% followed by N14 at 4.5%. The late season mean was 2.7%. The third ratoon average smut infection was 3.4%. Of the 11 varieties in the trial, four varieties, namely 90F3125 (4.2%), 90F2765 (4.4%), N14 (5.6%) and 90F0613 (9%) had above average smut infection. Variety 90F613 had persistently high smut levels in all seasons. The lowest ranking smut variety was 872719 at 1.5%.

Crop cycle average

Over the crop cycle evaluated of plant plus three ratoons, the lowest ranking smut infection was registered in N36 and 91F0820 at 1.1%. Variety 90F0613 had the heaviest smut infection at 3.8%. N14 (2.6%), 90F3125 (2.7%), 90F2765 (2.7%) and 90F0613 had infection levels above the 2% smut crop cycle mean. Varieties 91F0820 and N36 were the lowest ranking on average throughout the evaluated crop cycle.

General

The smut infection rises with each successive ratoon, indicative of the fact that crop sanitation measures must be intensified to guarantee more ratoons, all other factors being constant. This way more ratoons can be obtained, reducing the need for frequent plough-outs and as such reducing the costs of production to gain a competitive advantage. The high CVs are due to the very subjective nature of smut whip counts and removal. Variety 90F0613 was the most susceptible to smut by season and by ratoon, and N36 and 91F0820 the least susceptible. Over

the crop cycle evaluated of plant plus three ratoons, the lowest ranking smut infection was registered in N36 and 91F0820 at 1.1%.

Flowering

Table 2. Varietal flowering by ratoon by season.

Variety	% FLOWERING															
	2004 Plant cane				2005 Ratoon 1				2006 Ratoon 2				2007 Ratoon 3			
	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave
86F0504	7.9	3.2	11.4	7.5	0.6	0.6	0.8	0.7	0.9	3.0	6.0	3.3	2.7	4.0	0.2	2.3
87F2719	15.4	8.9	8.9	11.0	1.8	1.8	6.4	3.3	0.9	2.9	2.6	2.1	4.5	2.7	5.2	4.1
90F0613	2.2	3.2	2.6	2.7	0.5	0.5	3.2	1.4	0.2	0.1	1.4	0.6	0.0	0.0	0.2	0.1
90F2765	14.6	9.9	5.0	9.9	4.3	4.5	11.0	6.6	9.2	8.8	6.6	8.2	11.6	10.0	20.5	14.0
90F3125	16.0	8.1	9.5	11.2	5.7	5.5	6.2	5.8	8.7	11.7	14.2	11.5	11.1	13.8	12.4	12.5
91F0820	5.7	1.3	6.2	4.4	1.5	1.4	0.0	1.0	4.9	5.3	0.1	3.4	1.7	2.9	0.0	1.6
91F1161	0.3	0.2	7.8	2.8	0.4	0.4	0.0	0.3	0.4	1.2	5.9	2.5	1.5	0.1	0.0	0.5
N14	14.5	10.4	6.2	10.4	6.1	6.4	18.4	10.3	20.3	14.1	10.4	14.9	40.5	19.0	22.5	27.3
N35	10.7	6.7	3.2	6.9	5.1	5.0	11.2	7.1	7.6	6.4	11.6	8.5	11.8	13.7	5.6	10.4
N36	15.6	7.5	6.7	9.9	5.4	4.8	1.6	3.9	6.0	7.3	6.9	6.7	8.1	3.6	7.5	6.4
N38	0.2	0.2	5.2	1.9	0.4	0.4	0.8	0.5	1.0	0.0	1.8	0.9	0.0	0.0	1.5	0.5
Mean	9.4	5.4	6.6	7.1	2.9	2.8	5.4	3.7	5.5	5.5	6.1	5.7	8.5	6.4	6.9	7.2
LSD 5%	4.2	5.3	7.6	5.7	2.6	2.7	15.0	6.8	6.5	6.1	11.0	7.9	12.1	6.7	6.0	8.3
CV	35.5	76.3	89.7	67.2	70.7	73.4	217.0	120.4	93.5	86.7	140.1	106.7	112.0	82.6	68.8	87.8

