

REFEREED PAPER

REVIEW AND ANALYSIS OF VARIETY DISTRIBUTION TRENDS IN THE SOUTH AFRICAN SUGAR INDUSTRY: A 2013 PERSPECTIVE

RAMBURAN S

South African Sugarcane Research Institute, P/Bag X02, Mount Edgecombe, 4300, South Africa
Sanesh.Ramburan@sugar.org.za

Abstract

The South African sugar industry has experienced decades of sustainable sugar production due in part to continuous variety changes, yet the historic variety trends have not been reviewed. The objectives of this study were to (i) review the historic trends in variety distribution and discuss the impact of variety changes on industry sustainability, (ii) analyse trends in adoption patterns to elucidate future variety inclinations, and (iii) evaluate the accuracy of mill delivery data as a tool to study variety distribution. Historic variety distribution and Cane Testing Service (CTS) data from 1926 to 2011 was analysed. The historic changes in variety distribution in relation to pest and disease (P&D) incursions are discussed to highlight the role of variety changes in ensuring sustainability. Of the 40 gazetted commercial varieties available, 17 contribute more than 1% to total industry production. At an industry level, no single variety currently contributes more than 20% of total production. This is in contrast to periods before the 1990s, when single varieties such as NCo376, NCo310 and Uba contributed well over 40% to total industry distribution. At a regional level, variety distribution remains skewed toward one or two varieties, posing a P&D risk (particularly in the midlands region). There has been a decline in the adoption rates of varieties due to more focused selection and recommendations for niche conditions (a dilution effect). CTS data are good representation of the general variety distribution within a mill supply area, and may therefore be suitable for use in future distribution studies.

Keywords: sugarcane, variety adoption, variety distribution

Introduction

The earliest record of cultivation of sugarcane in KwaZulu-Natal (formerly Natal) was around 1635, when shipwrecked mariners observed the crop being grown by indigenous South Africans near Umzimkulu (McMartin, 1940). The first sustained commercial cultivation occurred in 1847 with the arrival of varieties such as Ribbon cane, Bourbon Yellow and Bourbon Purple from Mauritius and Reunion. During this period, the industry went through a phase of ‘uncontrolled introduction’ of sugarcane varieties from different parts of the world. The lack of controlled quarantine measures during this phase resulted in the introduction of exotic pests and diseases that posed serious threats to the sustainability of the industry. By 1880, the diseases smut (*Ustilago scitaminea*) and mosaic (*Sugarcane mosaic virus*) were responsible for significant loss in production of the predominant China cane and Green Natal varieties (McMartin, 1940). The subsequent introduction of the mosaic resistant variety Uba from India between 1883 and 1885 alleviated disease pressures at the time, and this variety went on to dominate production for approximately 50 years. During this time, the recognised need to control importation of varieties led to the establishment of a

quarantine glasshouse in Durban in 1925, effectively beginning a phase of ‘controlled introduction’ of varieties into the industry (Thomson, 1959). The South African Sugar Experiment Station (SASEX), later renamed the South African Sugarcane Research Institute (SASRI), was subsequently established in 1925 (McMartin, 1940) to handle the introduction, testing and release of new sugarcane varieties.

The variety Uba subsequently succumbed to sugarcane streak (*Sugarcane streak virus*), thereby necessitating the identification of other suitable varieties for local conditions. During the 1930s a wide range of varieties were imported from countries such as Java and India, with some varieties showing good adaptability. It was also recognised at the time that many imported varieties were either succumbing to pests and diseases, or were generally unsuited to local conditions. These factors ushered in a phase of introduction of ‘true’ sugarcane seed, whereby other breeding stations around the world were asked to make crosses between selected varieties and send the resultant true seed back to South Africa. Selection was subsequently conducted under local conditions, and this led to the release of the ‘NCo’ canes (where N=Natal and Co=Coimbatore in India). These included NCo310 and NCo376, which proved to be highly adapted to South African production environments. The importation of true seed was a necessity in South Africa due to the production of non-viable pollen in field grown cane, which prevented advancement of conventional breeding (Brett, 1946). However, dedicated research at SASEX on factors influencing flowering eventually led to the development of temperature (and later photoperiod) controlled facilities to stimulate and manipulate flowering. These breakthroughs heralded an era of sugarcane breeding in South Africa which became the foundation for the release of the current N varieties.

