THE VALUE OF N12 IN THE MIDLANDS NORTH AREA

PA DONOVAN

9 Woodside Village, Norton Way, Rondebosch, 7700

Abstract

The main varieties used in the Midlands North area between 1983/84 and 1996/97, were evaluated empirically and their benefit:cost (B:C) ratios estimated. The value of N12 was estimated as R9 million, which indicates an annual contribution of R0,69 million to the area's productivity, with a B:C ratio of 8,60. This study has highlighted the need for the rapid adoption of varieties, if they are to make a positive economic contribution to productivity, for the assessment in economic terms of their value to growers and, in view of the high cost of breeding, of their B:C ratios.

Introduction

The variety N12, resulting from a cross made in 1962 between NCo376 and Co331, was released in 1979. It was recommended for '...most rainfed situations although it does not appear to be very promising for the recent sands. It appears to be particularly suited to two-season cropping in the Midlands and ... It seems to be considerably less susceptible to mosaic than NCo376...' The release notice also indicated that in the Natal Midlands N12 outyielded NCo376 by 12% (Anon, 1979). Fifteen years later an article in the SA Sugar Journal (Anon, 1992) reported that trials indicated a sucrose advantage of 11% for N12 over NCo376 and NCo293 in the Midlands, which translates into a benefit of *R17,4 million per annum* for the KwaZulu-Natal Midlands. This estimate was presumably based on the assumption that no factor, other than variety, is responsible for productivity and that the costs of crop production and of varieties themselves can be ignored.

This prompts an attempt to evaluate N12 in monetary terms in the Noodsberg and Union Co-op mill areas, taking costs and the other contributors to productivity into account, and to express its value in benefit:cost terms.

The method of evaluation is essentially the same as was used to evaluate NCo310 on an industry-wide basis (Donovan, 1996) but suitably adapted to apply only to the Midlands North area.

Variety usage in Midlands North

Variety usage is expressed in terms of the percentage contribution of each of the main varieties to total cane production in the two mill areas. Figure 1 shows the pre-N12 variety position in Midlands North between 1966-67, when the two mills started milling, and 1983-84, which was the last year before N12 contributed at least 1% of the cane produced.