Plant cane

Early season the most prolific flowering varieties were 90F3125 (16.0%), N36 (15.6%), 87F2719 (15.4%), 90F2765 (14.6%) and N14 (14.5%). The flower shy varieties were N38 (0.2%) and 91F1161 (0.3%). Mid season N14 was the most prolific flowering variety at 10.4%. The flower shy varieties were N38 and 91F1161 at 0.2%. Late season 86F0504 was the most prolific flowering variety at 11.4%. The control N14 was ranked sixth at 6.2% flowering. The varieties with the lowest flowering were 90F0613 (2.6%) and N35 (3.2%). Late season flowering was heavier than in the previous seasons. On average across seasons, 90F3125 was the most prolific flowering variety at 11.2% and N38 the lowest at 1.9%. The control N14 ranked the third most flowering variety at 10.4%.

Ratoon 1

Early season N14 was the most prolific flowering variety at 6.1%. The most flower shy varieties were N38 and 91F1161 at 0.4%. Mid season, N14 at 6.1% flowering was the most prolific flowering variety. The most flower shy varieties were N38 and 91F1161 at 0.4%. Late season, N14 was the most prolific flowering variety at 18.4%. The most flower shy varieties were 91F0820 and 91F1161 at 0% flowering. On average, N14 was the most prolific flowering variety at 10.3% and the most flower shy varieties were 91F1161 and N38 at 0.3% and 0.5%, respectively.

Ratoon 2

Early season N14 was the heaviest flowering variety at 20.3% and the most flower shy variety was 90F0613 at 0.2%. Mid season N14 was the heaviest flowering variety at 14.1%. The most flower shy varieties were N38 at 0% and 90F0613 at 0.1%. Late season, 90F3125 was the most prolific flowering variety at 14.2%. The control N14 ranked third at 10.4% flowering. The most flower shy variety was 91F0820 at 0.1%. On average, across the Ratoon 2 seasons, N14 was the most prolific flowering variety at 14.9% and the lowest flowering was 90F0613 at 0.6%, followed by N38 at 0.9%.

Ratoon 3

Early season, N14 flowered the heaviest at 40.5%; the flower shy varieties were 90F0613 and N38 at 0%. Mid season, N14 was the most prolific flowering variety at 19.0%; the flower shy varieties were 90F0613 and N38 at 0%. Late season, N14 was again the most prolific flowering variety at 22.5% flowering. Varieties 91F1161 and 91F0820 did not flower. On average, N14 was the most prolific flowering variety at 27.3% flowering and 90F0613 the most flower shy variety at 0.1% flowering. Cognisance must be made of the subjective nature of obtaining the flower counts, hence the very high coefficient of variations of the respective season trails.

Fibre**Table 3. Varietal fibre percentage by ratoon by season.**

Variety	% FIBRE															
	2004 Plant cane				2005 Ratoon 1				2006 Ratoon 2				2007 Ratoon 3			
	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave
86F0504	12.6	12.1	14.2	13.0	12.8	13.1	13.7	13.2	12.0	14.8	15.1	14.0	11.7	13.7	12.1	12.5
87F2719	13.4	13.2	14.6	13.7	13.6	14.7	16.1	14.8	13.0	13.1	16.6	14.2	13.7	14.5	14.8	14.3
90F0613	13.6	11.4	13.8	12.9	11.2	11.7	12.6	11.8	10.4	11.2	13.8	11.8	10.6	13.4	11.3	11.8
90F2765	13.0	11.7	15.0	13.2	14.1	14.0	13.5	13.9	11.9	11.4	14.8	12.7	11.6	13.3	12.3	12.4
90F3125	13.4	12.6	13.1	13.1	12.6	13.4	13.1	13.0	12.2	12.2	17.9	14.1	11.9	13.1	15.4	13.5
91F0820	12.9	10.6	11.1	11.6	12.2	13.1	13.8	13.0	12.4	12.9	15.6	13.6	12.9	13.5	13.1	13.2
91F1161	13.6	13.7	13.3	13.5	15.3	15.0	16.7	15.7	14.4	15.2	17.5	15.7	15.0	14.3	16.9	15.4
N14	13.7	12.6	16.3	14.2	13.6	15.9	16.4	15.3	13.6	14.2	17.1	15.0	15.7	14.2	14.8	14.9
N35	12.9	13.1	13.1	13.0	13.7	14.0	16.2	14.6	15.5	13.4	17.9	15.6	14.7	14.2	13.7	14.2
N36	12.4	12.5	14.6	13.2	14.5	15.7	15.0	15.1	14.4	14.1	16.2	14.9	14.9	14.7	14.3	14.6
N38	14.5	11.6	12.9	13.0	12.7	13.8	14.1	13.5	12.1	12.5	14.7	13.1	12.8	13.6	13.4	13.3
Mean	13.3	12.3	13.8	13.1	13.3	14.0	14.7	14.0	12.9	13.2	16.1	14.1	13.2	13.9	13.8	13.6
LSD 5%	2.9	2.1	2.3	2.5	1.6	1.6	1.5	1.6	2.4	2.2	3.8	2.8	1.9	1.3	2.5	1.9
CV	17.1	13.7	13.2	14.7	9.4	9.0	8.2	8.8	14.6	13.1	18.3	15.3	11.3	7.6	13.9	10.9