Since the release of the first sugarcane variety (N50/211) using traditional breeding approaches in the late 1950s, SASRI has subsequently released approximately 52 commercial varieties. During this time, breeding methodologies and procedures have evolved to ensure the efficient delivery of improved varieties to the industry. In a recent external review of the Variety Improvement Programme at SASRI, it was recommended that the value of improved varieties be evaluated and illustrated to industry stakeholders to ensure continued investment in this critical area of crop production. A review of the role that varieties have played in the evolution of the sugar industry would highlight such value. To date, a review of the historic variety distribution trends at regional and industry levels has not been conducted. Such a review would provide perspective on sugarcane improvement in South Africa and possibly help direct future breeding efforts and release strategies. Additionally, the current source of industry-wide variety distribution data is from mill deliveries, the accuracy of which is often questioned by industry stakeholders. The general feeling is that field records provide a more accurate description of variety distribution, as they incorporate an ‘area planted’ component. However, the lack of a consistent field recording system across the industry prevents accurate variety distribution studies from being conducted. It is therefore necessary to evaluate the accuracy of mill delivery data to assess its use as a surrogate for field records in future distribution studies. The objectives of this study were to (i) review the historic trends in variety distribution and discuss the impact of variety changes on industry sustainability, (ii) analyse trends in adoption patterns to elucidate future variety inclinations, and (iii) evaluate the accuracy of mill delivery data as a tool to study variety distribution.

Materials and Methods

Most of the data for this study was sourced from the South African Sugar Association’s Cane Testing Service (CTS), which is responsible for the recording and analysis of sugarcane

consignments delivered to mills in the industry. Sugarcane deliveries are measured at the mill weighbridge, and data on variety, mass, and various quality parameters are determined. A database of weekly variety deliveries is generated for each mill in each production season. A combined database for all mills and across 22 seasons (1990-2011) was developed, and the cane tonnage delivered per variety per season was extracted. For seasons prior to 1990, information on historical variety distributions was sourced from SASRI annual reports, South African Sugar Technologists' Association (SASTA) proceedings, and SASRI Senior Certificate Course notes. These figures were linked to the CTS dataset, where appropriate, to generate a continuous industry distribution from 1926 to 2011. The CTS production data was also divided into regions to evaluate the different variety trends in the three major regions of the industry (irrigated north, coast, and midlands). All 'unknown' or 'mixed' variety deliveries were distributed proportionally among all varieties in a given season.

In order to evaluate the accuracy of CTS data in describing variety distribution patterns, field record data from three mill supply areas (MSAs) were compared to the corresponding CTS data trends. For the Malelane MSA, field record data were extracted from a production database administered by TSB Sugar Ltd, and compared to the corresponding CTS data from 2006 to 2010. For the Felixton MSA, distribution data were obtained from grower estimates of production from 1999 to 2005. The third comparison was made for the Umzimkulu MSA, where data from a grower survey of variety distributions was compared to CTS data from 1999 to 2009.