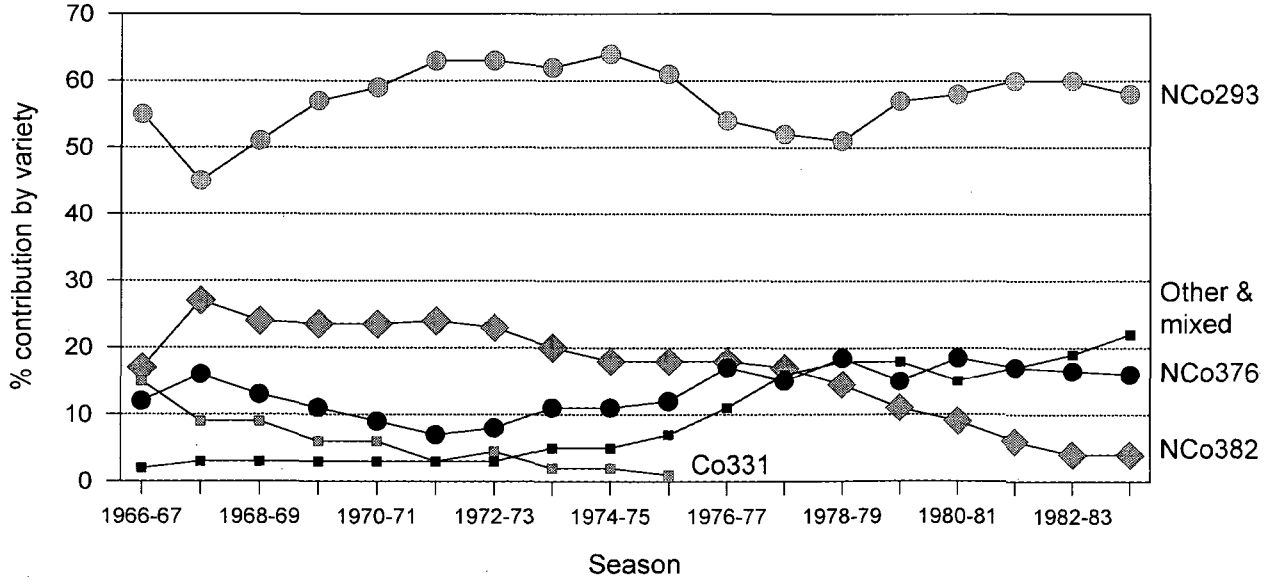

Figure 1. Percentage contribution by varieties to total cane production in Midlands North, 1966-67 to 1983-84.

Throughout the period NCo293 was the dominant variety, producing between 45% and 64% of the cane; NCo382 declined from a maximum of 26% to 4% and NCo376 started and ended the period at about the same level of contribution, namely 16%.

Among the varieties included in the 'Other and Mixed' (O&M) category were NCo310, CB36/14, N50/211, N53/216 and N55/805, none of which individually contributed as much as 1% to annual cane production during the whole period.

Figure 2 shows the variety position from 1984-85, when N12 first contributed at least 1% of the cane milled at the two mill areas, to the present, 1996-97.

The main features of variety usage during this period were the 6% *per annum* increase in area planted to N12, the decline to nearly zero in the production of NCo293 and NCo376, and the indication that N12 was approaching its maximum contribution due to the increase in the production of N16. Other varieties grown included CB36/14, N53/216, N55/805, N6, N8 and N11, none of which individually contributed as much as 1% to annual cane production during the period.

Estimating the value of varieties

The evaluation of a variety is based on the hypothesis that it is a product of the plant breeding component of a research portfolio, which is one of a number of factors determining the productivity of sugar production. Estimating the value of N12 in Midlands North is, therefore, a five step procedure:

- Determining the value of sugar produced in the Midlands North area since 1984-85 when N12 first contributed at least 1% to the area's production.
- Estimating technology's contribution to the value of production in the area.
- Estimating research's share of the value of technology.
- Calculating plant breeding's share of research's value.
- Apportioning plant breeding's value among the varieties used in the area during the period concerned, in this case particularly of N12.

Value of Midlands North sugar production

The value, at 1996 prices, of sugar production in Midlands North is calculated as the product of the area's annual production of sugar and its shadow price, which is represented by its average annual export realisation ([1]personal communication). These data are given in columns 1, 2 and 3 of Appendix 1.

Contribution of technology to production in Midlands North

Donovan and Nieuwoudt (1992) found that during the decade 1976-77 to 1985-86 technology's percentage contribution to the sugar industry's total productivity was 29,12%, but there appears to have been no study since then to bring this datum up to date. However, taking into account the main factors affecting productivity, viz: the percentage changes in rainfall ([2]personal communication), cost of production ([1]personal communication) and expenditure on technology ([3]personal communication), technology's contribution can be said to have increased by 3% per annum, that is to 32%, over the period 1984-85 to the present.

The value of technology to Midlands North can therefore be estimated as 32% of the value of the sugar produced in the area, as given in column 4 of Appendix 1. It is of interest to note in this connection that although the mean value of technology increased by about 3% over this period of 13 years (1984-85 to 1996-97), it declined by an average of 5% per annum over the last four years of the period, indicating a serious under-investment in production technology by the industry in recent years.