Plant cane

Early season N38 fibre was the highest of all test varieties at 14.5%, followed by N14 at 13.7%, the lowest being N36 at 12.4%. Mid season 91F1161 had the highest fibre content at 13.7%. The control N14 was ranked fourth at 12.6%. Variety 91F0820 had the least fibre at 10.6%. Late season N14 had the highest fibre at 16.3% fibre and the least fibrous variety was 91F0820 at 11.1%. On average, the most fibrous variety was N14 at 14.2% fibre and the least was 91F0820 at 11.6%.

Ratoon 1

Early season 91F1161 was the most fibrous variety at 15.3%, the control variety N14 was at 13.6% fibre and the least fibrous variety was 90F0613. Mid season N14 was the most fibrous at 15.9% and the least fibrous was 90F0613 at 11.7%. Late season 91F1161 was the most fibrous at 16.7%, followed by N14 at 16.4%, the lowest being 90F0613 at 12.6%. On average across seasons, the most fibrous varieties were 91F1161 at 17.5% and N14 at 15.3%, and the least fibrous was 90F0613 at 11.8%.

Ratoon 2

Early season N35 was the most fibrous variety at 15.5%, N14 had 13.6% fibre and the least fibrous variety was 90F0613 at 10.4%. Mid season 91F1161 was the most fibrous variety at 15.2% fibre, N14 was at 14.2% and the least fibrous was 90F0613 at 11.4%. Late season N35 and 90F3125 were the most fibrous at 17.9%, with N14 at 17.1% fibre. The least fibrous variety was 90F0613 at 13.8%. On average, the most fibrous varieties were 91F1161 (15.7%), N35 (15.6%) and N14 (15.0%). The least fibrous was 90F0613 (11.8%).

Ratoon 3

Early season, N14 at 15.7% was the most fibrous variety and the lowest was 90F0613 at 10.6%. Mid season, N36 at 14.7% was the most fibrous variety and the lowest was 90F3125 at 13.1%. Late season, 91F1161 at 16.9% was the most fibrous variety and the lowest was 90F3125 at 11.3%.

Population**Table 4. Varietal population density by ratoon by season.**

Variety	POPULATION PER HECTARE															
	2004 Plant crop				2005 Ratoon 1				2006 Ratoon 2				2007 Ratoon 3			
	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave
86F0504	104210	106467	118570	109749	113031	123698	121134	119288	110980	213857	203805	176214	190471	214165	245346	216661
87F2719	133135	127699	132314	131049	115698	133135	137750	128861	154777	279501	236832	223703	253756	246269	264218	254748
90F0613	116006	104005	136315	118775	83799	98672	122980	101817	100005	140007	149956	129989	152110	162880	204728	173239
90F2765	111185	99082	118057	109441	120519	119698	125237	121818	123801	229242	203497	185513	206164	220524	221857	216182
90F3125	106877	112724	128006	115869	116416	129442	129135	124998	137853	217036	198677	184522	236627	245858	248833	243773
91F0820	119903	120724	124724	121784	121339	134468	128622	128143	135186	242474	273039	216900	234678	201959	268834	235157
91F1161	139597	140622	131083	137101	137340	142264	133545	137716	144315	271398	295194	236969	204010	225960	282373	237448
N14	146674	132725	147597	142332	148623	157444	157956	154674	161444	254885	260936	225755	267398	261552	314375	281108
N35	141443	118775	145853	135357	136109	131289	136827	134742	149341	267808	219190	212113	226781	232319	267501	242200
N36	116211	105749	130468	117476	89543	125032	105852	106809	111800	216831	203190	177274	210882	236730	258474	235362
N38	133135	130571	150879	138195	123801	143289	137135	134742	145853	285450	227499	219601	274988	211190	266372	250850
Mean	124398	118104	133079	125194	118747	130766	130561	126691	134123	238045	224711	198960	223442	223582	258446	235157
LSD 5%	20689	16095	27947	21577	27817	29958	31570	29782	26431	41209	55622	41087	74695	45842	72258	64265
CV	13	11	16	13	18.0	18.0	19.0	18.3	15	14	19	16	26	16	22	21