Results and Discussion

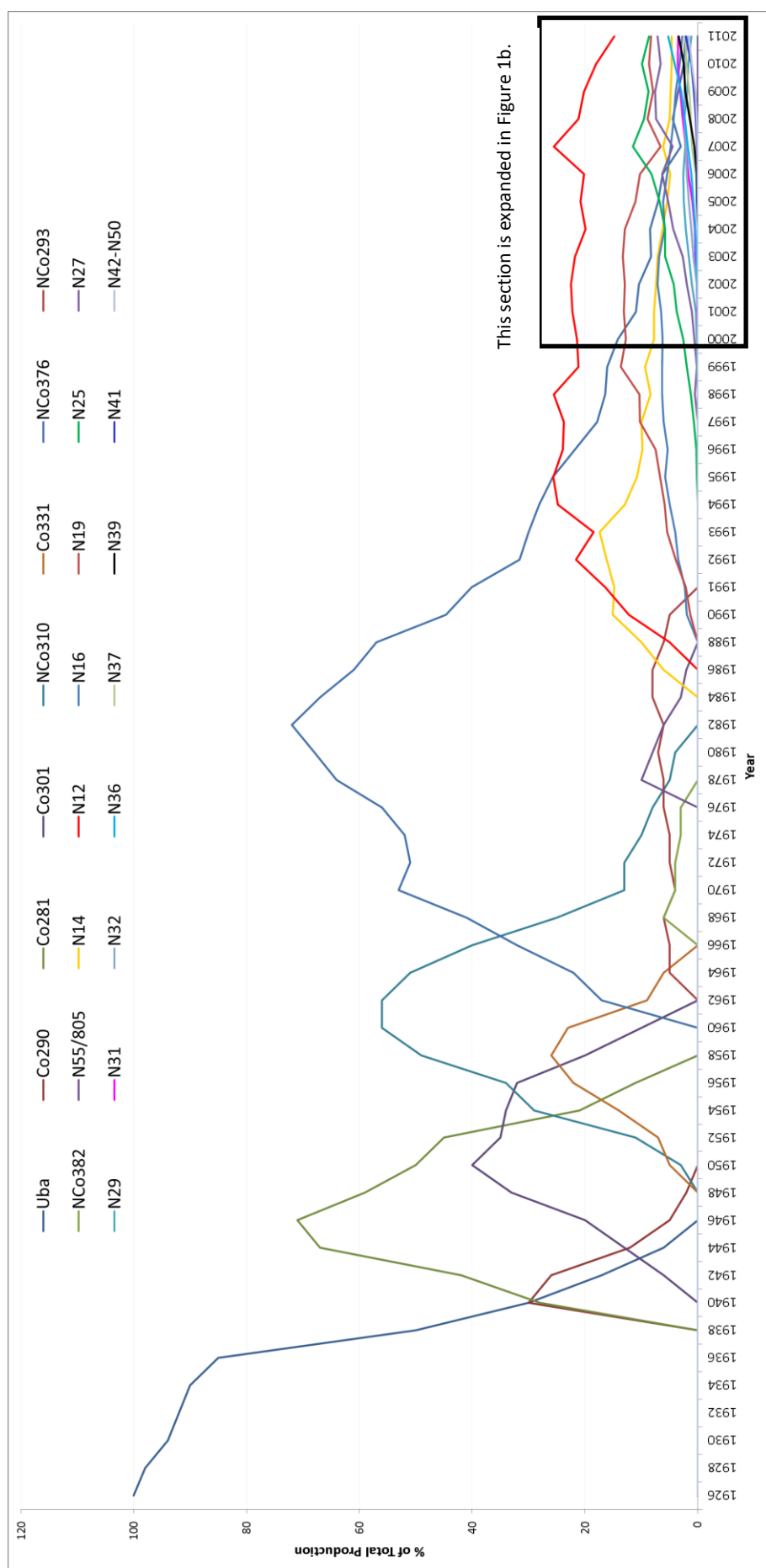
Industry variety trends

Figure 1a shows the industry variety production trends from 1926 to 2011 (Figure 1b shows 2000 to 2011). Prior to the 1990s, the industry was dominated by single (or at most three) varieties in any given year. The percentage contribution of these dominant varieties ranged from 100% with variety Uba in the 1920s, to 26% with variety Co331 in the 1950s. Besides Uba, the maximum adoption of any variety was NCo376, which reached 72% in 1982. A distinctive feature of Figure 1a is that the size of the variety peaks have become progressively smaller with time, illustrating a reduction in the maximum adoption levels and a shift away from dependency on single (or a few) varieties, to dependency on multiple varieties. The last variety to breach the 20% level was N12, which was released in 1979. Additionally, prior to the release of NCo376, the width of variety peaks were relatively narrow, suggesting that those varieties remained in the industry for relatively shorter periods compared to varieties released after NCo376. This apparent 'longevity' of varieties released after NCo376 may be due to direct gains in selection for P&D resistance. Alternatively, the persistence of later released varieties may be due to niche specific variety recommendations and placement, whereby varieties persist in the industry because they are suited to specific growing conditions. A good example of this is variety N16, which has for many years been the variety of choice for humic soils at altitude. With the greater focus on regional breeding and niche specific variety recommendations (Ramburan *et al.*, 2010), it is expected that future industry distribution trends would comprise many varieties, each contributing in small quantities, over longer periods of time.

Another distinctive feature of the industry is that the rate of variety adoption seems to have declined over the years. Figure 2 shows the percentage production of varieties plotted against year after release for varieties released before 1970 (Figure 2a), between 1970 and 1990 (Figure 2b) and after 1990 (Figure 2c). Prior to 1970 (Figure 2a), varieties such as NCo310

and NCo376 were rapidly adopted and comprised 30% of production within 10 years after release. Varieties released between 1970 and 1990 (Figure 2b) showed more gradual adoption patterns, with most varieties reaching levels below 15% within 10 years after release. Varieties released after 1990 (Figure 2c) achieved 7% and under within 10 years after release. This apparent reduction in the rate of adoption may not necessarily be due to reduced grower technology uptake, and is more likely a simple dilution effect, whereby the larger number of varieties released after 1990 meant that no single variety dominated the adoption patterns. This is in contrast to the period prior to 1990, whereby rapid uptake of single varieties was the norm due to the lack of suitable alternatives and the need to control diseases (crisis management).

Another general trend is that most varieties only start contributing to production 4-6 years after their release. This lag in uptake may be due to the lack of available seedcane of new varieties, an issue which may be addressed through the implementation of the Novacane® tissue culture (Meyer *et al.*, 2010) protocols as a means for rapid propagation. The slow adoption may also be linked to the uniquely long ratoon lengths typical of the South African industry (Ramburan *et al.*, 2012). Such long ratoon crop cycles are inherently associated with less frequent replanting and reduced opportunity to change varieties. Growers in the industry are also reluctant to adopt newer varieties until they have been proven to possess good ratooning potential. The recent focus on crop management, as opposed to variety choice, to increase ratoon longevity (Ramburan *et al.*, 2012) may change such perceptions.