[1]Jill Scheepers, SA Cane Growers' Association, Durban
[2]A Singels, SASA Experiment Station, Mount Edgecombe
[3]RD Southey, SASA Experiment Station, Mount Edgecombe

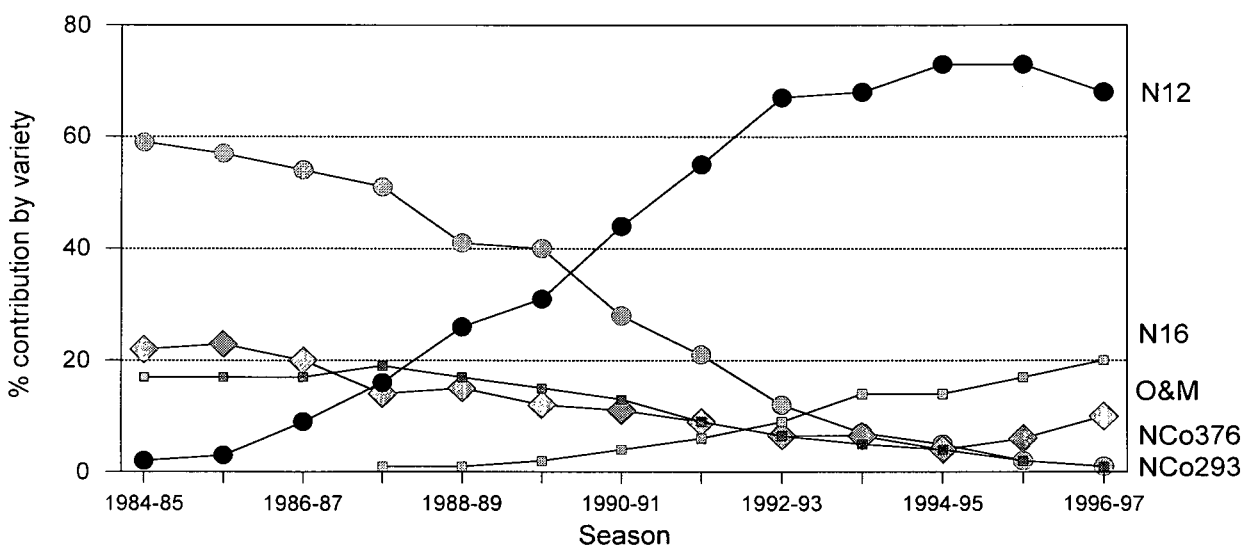

Figure 2. Percentage contribution by varieties to total cane production in Midlands North, 1984-85 to 1996-97.

Estimating research's share of technology

For the decade 1976-77 to 1985-86, Donovan and Darroch (1991) estimated the research share of technology generated at the Experiment Station at 17%. There has been no more recent study to up-date this estimate for the last decade but an acceptable empirical estimate can be obtained from the changes in budget provision over the period as a result of major changes in policy. These policy decisions were (i) to establish a Biotechnology unit in 1992-93 and (ii) to delegate to mill areas the responsibility for financing Regional Extension from 1995-96. The effect of these two major changes increased the research proportion of total Experiment Station expenditure from 17% at the beginning of the period under consideration (1984-85) to an estimated 24% at the end of the period (1996-97). However, the mean increase in research's share of technology for the whole period is 20% because the policy changes were only effected during the last five of the 14 years. Estimates of research's annual share of the value of technology are given in column 5 of Appendix 1.

Calculating plant breeding's contribution to research

The calculation of plant breeding's share of the value of research is more difficult; Donovan (1996) estimated it at 9,3% of the value of research at the end of the decade 1976-77 to 1985-86 and since then no definitive study has been done.

In the paper referred to, it was proposed that plant breeding's share of research value can be considered proportional to total variety productivity. For the period under study, 1983-84 to 1996-97, the total variety productivity index increased from 104 to 114 (Table 1), an increase of 9,6% over the previous decade. This indicates that plant breeding's share of the value of research can be estimated at 10% (9,6% increase on 9,3%). Column 6 of Appendix 1 gives, therefore, the calculated annual value of plant breeding derived in this way.