Plant Cane

The number of millable stalks per hectare is important as the stalks are the sucrose sinks per unit of production. High plant population is also beneficial for weed suppression. Early season, N14 had the highest plant population of 146674 plants per hectare. The lowest plant population was 86F0504 at 104210 stalks per hectare. Mid season, 91F1161 had the highest millable stalk population at 140622 stalks per hectare, followed by N14 at 132725. The lowest populated variety was 90F2765 at 99082 plants per hectare. Late season, N38 at 132725 had the highest population followed by N14 at 130571 plants per hectare. The lowest stalk population was variety 90F2765 at 118057 plants per hectare. Overall across seasons, N14 and N38 had the highest population densities of 142332 and 138195, respectively. The lowest plant population variety was 90F2765 at 109441 plants per hectare.

Ratoon 1

Early season N14 had the highest population of 148623 plants per hectare, followed by 91F1161 at 137340 plants. The lowest plant population was 83799 plants per hectare in variety 90F0613. Mid season the highest population density was N14 at 157444, and the lowest was 90F0613 at 98672 plants per hectare. Late season N14 was the highest at 157956 and the lowest was N36 at 105852 plants per hectare. The general trend is a population increase from Early season to Late season, an important factor with the increasing importance of biofuels. Across the Ratoon 1 season, N14 was the most heavily populated variety at 154674 and the lowest was 90F0613 at 101817 plants per hectare.

Ratoon 2

Early season, N14 plant population was the highest at 161444 plants per hectare, followed by 87F2719 at 154777 plants. Lowest plant population was from 90F0613 at 100005 plants per hectare. Mid season N38 had the highest plant density at 285450 plants per hectare, the control variety N14 had 254885 plants per hectare and the lowest was 90F0613 at 140007 plants per hectare. Late season 91F1161 at 295194 plants per hectare was the most densely populated, the control N14 was at 260936 plants per hectare and the lowest was 90F0613 at 149956 plants per hectare. Overall across Ratoon 2 seasons, the high population varieties were 91F1161 at 236969 and N14 at 225755 plants per hectare. The lowest was 90F0613 at 129989 plants per hectare.

Ratoon 3

Early season N38 had the highest population followed by N14 at 274988 and 267398 plants per hectare, respectively. The lowest plant density was of variety 90F0613 at 152110 plants per hectare. Mid season, N14 and 87F2719 had the highest plant densities at 261 552 and 246269 plants per hectare respectively. The lowest plant density was of variety 90F0613 at 162880 plants per hectare. Late season, N14 and 91F1161 had the highest population densities at 314375 and 282373 plants per hectare, respectively. The lowest plant density was of variety 90F0613 at 204728 plants per hectare. On average, N14 had the highest plant population by season and ratoon, and 90F0613 the lowest. This has implications for value-added enterprises such as biofuel production, weed suppression and yield parameters such as tons cane per hectare and tons sucrose per hectare.