**Figure 1a. The percentage of total production of different varieties in the South African Sugar Industry from 1926 to 2011.
Mixed and Unknown deliveries are excluded.**

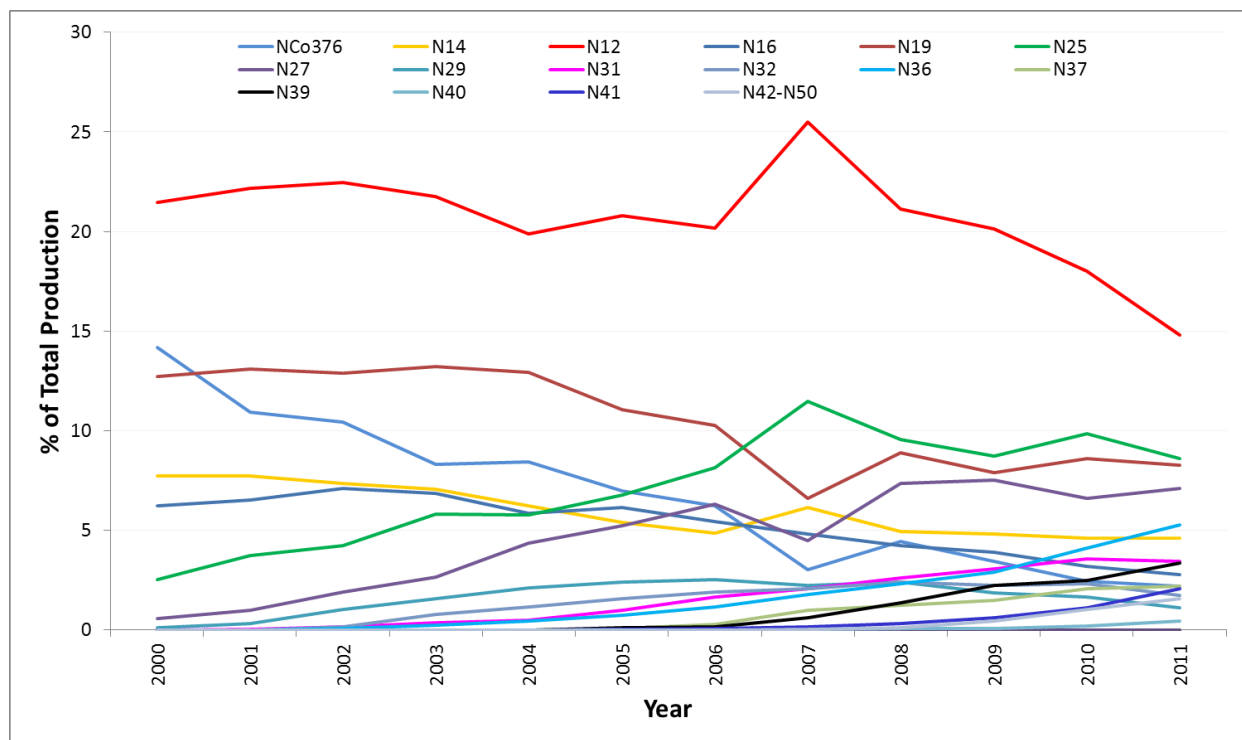


Figure 1b. Insert from Figure 1a. The percentage of total production of different varieties in the South African sugar industry from 2000 to 2011. Mixed and Unknown deliveries are excluded.