Estimated values of varieties

The value of each variety is obtained by apportioning the value of plant breeding among the varieties producing sugar in proportion to their individual productivities. A variety's productivity is calculated as the product of its yield index (VI) and its percentage contribution to the area's cane production (VP). A variety's yield index (VI) is the factor by which its yield exceeds a reference or standard variety which, for the purposes of this paper, is NCo376 with a yield index of 1. The yield indices of the varieties considered in this paper were calculated from the results of variety trials (RVTs and EVTs) conducted in the Midlands North area between 1978-79 and 1995-96 by the Experiment Station ([4]personal communication). Data on variety contribution to cane production (VP) were obtained from Lamusse (1984) and Lionnet (1997).

The variety yield indices (VI), individual variety productivity (VIxVP) of the main varieties and total variety productivity (TVP), the sum of the productivity of all varieties relevant to this study, are given in Table 1.

The values of the main varieties were then calculated as the product of each variety's productivity (Table 1) and the unit value of plant breeding for the same year. The unit of plant breeding value is the quotient of the value of plant breeding and total variety productivity for each year. Appendix 2 sets out the data and calculation of variety values in this way.

An evaluation of N12 should also take into account the loss in value if it had not been bred and released. This is calculated by replacing the productivity of N12 with the productivities of the other main varieties in use over the same period, in the proportions of their use. Productivities of main varieties and total variety productivity (N12 excluded) are given in Table 1.

[4]R Mcintyre, SASA Experiment Station, Mount Edgecombe

Table 1. Yield indices and productivity for the main varieties grown 1983-84 to 1996-97.

	Variety productivity (VI x VP)					Total variety productivity (TVP)
Main varietiess and their yield indices (VI)	NCo376 1,0	NCo293 1,1	N12 1,15	N16 1,18	O&M* 0,92	
1984-85	17	64,9	2,30	–	20,24	104
1985-86	17	62,7	3,45	–	21,16	104
1986-87	17	59,4	10,35	–	18,40	105
1987-88	19	56,1	18,40	1,18	11,96	107
1988-89	17	45,1	29,90	1,18	13,80	107
1989-90	15	44,0	35,65	2,36	11,04	108
1990-91	13	30,8	50,60	4,72	10,12	109
1991-92	9	23,1	63,25	7,08	8,25	111
1992-93	6	13,2	77,05	10,62	5,52	112
1993-94	5	7,7	78,20	16,52	11,96	119
1994-95	4	5,5	83,95	16,52	8,25	118
1995-96	2	2,2	83,95	20,06	7,36	116
1996-97	1	1,1	78,20	23,60	10,12	114
					TOTAL	1 434

*The varieties included in 'O&M'are N8, N11, CB36/14, N53/216 and N55/805, none of which contributed individually more than 1% to total production.

