SORGHUMS FOR CONSERVED FEED IN NORTHLAND

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ABSTRACT

Sorghums seem to be useful crops for silage production in Northland, especially on land rather marginal for maize production because of low soil water availability. Yields of over 20,000 kg/ha total dry matter are possible on sites with reasonable moisture, though total forage yields can be halved on dry sands.

Dwarf grain sorghums are not as seriously affected by drought and grain yields of around 6300 kg/ha (110 bu/acre) were obtained on sand in a dry season.

Sorghums show a considerable variation in maturity and in size, and hence in potential yield and water use. The best sorghum to use depends on early season soil temperatures, soil moisture availability during summer and night minimum temperatures in late summer on that site. Two grain hybrids, one medium early and one medium late and two forage types, about 1.5m and 2.5m high respectively, will need to be commercially available to cope with the majority of site requirements.

Sorghum silage is high in energy (43% soluble carbohydrates) and low in protein (6%). Well made, high-protein pasture silage could be an ideal feed to use in conjunction with sorghum silage. Direct drilling seems a useful establishment technique for sorghum on sand and peat soils provided some problems of weed control and seed germination can be overcome. Compacted loams and clay loams should receive adequate soil preparation.

INTRODUCTION

There are two serious problems in areas of Northland which require forage conservation in one form or another to cover seasonal feed gaps in pasture production. Summer droughts, compounded by black beetle damage, are severe in some areas, while peat or clay-pan soils can give serious pugging problems in winter.

In the past, many Northland farmers have made substantial quantities of hay; some have grown specialist green feed crops, especially brassicas and latterly some Sudax or Trudan; while others have attempted to save pasture in one way or another. Many farmers and the Department of Lands and Survey have not found these procedures completely successful and the material and labour cost of hay making is continuing to rise.

Sorghums are drought-tolerant, warm season crop plants that originated in North Africa. Breeding programmes in the US have recently produced hybrids to serve a wide range of purposes and seed of many of these types can be imported from Australia.

We would like to detail the yield and potential use that sorghums can have in Northland as warm season forage crops to alleviate pasture feed gaps, and also describe briefly the dual use that equipment necessary for the harvesting, storage and feed-out of conserved sorghum forage can have in the production and utilization of wilted, fine-chop silage from spring flush pasture.

TRIALS

Three major trials were laid down in the summer of 73-74 on a range of soil types on Lands and Survey development blocks in Northland. These were as follows:

SITE	SOIL TYPE	SOWING DATE
CAPE VIEW 10 km N of Houhora	Te Kopuru sand, with pan at 1 metre. pH 5.7	24.10.73
STONEY CREEK 20 km E of Mangonui	Clay loam. pH 5.6	25.10.73
SWEETWATER 12 km N/W of Kaitaia	Raw peat, 47% organic matter. pH 4.6	26.10.73

Drilling direct techniques were used on all sites. Existing pasture was first grazed, then treated with paraquot (4 1/ha) and the area sown with a Duncan 730 multiseeder. A range of grain sorghums, silage type sorghums and maize were sown in 45 cm rows as replicated blocks and this 1/3 ha area surrounded by 1-2 ha of Sudax. Some cultivars were used at all sites and these are shown in Table 2.

In addition to these, several other grain sorghums were sown at Cape View only. These were: De Kalb A26, B36, C42a and C42y and Pioneer 451, 1434, 8048 and 9663.

Urea at 112 kgN/ha was drilled into the ground at planting, then 630 kg/ha 30% potassic super and 250 kg/ha ammonium sulphate surface applied. High levels of insect protection were given at establishment to ensure control of black beetles. These were applied in granule form by prill spreader at 2 kg ai/ha fensulfothion as Dasanit 5G and 2 kg ai/ha diazanon and Dyzol 20G. Sites were finally sprayed with propachlor as Ramrod 65 (9 kg/ha) and 2, 4, 5-T (31/ha) or atrazine (0.5 kg ai/ha) for weed control.