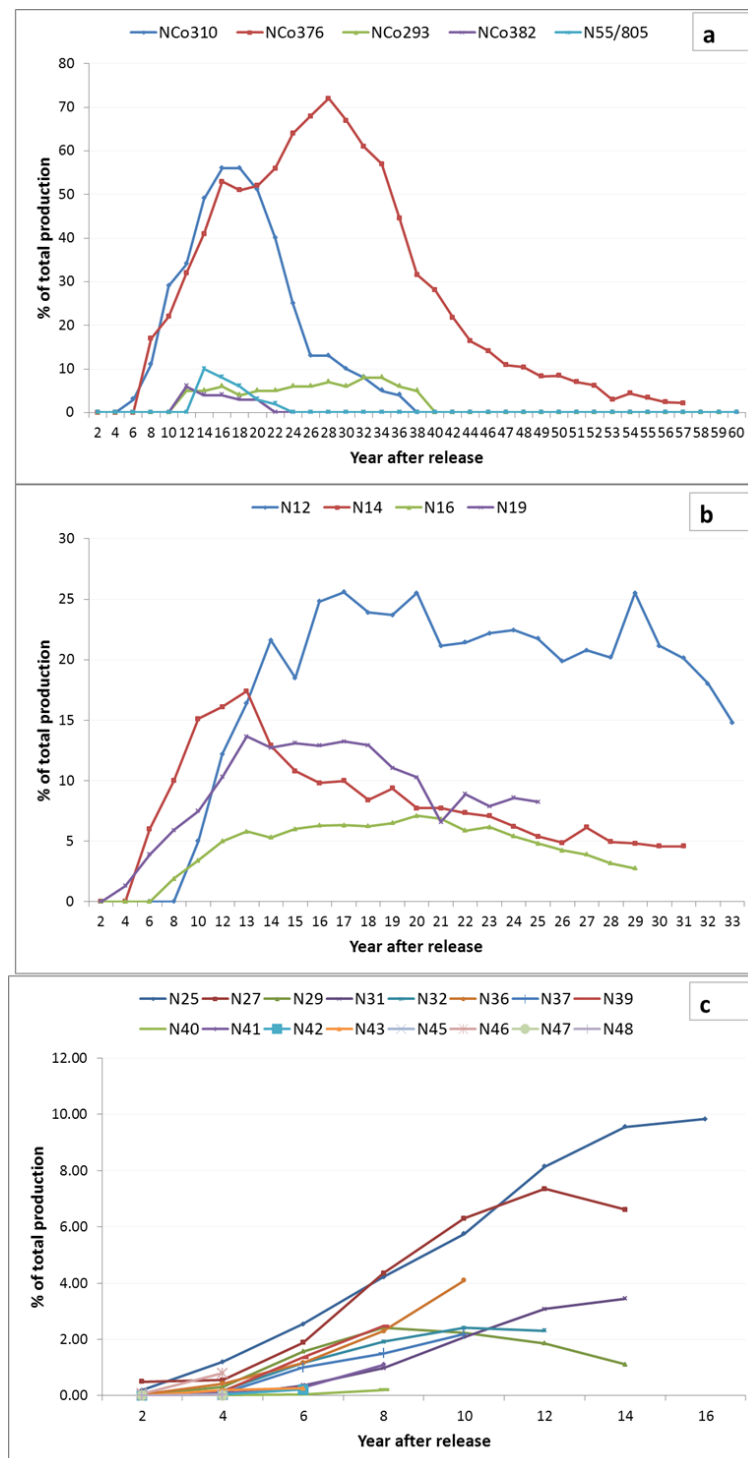


Figure 2. The percentage of total industry production against year after release for varieties released before 1970 (a), between 1970 and 1990 (b), and after 1990 (c).

Figure 3 shows that the industry distribution is currently comprised of 17 principal varieties, i.e. those that contribute more than 1% to productivity (Rice *et al.*, 2012). No single variety occupies more than 20% of production, and this is an improvement on the trends experienced prior to the 1990s. Variety N12 is still the dominant variety in the industry, and this is likely to persist for the next few years. Of all varieties released after the year 2000, only N36, N37, N39 and N41 have achieved principal variety status. Variety NCo376, which once contributed 72% to production, has declined to approximately 4%.

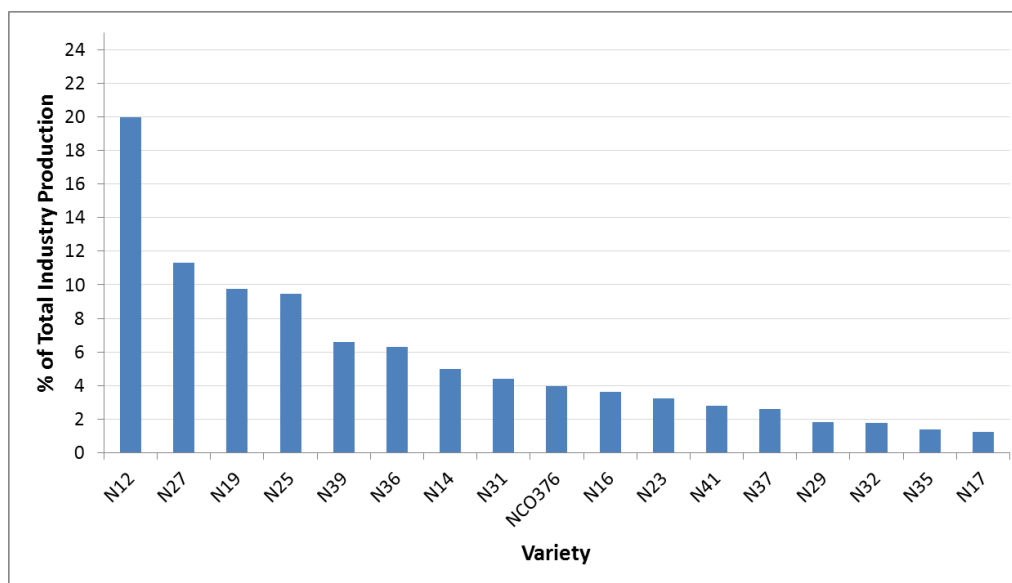


Figure 3. The percentage of total production of 17 principal varieties (those that contribute more than 1% to total productivity) as at 2011. Mixed and Unknown deliveries were distributed proportionally to each variety.