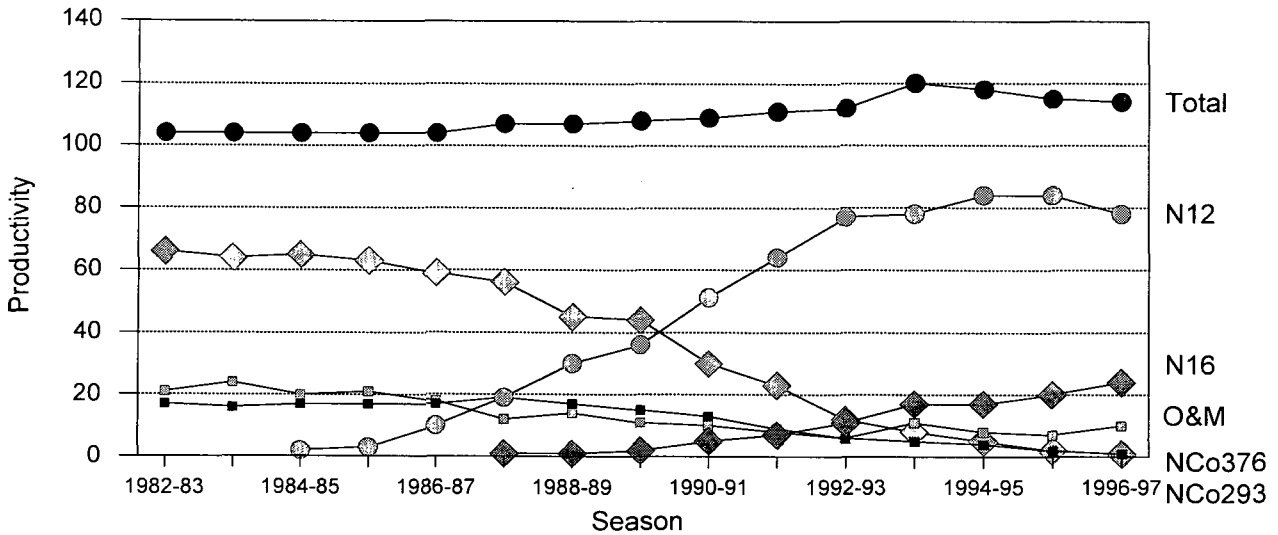

Figure 3. Productivity of main varieties in Midlands North, 1982-83 to 1996-97.

Decline in total productivity from 1 434 with N12 (Table 1) to 1 392 without N12 (Table 2), is 2,93%. In value terms this is R0,5719 million, i.e. 2,93% of the total variety value of R19,5173 million (Appendix 2, column 9).

The total value of N12 estimated in this way for the period of 13 years from 1984-85, when it first contributed 1% to cane production in the Midlands North area, until and including 1996-97 is, therefore, R9,0 million made up of a direct value of R8,4254 million plus an 'if not grown' value of R0,5719 million. The total value of N16 for the 10 years it has been in use was calculated as R1,5 million, made up of R1,2626 million direct value plus R0,1361 million 'if not grown' value. The value estimates (excluding any 'if not grown' value) of the other two varieties for the same period were NCo293 R5,7 million and NCo376 R2,0 million.

Effects of mosaic disease

The evaluation of N12 should also include an estimate of the value of its mosaic resistance, which was one of the advantages claimed for it over NCo376 at the time of its release and subsequently demonstrated in commercial production in the Midlands South area (Harding, 1992; Irons and Payn, 1992).

According to Bailey ([5]personal communication) there is no direct experimental evidence of yield decline in NCo376 and NCo293 due to mosaic in Midlands North and he agrees with Mann ([6]personal communication) that field disease surveys and observational evidence indicate that mosaic is not a significant contributing factor in yield decline in the area. Even before field control measures (appropriate time of planting and the use of N12) were adopted in the early 1980s, the peak mean level of mosaic infection was no more than 3-4% stools infected per hectare which would have resulted in a yield decline of less than 1% (Bailey and Fox, 1987). Subsequent disease surveys in Midlands North, conducted during 1987 and 1988, showed the average infection had been reduced to 1,2 and 1,3% stools infected per hectare respectively, indicating yield declines of much less than 1% ([6]personal communication). It is therefore unlikely that during the 13 year period of this study, during which time mosaic control measures were advocated by Extension and generally applied by growers, the yields of NCo376 and NCo293 would have declined by more than 1% due to mosaic.

The calculation of loss in value that a 1% decline in yield would cause indicates a loss of R0,019 million for NCo376 and R0,057 million for NCo293, representing an 'increase' in value of only R0,076 million or 0,9% for N12. In view of this low value, obtained from subjective estimates, there would seem to be no justification for its addition to the previously estimated value of R9,0 million.

Table 2. Yield indices and productivities of the main varieties excluding N12, to calculate total variety productivity without N12.