Tons cane per hectare**Table 5. Varietal tons cane per hectare by ratoon by season.**

Variety	TONS CANE PER HECTARE															
	2004 Plant cane				2005 Ratoon 1				2006 Ratoon 2				2007 Ratoon 3			
	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave
86F0504	164.51	144.41	150.2	153.0	148.1	139.1	89.4	125.5	117.3	128.6	79.9	108.6	129.2	99.7	78.1	102.3
87F2719	167.59	132.1	149.2	149.6	128.4	132.3	92.1	117.6	118.7	125.0	76.0	106.6	128.4	86.4	72.4	95.7
90F0613	211.08	170.46	170.8	184.1	147.7	130.1	86.6	121.4	113.8	87.2	93.2	98.1	137.0	71.5	86.1	98.2
90F2765	154.26	125.95	151.7	144.0	140.9	138.9	86.8	122.2	108.9	129.2	92.6	110.3	134.5	98.9	76.4	103.3
90F3125	163.9	123.9	144.6	144.1	154.5	130.9	75.5	120.3	135.4	112.2	79.0	108.9	122.4	104.8	62.8	96.7
91F0820	163.28	155.49	162.2	160.3	134.0	152.0	99.3	128.4	111.9	130.0	97.2	113.1	130.4	109.2	92.5	110.7
91F1161	156.51	136.62	160.3	151.1	145.0	139.7	100.9	128.6	125.5	143.0	101.4	123.3	136.4	107.2	90.1	111.2
N14	189.54	157.33	178.5	175.1	154.5	160.2	125.8	146.8	155.1	153.5	123.5	144.0	138.6	131.4	118.1	129.4
N35	150.15	129.85	159.4	146.5	142.6	142.6	90.7	125.3	131.5	125.5	99.6	118.9	143.0	121.7	89.0	117.9
N36	179.9	143.79	158.5	160.7	155.3	136.6	93.9	128.6	140.9	128.1	92.1	120.3	137.3	121.2	82.2	113.6
N38	202.87	160.82	191.1	184.9	160.6	160.4	107.3	142.8	136.9	141.3	101.6	126.6	140.5	117.9	98.9	119.1
Mean	173.05	143.7	161.5	159.4	146.5	142.1	95.3	128.0	126.9	127.6	94.2	116.2	134.3	106.3	86.1	108.9
LSD 5%	21.34	16.1	30.6	22.7	15.6	20.5	17.7	17.9	24.1	23.9	12.4	20.1	28.5	22.1	18.5	23.0
CV	9.68	8.79	14.9	11.1	8.3	11.3	14.6	11.4	14.9	14.7	10.3	13.3	16.6	16.3	16.8	16.6

Plant Cane

Early season the top yielding varieties were 90F0613 at 211.1 tons cane per hectare (TCH) and N38 at 202.9 TCH. The lowest yielding was N35 at 150.2 TCH. The control N14 was third in rank yielded 189.5 TCH. Mid season 90F0613, N38 and N14 were the top ranking varieties at 170.5, 160.8 and 157.3 TCH, respectively. The lowest yielding variety was 90F3125 at 123.9 TCH. Late season N38, N14 and 90F0613 were the top ranking varieties at 191.1, 178.5 and 170.8 TCH, respectively. The lowest yielding variety was 90F3125 at 144.6 TCH. On average across plant seasons, the top yielding varieties were N38, 90F0613 and N14 at 184.9, 184.1 and 175.1 TCH, respectively. The lowest yielding varieties were 90F2765 and 90F3125 at 144.0 and 144.1 TCH, respectively. The high yields obtained reflect the potential under experimental conditions. The production objective should be to narrow the gap between experimental and commercial production levels.

Ratoon 1

Early season the top yielding varieties were N38, N36, N14 at 160.6, 155.3 and 154.5 TCH, respectively. The lowest yielding was 87F2719 at 128.4 TCH. Mid season N38 and N14 had the highest TCH at 160.4 and 160.2, respectively. At the 5% level there was no significant difference between N14 and N38 TCH. The lowest yielding variety was 90F0613 at 130.1 TCH. Late season the highest TCH was from N14 at 125.8, followed by N38 at 107.3 TCH. The lowest ranked was 90F3125 at 75.5 TCH. On average across seasons, N14 at 146.8 TCH was the highest yielding variety, followed by N38 at 142.8 TCH and N36 at 128.6 TCH. At the 5% level, there was no significant difference between N14 and N38. The lowest ranking variety was 87F2719 at 117.6, followed by 90F3125 at 120.3 TCH.