Regional variety trends

The variety distribution trends for the coast (Figure 4a), irrigated north (Figure 4b) and midlands (Figure 4c) regions from 1990 to 2011 illustrate the differences in adoption trends in these major regions. Of the three regions, the coast is the most diverse, with production occurring under a wider range of soil types, topography and harvest ages, and with varying irrigation regimes in some areas. Despite this diversity in production conditions, most of the variety distribution for this region was dominated by NCo376 for the majority of the 1990s (Figure 4a). This illustrates the wide adaptability of NCo376 and justifies its use as a control variety in selection trials. The susceptibility of NCo376 to smut disease in mill supply areas such as Felixton (Fortmann *et al.*, 2006), and its general susceptibility to the borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (eldana) in most coastal areas led to the gradual withdrawal of this variety. The area devoted to NCo376 dropped from 75% in 1990 to around 7% in 2010. Variety N12 began replacing NCo376 in higher altitude areas along the coast in the early 1990s, and then remained around the 30-40% level for the next decade. After reaching peak production in 2001, N12 started to decline gradually as more emphasis was placed on early harvesting to avoid eldana damage (N12 is more suited to late harvesting). The area of NCo376 also declined in the 2000s due to the release of N27, which was regarded as a widely adapted coastal variety that was superior to NCo376. Variety N27 is currently the most widely produced variety in the coastal region (2011 data not shown).

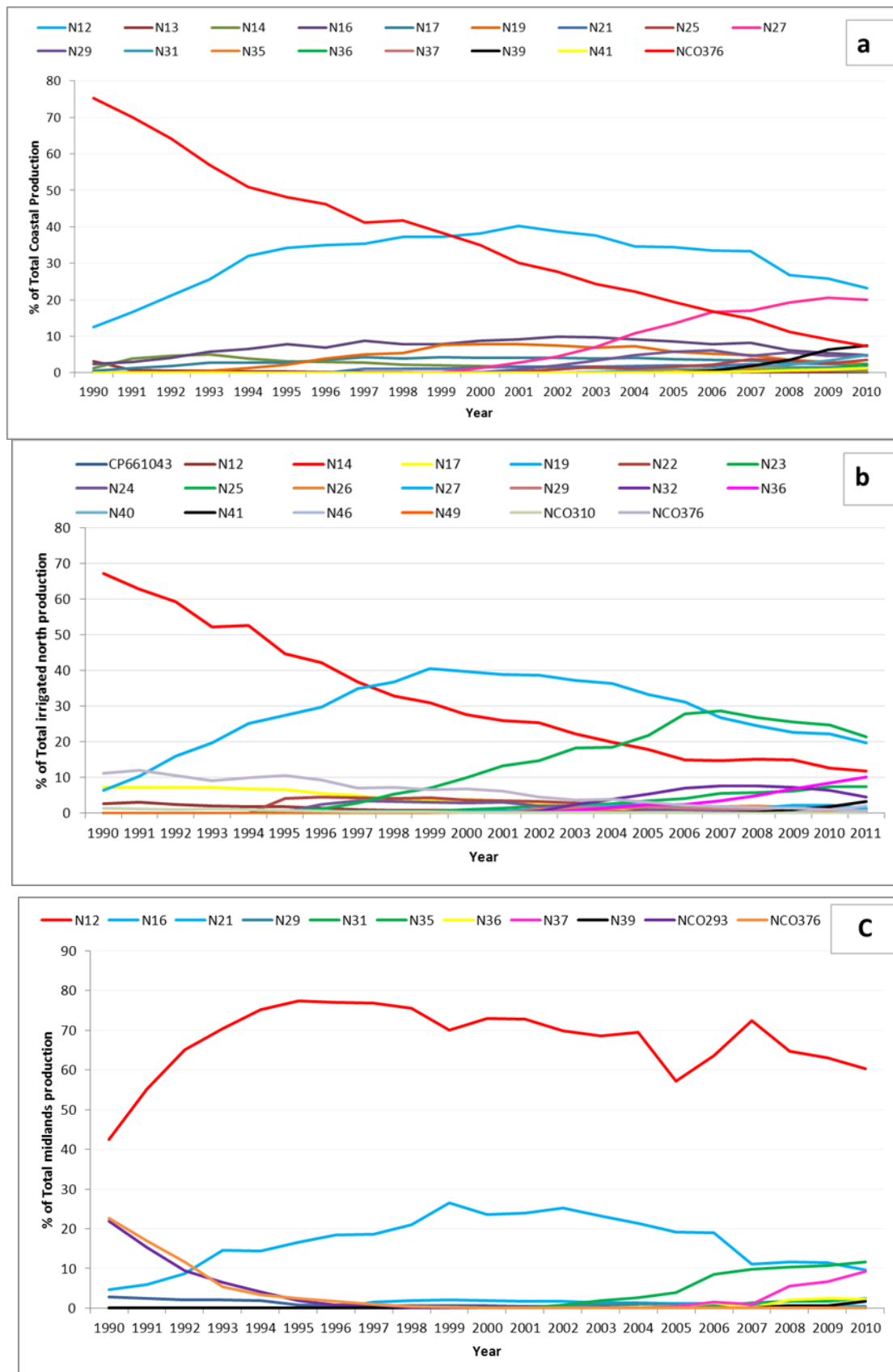


Figure 4. The percentage of total production of different varieties in the coastal (a), irrigated north (b) and midlands (c) regions of South Africa from 1990 to 2010/2011. Mixed and Unknown deliveries were distributed proportionally to different varieties.