Year	NCo376 1,0	NCo293 1,1	N16 1,18	O&M 0,92	Total variety productivity
1984-85	17	67	–	20	104
1985-86	18	65	–	21	104
1986-87	20	66	–	18	104
1987-88	24	68	1	12	105
1988-89	23	67	1	14	105
1989-90	22	70	2	13	107
1990-91	27	60	6	12	105
1991-92	30	57	7	11	105
1992-93	25	45	24	11	105
1993-94	17	30	52	11	110
1994-95	13	18	72	9	112
1995-96	10	11	83	9	113
1996-97	5	5	94	9	113
				TOTAL	1 392

[5]RA Bailey, SASA Experiment Station, Mount Edgecombe
[6]QV Mann, SASEX Regional Extension Officer, Midlands North

Estimating the cost of varieties

Estimating the cost of producing a variety is based on the assumptions that it takes an average of 14 years from crossing to release and that the cost of plant breeding is shared equally by all varieties (or potential varieties) in the 'breeding pipe-line' at the same time *that are eventually released.*

Appendix 3 contains the data and step-by-step procedure for calculating the costs, attributable to the Midlands North area, of breeding the varieties N12 and N16. It lists (i) the varieties in the breeding pipe-line at the same time as N12 and N16 in order to calculate (ii) the per variety share of breeding costs, (iii) the annual industrial and Midlands North share of the cost of plant breeding (inflated to 1996-97 values) for the years concerned and finally (iv) the Midlands North share of the costs of breeding N12 and N16, namely R1,045 million and R1,312 million respectively.

The industrial costs, at 1996 values, of breeding NCo376 and NCo293, calculated in a previous study (Donovan, 1996) were the same, namely R3,01 million but because there was no production in the Midlands North area when these two varieties were in the breeding pipe-line, their share of the breeding costs cannot be calculated in the same way.

However, a notional estimate of the Midlands North share of NCo376 and NCo293 breeding costs can be obtained by using the same Midlands North percentage of the industrial breeding costs that was used in estimating the breeding costs of N12 and N16, namely 6%. This would indicate breeding costs attributable to Midlands North for both NCo376 and NCo293 of R0,181 million.

It is of interest to note, in passing, that the cost of plant breeding for the industry declined from 9,3% of the total Experiment Station costs in the mid-1980s to about 5,0% by 1993 and then increased again to about 8,4% in 1996. Further increase in plant breeding costs can be anticipated when the department is required to test and apply in practice the technologies produced by the more recently established Biotechnology unit.

Benefit:cost ratio estimates

Benefit:cost ratios for the four main varieties grown in the Midlands North area for the period 1983-84 to 1996-97, and only for that area, are given in Table 3.

Table 3. Estimates of the benefit:cost ratios for the main varieties used in the Midlands North area between 1983-84 and 1996-97.

Variety	Estimated benefit (Rm value)	Estimated costs (Rm)	B:C ratios
N12	8,9973	1,045	8,61
N16	1,3987	1,312	1,10
NCo376	2,0340	0,181*	11,23*
NCo293	5,4520	0,181*	30,12*

*Notional costs and B:C ratios

The ratio for N12 may be close to its maximum because its contribution to total cane production appears to have flattened out (Figure 2) while the ratio for N16 will probably increase for a few more seasons, perhaps until it is superseded by newer varieties such as N31.

The benefit:cost ratios for NCo376 and NCo293 are notional estimates because their cost estimates are hypothetical, as described earlier, and are therefore of little interest.

Discussion

The results of this study have confirmed the high value of the variety N12 to Midlands North growers, viz. an average of R0,69 million per annum over the 13 years it has been grown. N12 has also given a very good return on the investment in its breeding, viz. R8,6 on every rand invested.

It is generally accepted that the breeding of specialist varieties, that is varieties bred for particular environments or disease or pest resistance, rather than varieties of general adaptability, should now be the plant breeding strategy. However, it is interesting to note that the high value of N12 in Midlands North has been due, not to its 'specialist' quality of mosaic resistance, nor its yield advantage over other varieties in the area, but has been due mainly to its rapid adoption by growers.