Ratoon 2

Early season, the highest TCH yield was from N14 at 155.1 TCH, followed by N36 at 140.9 TCH and N38 at 136.9 TCH. At the 5% level, there was no significant difference between the three top ranking varieties. The lowest yielding variety was 90F2765 at 108.9 TCH. The early season trial mean was 126.9 TCH. Mid Season, N14 yielded the highest TCH at 153.5, followed by 91F1161 at 143.0 and N38 at 141.3 TCH. The Mid season trial mean was 127.6 TCH. The lowest yielding variety was 90F0613 at 87.2 TCH, representing 68.3% of the trial mean TCH. Late season, N14 was top ranking at 123.5 TCH, followed by N38 and 91F1161 at 101.6 and 101.4 TCH, respectively. The lowest yielding varieties were 87F2719 and 90F3125 at 76.0 and 79.0 TCH, respectively. The late season TCH trial mean was 94.2 TCH. On average across seasons, ratoon 2 top ranking varieties were N14 at 144.0 TCH, N38 at 126.6 TCH and 91F1161 at 123.3 TCH. The lowest yielding variety was 90F0613 at 98.1 TCH.

Ratoon 3

Early season, N35 was top ranking at 143.0 TCH, followed by N38 and N14 at 140.5 and 138.6 TCH, respectively. The lowest yielding variety was 90F3125 at 122.4 TCH. The Early season trial mean was 134.3 TCH. Mid season, N14 had the highest cane yield at 131.4 TCH, followed by N35 and N36 at 121.7 and 121.2 TCH, respectively. The lowest yielding variety was 90F3125 at 71.5 TCH. The Mid season trial mean was 106.3 TCH. Late season, N14 again was the highest yielding at 118.1 TCH, followed by N38 at 98.9 TCH. The lowest yielding variety was 90F3125 at 62.8 TCH. Late season had the lowest varietal yields. On average across seasons in Ratoon 3, N14 was the highest yielding variety at 129.4 TCH, followed by N38 at 119.1 TCH. The lowest yielding varieties were 87F2719 at 95.7 TCH and 90F3125 at 96.7 TCH.

Tons sucrose per hectare

Table 6. Varietal tons sucrose per hectare by ratoon by season.

Variety	TONS SUCROSE PER HECTARE															
	2004 Plant				2005 Ratoon 1				2006 Ratoon 2				2007 Ratoon 3			
	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave	Early	Mid	Late	Ave
86F0504	24.8	24.6	23.6	24.3	24.3	24.7	15.4	21.4	21.0	22.9	12.0	18.6	22.1	17.3	12.6	17.3
87F2719	26.3	22.9	24.3	24.5	22.6	24.3	15.8	20.9	22.5	23.4	11.7	19.2	22.5	15.5	12.1	16.7
90F0613	31.1	28.1	25.2	28.1	23.3	21.6	13.2	19.4	19.5	15.1	13.9	16.1	21.9	12.2	13.7	15.9
90F2765	22.1	20.2	19.3	20.6	20.2	23.0	13.0	18.7	18.2	21.3	12.1	17.2	20.2	15.8	11.6	15.9
90F3125	23.1	21.2	21.0	21.8	23.4	23.6	11.3	19.4	21.7	20.0	10.6	17.4	18.8	17.2	9.46	15.2
91F0820	25.6	26.6	26.1	26.1	22.0	25.8	16.1	21.3	19.1	21.8	14.2	18.4	19.8	18.2	14	17.3
91F1161	24.4	21.2	24.5	23.4	23.6	24.1	15.3	21.0	21.9	24.7	14.3	20.3	22.1	17.8	14.9	18.2
N14	28.8	25.2	26.5	26.8	24.5	27.0	18.3	23.3	25.9	25.3	16.5	22.6	22.0	21.4	18.4	20.6
N35	23.9	22.2	27.1	24.4	25.9	26.2	15.9	22.7	23.1	22.2	14.7	20.0	24.6	22.3	15.3	20.7
N36	26.0	24.1	19.9	23.3	24.4	22.8	13.9	20.4	23.7	20.8	12.9	19.1	21.2	20.5	12.4	18.0
N38	29.0	23.4	27.9	26.8	23.3	25.4	16.6	21.8	21.7	22.8	14.8	19.8	20.8	19.0	15.3	18.4
Mean	25.9	23.6	24.1	24.5	23.4	24.4	15.0	20.9	21.7	21.8	13.4	19.0	21.5	17.9	13.6	17.7
LSD 5%	4.7	3.6	5.3	4.5	3.3	3.6	3.3	3.4	4.4	4.3	1.8	3.5	4.8	3.6	2.86	3.8