In the irrigated region, N14 was the dominant variety for most of the 1990s (and the late 1980s), before it was gradually replaced in some areas by N19. This variety is considered to have higher sucrose content than N14, and N19 attained peak production of 40% in 1999 (Figure 4b). The decline in production of N14 from 67 to 11% between 1990 and 2011 and the decline in production of N19 from 40 to 19% between 1999 and 2011 was due in part to smut disease, when the region experienced an outbreak in this time frame. Additionally, the release of the higher yielding and smut resistant N25 in 1993 also contributed to the withdrawal of N14 and N19 in many areas. Other varieties making significant contributions during the 2000s were N32, which has now been degazetted due to smut susceptibility, and N23, which has steadily increased in production due to its moderate but consistent yields. Promising new varieties that could replace the dominant N25 in many areas are N36, N41, and N46.

Of the three regions, the midlands demonstrated the most static distribution trends (Figure 4c). Variety N12 reached peak production of 77% of the region in 1995 and has remained the dominant variety in the midlands for well over two decades. In 2010, N12 continued to occupy 60% of the total production in the midlands. The high yielding variety N31, which was released in 1997, has replaced N12 on sandy soils in the midlands, and is currently the second most popular variety in the midlands (11% in 2010). Variety N16 has also been a consistent contributor to production in the midlands over the last two decades, specifically for humic soils. However, in recent times, the release of the higher yielding N37 for the same conditions has resulted in a decline to the area planted to N16.

Mill deliveries vs field records

Figure 5 shows the variety distribution trends of three MSAs using data from field records (graphs on left hand side) compared to data from CTS records of tons delivered per variety (graphs on right hand side). In general, the CTS distribution trends (Figure 5b,d,f) corresponded to the field record trends (Figure 5a,c,e) in all three MSAs. In most instances the absolute percentages of varieties differed between the data sources, e.g. N25 showed a 35% contribution at Malelane in 2010 using field data (Figure 5e), while it showed a 40% contribution for the same year using CTS data (Figure 5f). Although the absolute percentages differed between the data sources, the relative contributions of different varieties were similar, i.e. the rankings of varieties across years from CTS data mimicked the rankings from the field records. This was particularly the case for the popular varieties that contributed more than 5%. This suggests that CTS data is a good representation of the general variety distribution within a MSA and may therefore be suitable for use in future distribution studies. Follow-up studies should correlate the ranks of varieties between the two datasets to determine whether the relationship has statistical significance.