This is illustrated by the contrast between N12 and N16. Due to its 6% per annum increase in area grown, N12 achieved a value of R0,69 million per annum and a breeding benefit:cost ratio of 8,6, whereas N16's 2% increase in area per annum achieved a value of only Rm 0,15 per annum and a barely economic breeding benefit:cost ratio of only 1,1.

Indications are that N12 has probably reached its maximum use in terms of cane area and from now on will probably not improve its B:C ratio nor increase the productivity of the area. N16 may show some increase in cane area from the present 20% to possibly 25% ([6]personal communication) over the next few years. This is unlikely to improve its B:C ratio significantly, particularly in view of the prospects of new varieties in the pipeline, such as N31, that are reputed to be mosaic resistant and higher yielding.

This is probably particularly important in the Midlands North area where, as has been indicated in this study, disease – and probably also pest – resistance qualities are less important than yield advantage.

In view of the high and increasing costs of variety improvement, which should now presumably consist of the combined cost of the Plant Breeding and Biotechnology departments, it would seem to make economic sense to take a variety's B:C status into account when decisions are taken on its release or replacement in a particular area. This means evaluating the proposed new variety's expected improvement over existing varieties in terms of yield, disease or pest resistance, as well as calculating the rate of adoption that would be required to ensure an economic B:C ratio.

Conclusions

- That the favourable value and B:C ratio of N12 was due more to rapid adoption than to high yield or disease resistance, emphasises the importance of Extension in ensuring good returns for the industry, on investment in research and development (R&D) at the Experiment Station.
- Due to the high and increasing cost of variety improvement, it would seem to make economic sense to estimate ex-ante the B:C status of varieties before their release or replacement.
- In view of the high returns on R&D indicated in this and other studies, the decrease between 1992-93 and 1996-97 of about 5% in real terms in investment in R&D at the Experiment Station indicates a poor investment decision by the industry's policy makers.

Acknowledgements

The author is especially grateful to Quin Mann for his advice and personal interest in this paper and, appropriately at this time of his retirement, to pay tribute to his personal knowledge of his extension area and region, and his enthusiasm for the wellbeing of the growers and the environment he has served so well. The author is also indebted to Roger Bailey for valuable advice and to Ross McIntyre, Perumal Sackhan, Abraham Singels and Bill Southey of the Experiment Station, and Jill Scheepers of Cane Growers for providing much of the data used.

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APPENDIX 1
Calculation of the value of Plant Breeding.

COLUMN	1	2	3	4	5	6
Year	Sugar production (tons)	Export price (R/ton)	Value of production Rm (1996 = 100)	Value of technology (Rm)	Research share of tech value (Rm)	Value of plant breeding (Rm)
1984-85	194 973	205,58	174,1	55,7	11,1	1,11
1985-86	218 057	225,90	184,1	58,9	11,8	1,18
1986-87	184 728	334,74	194,8	62,3	12,5	1,25
1987-88	198 086	312,71	168,1	53,8	10,8	1,08
1988-89	263 499	550,72	348,8	111,6	22,3	2,23
1989-90	219 949	777,53	358,5	114,7	22,9	2,29
1990-91	180 780	778,58	257,8	82,5	16,5	1,65
1991-92	220 519	574,75	201,4	64,4	12,9	1,29
1992-93	235 012	821,69	269,4	86,2	17,2	1,72
1993-94	108 669	943,63*	130,3	41,7	8,3	0,83
1994-95	210 763	1 065,58	261,9	83,8	16,8	1,68
1995-96	221 332	1 070,80	254,5	81,4	16,3	1,63
1996-97	206 269	1 196,23	246,7	78,9	15,8	1,58

*No data; mean of previous and next year used.

APPENDIX 2
Calculation of value of main varieties.