Plant cane

Varieties with tons sucrose per hectare (TSH) above the Early season trial mean of 25.9 were N36 (26.0), 87F2719 (26.3), N14 (28.8), N38 (29.0) and 90F0613 (31.1). At the 5% level of significance, N14 and N38 were not significantly different from the top ranking variety 90F0613. The lowest yielding variety was 90F2765 (22.1 TSH) and the control N14 yielded 28.8 TSH. Mid season the trial mean was 23.6 TSH, of which N36 (24.1), 86F0504 (24.6), N14 (25.2), 91F0820 (26.6) and 90F0613 (28.1) were above average. The highest yielding variety was 90F0613 at 28.1 TSH. At the 5% level, the yields of varieties 86F0504, N14 and 91F0820 were not significantly different from that of top ranking 90F0613. Late season the highest yielding varieties were N38 (27.9 TSH), N35 (27.1 TSH) and N14 (26.5 TSH). The lowest yielding variety was 90F2765 at 19.3 TSH, followed by N36 at 19.9 TSH. At the 5% level of significance 90F2765, N36 and 90F3125 were significantly different from N38. On average through the seasons, the highest yielding variety was 90F0613 (28.1 TSH), followed by N14 and N38 at 26.8 TSH. The lowest yielding varieties were 90F2765 (20.6 TSH) followed by 90F3125 (21.8 TSH).

Ratoon 1

Early season, the three top ranking varieties were N35 (25.9 TSH), N14 (24.5 TSH) and N36 (24.4 TSH), followed closely by 86F504 (24.3 TSH). The lowest ranking was 90F2765 (20.2 TSH). Mid Season the highest yielding variety was N14 (27.0 TSH), followed by N35 (26.2 TSH), 91F0820 (25.8 TSH) and N38 (25.4 TSH). The lowest yielding was 90F0613 (21.6 TSH). Late season, although lower yielding than Early and Mid season, N14 remained the highest yielding at 18.3 TSH, followed by N38 (16.6 TSH) and 91F0820 (16.1 TSH). The lowest yielding was 90F3125 at 11.3 TSH. Based on the seasonal average, N14 was the highest yielding at 23.3 TSH, followed by N35 at 22.7 TSH and N38 at 21.8 TSH. The lowest yielding variety was 90F2765 at 18.7 TSH.

Ratoon 2

Early season highest yielding variety was N14 at 25.9 TSH, followed by N36 at 23.7 TSH and N35 at 23.1 TSH. The lowest yielding variety was 90F2765. Mid season, N14 was again the highest yielding at 25.3 TSH, followed by 91F1161 at 24.7 TSH. The lowest yielding variety was 90F0613 at 15.1 TSH. The Late season yield drop manifested itself again in Ratoon 2 compared to Early and Mid season varietal yields. However, N14 was still the highest yielding at 16.5 TSH, representing a yield drop of 8.8 TSH compared to Mid season yield and 9.4 TSH compared to Early season yield. This indicates that N14 must be planned for Early season harvest to maximise yields and reduce production costs. The lowest yielding variety was 90F3125 at 10.6 TSH, representing an almost 50% drop when compared to its respective Mid and Early season yields. On average, the highest yielding Ratoon 2 variety was N14 at 22.6 TSH and the lowest was 90F0613 at 16.1 TSH. At the 5% level, the yields of these two varieties were significantly different.

Ratoon 3

Early season, N35 had the highest TSH yield at 24.6. The control N14 was ranked fifth and yielded 22.0 TSH, 2.6 TSH less than N35. The lowest yielding variety was 90F3125. At the 5% level, the yields of N14, N38, 86F0504, 91F1161 and N35 were not significantly different. On Average for ratoon 3 across seasons, N35 and N14 were the highest yielding varieties at 20.7 and 20.6 TSH, respectively. The lowest yielding variety was 90F3125 at 15.2 TSH. Late season harvests experienced the lowest yields, the highest being Early season followed by the Mid season yields.

Crop cycle average

Across seasons and plant crop and three ratoons, N14 was on average the highest yielding variety (23.3 TSH), followed by N35 (21.9 TSH) and N38 (21.7 TSH). The lowest yielding varieties were 90F2765 (18.1 TSH) and 90F3125 (18.4 TSH).