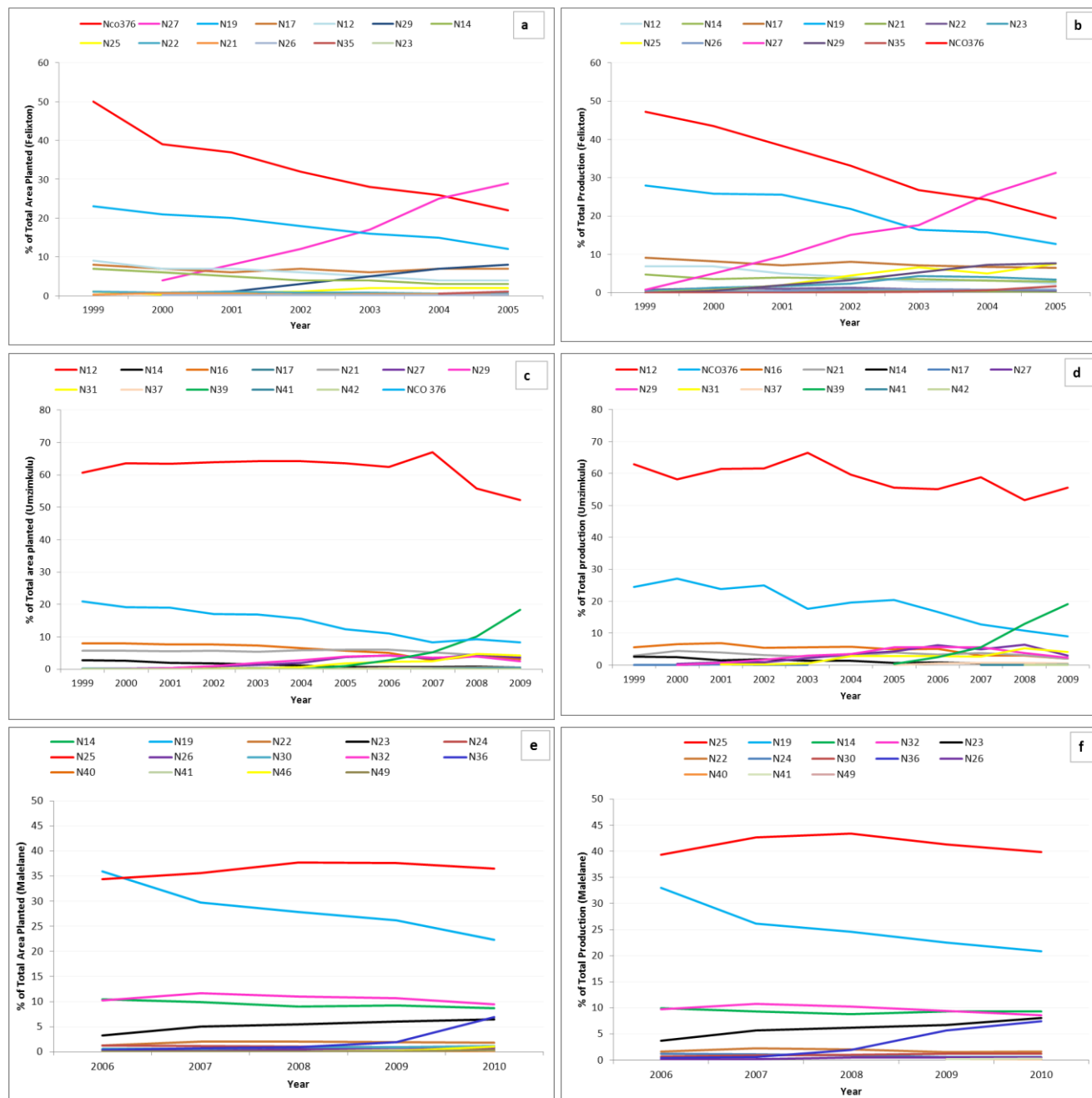


Figure 5. The percentage of total area planted to different varieties in the Felixton (a), Umzimkulu (c) and Malelane (e) mill supply areas over different years (data from field records) vs the percentage of total production of different varieties in the Felixton (b), Umzimkulu (d), and Malelane (f) mill supply areas (data from CTS mill deliveries).

Conclusions

The adoption of new and improved varieties has always been a central feature of the sugar industry and has played an important role in ensuring sustainability. Rapid variety changes in the early days were generally in response to P&D incursions (crisis management) rather than due to natural adoption. Such responsive variety changes often saved the industry from complete crop loss. It is hoped that future responsive variety shifts are not required, as the industry focuses on preventative biosecurity measures. Variety diversification is one such measure that is aimed at risk management in times of P&D incursions. In this respect, the

industry has appropriately moved from single variety dependencies to multi-variety dependencies, particularly over the last two decades. At an industry level there is appropriate variety diversification, with no single variety exceeding 20% of production. However, at regional levels, single varieties do tend to dominate production. This is particularly the case in the midlands, where the levels of N12 are still very high. Continual efforts on regional selection and niche-specific evaluation and recommendations are encouraged to promote greater diversification at the regional level. The lack of single dominant varieties across the industry may be construed by stakeholders as a lack of progress. However, the reality is that variety diversification prevents crisis management. Future studies will attempt to quantify the economic benefit of new varieties in terms of yield benefits, as well as improvements in P&D resistance. Variety trends derived from the adjusted tons delivered corresponded to variety trends from field records for three MSAs, suggesting that CTS data were a suitable surrogate for field records. However, an extensive variety field survey or improved grower field recording (through extension efforts and/or software development) is still encouraged to ensure comprehensive and accurate variety distribution data in the future.

REFERENCES

- Brett PGC (1946). Seed setting of sugarcane in South Africa. *Nature* 157: 657.
- Fortmann RR, Brenchley PG and Matthew AK (2006). Selection and management of varieties through the Felixton seedcane scheme. *Proc S Afr Sug Technol Ass* 80: 120-129.
- McMartin A (1940). The sugarcane varieties of Natal. *Proc S Afr Sug Technol Ass* 14: 33-44.
- Meyer GM, Banasiak M, Keeping N, Pillay N, Parfitt R and Snyman SJ (2010). Novacane as a tool for rapid propagation of material for the SASRI plant breeding programme. *Proc S Afr Sug Technol Ass* 83: 117-121.
- Ramburan S, Paraskavoupolos A, Saville G and Jones M (2010). A decision support system for sugarcane variety selection in South Africa based on genotype-by-environment analyses. *Expl Agric* 46: 243-257.
- Ramburan S, Wettergreen T, Berry SD and Shongwe B (2012). Effects of variety, environment and management on sugarcane ratoon yield decline. *Proc S Afr Sug Technol Ass* 85: 180-192.
- Rice L, Baucum L and Glaz B (2012). Sugarcane variety census: Florida 2011. *Sugar Journal* 75: 8-15.
- Thomson GM (1959). Sugarcane quarantine in South Africa. *Proc S Afr Sug Technol Ass* 33: 90-94.