Column	1	2	3	4	5	6	7	8	9
Year	Value of Plant Br. (from App.1, Col 6)	Total variety productivity (from Table 1)	Pl. Br. value per unit of total productivity	Individual variety values (variety productivity (Table 1) x Pl. Br. unit values)					Sum of variety values
				N12	NCo376	NCo293	N16	O&M	
1984-85	1,11	104	0,01067	0,0245	0,1814	0,6925	–	0,2160	1,1144
1985-86	1,18	104	0,01135	0,0392	0,1929	0,7116	–	0,2402	1,1839
1986-87	1,25	105	0,01190	0,1232	0,2023	0,7069	–	0,2190	1,2514
1987-88	1,08	107	0,01009	0,1857	0,1917	0,5660	0,0119	0,1207	1,0760
1988-89	2,23	107	0,02084	0,6085	0,3543	0,9399	0,0246	0,2876	2,2149
1989-90	2,29	108	0,02120	0,7558	0,3180	0,9328	0,0500	0,2340	2,2906
1990-91	1,65	109	0,01514	0,7661	0,1968	0,4663	0,0715	0,1532	1,6539
1991-92	1,29	111	0,01162	0,7350	0,1046	0,2684	0,0823	0,0959	1,2862
1992-93	1,72	112	0,01536	1,1835	0,0922	0,2028	0,1631	0,0848	1,7264
1993-94	0,83	119	0,00697	0,5451	0,0348	0,0537	0,1151	0,0834	0,8321
1994-95	1,68	118	0,01424	1,1954	0,0570	0,0783	0,2352	0,1175	1,6834
1995-96	1,63	116	0,01405	1,1795	0,0281	0,0309	0,2818	0,1034	1,6237
1996-97	1,58	114	0,01386	1,0839	0,0139	0,0152	0,3271	0,1403	1,5804
			TOTALS	8,4254	1,9680	5,6653	1,3626	2,0960	19,5173

APPENDIX 3
Sharing of Plant Breeding costs by varieties and estimated costs of N12 and N16.

Year	Varieties in the breeding pipe-line at the same time								Share of breeding costs per variety	Breeding costs Rm (1996 = 100)		Estimated cost of breeding	
	N52/219	N12	N14	N16	N21	N17	N19	N22		Whole industry	Midlands North	N12	N16
1965-66	X	X							0,50	5,269	–	–	–
1966-67	X	X							0,50	5,161	0,194	0,097	–
1967-68	X	X	X						0,33	5,166	0,326	0,108	–
1968-69	X	X	X	X	X	X			0,17	6,056	0,485	0,082	0,082
1969-70	X	X	X	X	X	X			0,17	4,796	0,240	0,048	0,048
1970-71	X	X	X	X	X	X			0,17	5,077	0,416	0,071	0,071
1971-72	X	X	X	X	X	X			0,17	4,809	0,280	0,048	0,048
1972-73	X	X	X	X	X	X	X		0,14	6,486	0,426	0,060	0,060
1973-74	X	X	X	X	X	X	X		0,14	6,467	0,407	0,057	0,057
1974-75	X	X	X	X	X	X	X		0,14	8,276	0,480	0,067	0,067
1975-76		X	X	X	X	X	X		0,17	7,112	0,536	0,091	0,091
1976-77		X	X	X	X	X	X		0,17	9,720	0,742	0,126	0,126
1977-78		X	X	X	X	X	X	X	0,14	7,631	0,567	0,079	0,079
1978-79		X	X	X	X	X	X	X	0,14	9,471	0,793	0,111	0,111
1979-80			X	X	X	X	X	X	0,17	7,689	0,789	–	0,134
1980-81			X	X	X	X	X	X	0,17	8,164	0,816	–	0,139
1981-82				X	X	X	X	X	0,20	9,956	0,996	–	0,199
									TOTALS N12	86,228	5,099	1,045	
									TOTALS N16	101,710	6,174		1,312