Discussion

Smut

The control variety, N14, under commercial field conditions has succumbed to smut, hence it has become necessary to replace this variety over time. However, in the absence of crop stress factors such as inadequate irrigation and untimely roguing, the smut found in N14 can be contained in order to sustain productive ratoons. Over the crop cycle evaluated of plant plus three ratoons, the lowest ranking smut infection was registered in N36 and 91F0820 at 1.1%. Variety 90F0613 had the heaviest smut infection at 3.8%. N14 (2.6%), 90F3125 (2.7%), 90F2765 (2.7%) and 90F0613 had infection levels above the 2% smut crop cycle mean. Varieties 91F0820 and N36 were the lowest ranking on average throughout the evaluated crop cycle. In general, smut infection rises with ratoon, indicative of the fact that crop sanitation measures must be intensified to guarantee more ratoons, all other factors being constant. This way more ratoons can be obtained, reducing the need for frequent and expensive plough-outs consequently reducing the costs of production and saving money. The control of smut and its precursors is very important to eliminate avenues of yield and revenue loss.

Flowering

On average N14 was the most prolific flowering variety at 27.3% flowering and 90F0613 the most flower shy variety at 0.1% flowering. Flowering-induced pithiness leads to yield losses in tons cane per hectare and tons sucrose per hectare, hence the importance of timely harvesting at the peak sucrose accumulation point in the crop cycle.

Population

With rising prominence of biofuels and carbon credits trade, and with good corporate governance exerting pressure to produce sugarcane in an environmentally friendly and self-sustaining manner, fibre and plant population are becoming increasingly important parameters. The naturally high plant population of N14 gives this variety inbuilt economies of scale in terms of tons cane per hectare and tons sucrose per hectare when cultivated in Early and Mid season, and in good agronomic environments. The number of millable stalks per hectare is an important factor, as the stalks are the sucrose sinks per unit of production. With the rising costs of herbicides, a high stalk population is also beneficial for effective weed suppression. On average, N14 had the highest plant population by season and ratoon, and 90F0613 the lowest.

Fibre

The advent of high sucrose varieties has constrained the sugar mill's energy balance. The high fibre content of N14 can help to reduce this problem. Fibre is important as a source of renewable energy.

Tons cane per hectare

On average across seasons N14 was the highest yielding variety at 129.4 TCH, followed by N38 at 119.1 TCH. The lowest yielding varieties were 87F2719 at 95.7 TCH and 90F3125 at 96.7 TCH. Its high plant population gave N14 a competitive edge over the varieties evaluated. This edge can be sustained to economic advantage by manipulating the environment in which N14 is cultivated.

Tons sucrose per hectare

Across seasons and plant crop and three ratoons, N14 was the highest yielding variety at 23.3 TSH, followed by N35 at 21.9 TSH and N38 at 21.7 TSH. The lowest yielding varieties were 90F2765 at 18.1 TSH and 90F3125 at 18.4 TSH. The overall significant difference between varieties was 3.8TSH at the 5% level. The high population of millable stalks gives N14 a competitive edge over the observed varieties as the TSH is a factor of sucrose content by the number of millable stalks. It is thus cheaper to produce sugar from N14 per unit area compared to other varieties in an agronomic environment of good and timely irrigation, smut control, weed control and non-saline soil, amongst other crop husbandry factors.

Conclusions

With the increasing importance of biofuels and carbon credits trading, N14 is a high potential dual-value crop of sugar and natural fibre. By virtue of its high plant population, its increased leaf area index can be used in carbon credits trading and act as a sink for greenhouse gas emissions. For quick returns on investments, N14 would be suitable for planting in high investment crop equipment areas like pivots, under high calibre management. With the irrigation trend moving towards pivots and improvement in the level of smut management, N14 could be the variety of choice for overhead irrigated high management cane at Nchalo in non-saline areas.

At the current level of management at Nchalo, N38 and N35 have been identified as the varieties of choice to replace N14, which has succumbed to smut pressure.

Acknowledgements

The authors would like to acknowledge the trial work contribution of the Nchalo Agronomy team, SASTA secretariat for coordinating and availing the forum to present our findings and to the SASRI Plant Breeding team for their research and development efforts to produce new varieties important for the sustainability of the sugar industry, on which many Malawians depend for their livelihood.

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