No further fertiliser, weed or insect control was used and trials were harvested on 28.3.74. Harvests comprised

	Oct	Nov	Dec	Jan	Feb	Mar	6 month total
Mangonui	53.7 (102)	60.3 (87)	23.9 (83)	12.6 (86)	80.6 (91)	59.0 (90)	290.1 (539)
Kaitaia	45.6 (99)	49.2 (91)	49.2 (91)	24.0 (91)	51.8 (99)	44.7 (74)	290.0 (550)

standard row lengths from each of 3 replications, and means of these are shown in the results section. Subsamples of head and stover were deep frozen and flown to Palmerston North where they were vacuum dried for further analysis.

Rainfall records for 73-74 from two meterological stations close to the trial sites are shown below. Data for the period immediately prior to crop establishment and for the full crop growth period are shown along with 40 year monthly rainfall means in parentheses. It can be seen that the whole period of crop establishment and growth was particularly dry, averaging approximately half normal rainfall.

RESULTS AND DISCUSSION

General agronomic

Seed germination following direct drilling was somewhat variable on each site and between sites. Establishment was best on the sand, with germination approaching 60%, while on the clay loam and peat, germination varied between 20 and 50% across the sites. Paraquot effectively desiccated existing pasture green matter on all sites, although subsequent pasture or weed regrowth was sometimes substantial. Ramrod and 2, 4, 5-T or atrazine sprayed on desiccated pasture in a dry period gave poor results. On the sand site some broadleaf weeds subsequently established, but they did not become serious. On the clay loam a strong growth of clover developed and this competed strongly for water with the developing sorghum seedlings. Root penetration into this rather tight soil was also poor and roots tended to run along the base of the disc cuts left by the drill. These two features combined with the extremely dry summer of 73-74 starved the seedlings of moisture to such an extent that they seldom grew above 30 cm in height. On the peat, paraquot also left a serious weed problem, consisting largely of temperature and tropical grasses and broadleaf weeds. Seedling sorghum growth was slow initially, because of wet cool conditions in the peat, but as the soil surface warmed in late November, they overtopped the weeds and tillered strongly to fill up much of the rather poor initial establishment.

The high level of insecticide protection given appeared adequate since no insect problems were experienced at establishment, despite overwintering black beetle adults on at least two sites. Many dead adults were noticed on the sites during early November. Future work to determine the amount of insecticide protection necessary for economic control is planned.

Differences in infestation levels of various insect pests were noted in the grain heads of maize and sorghum, particularly late in the season. Army caterpillar **Pseudaletia separata** was initially held well in check by the parasite **Apanteles ruficrus** and spraying for control was not considered to be necessary. As the season progressed, however, some damage was evident, particularly on the maize, while there was little evidence of feeding on the forage and grain sorghums. A very high level of attack by a nuclear polyhedroses virus (N.P.V.) was evident in populations of the corn ear worm **Helicoverpa armigera conferta** in January, particularly on the Cape View site. Later in the season some damage was evident on maize cobs, particularly on the peat site; lack of rainfall may have inhibited the spread of virus particles. No evidence of virus attack was found on **Pseudaletia.** The green vegetable bug **Nezara viridula** reached high levels at both trial sites, but infestation was noticeably less on the open and semi-open headed sorghums. Aphids were prevalent on some of the grain sorghums, but no evidence of plant virus was seen.

In preliminary commercial sorghum trials in the Gisborne area some years ago, grain frequently developed rather serious mould after weathering. This is generally regarded to be less of a problem in open headed, bronze grained types. Even semi-compact yellow endosperm types (C42y) produced reasonably clean grain in Northland, however, but 73-74 was a dry summer and it may eventually prove desirable to use hybrids with better mould resistance.

Threat of bird damage is frequently considered as a major problem in the growing of grain or grain/silage sorghums. Sparrows are especially bad and they can decimate small crops. On the Lands and Survey trial sites in Northland we had no bird problem, however, probably because they were at least 400 m away from the nearest nesting sites in trees and several miles away from urban areas. Provided reasonable sized plantings and common sense are used, birds should not present an undue hazard.

Grain yield

We do not envisage that sorghum would be grown predominantly for grain in Northland, because grain yields of maize on more favoured cropping sites are

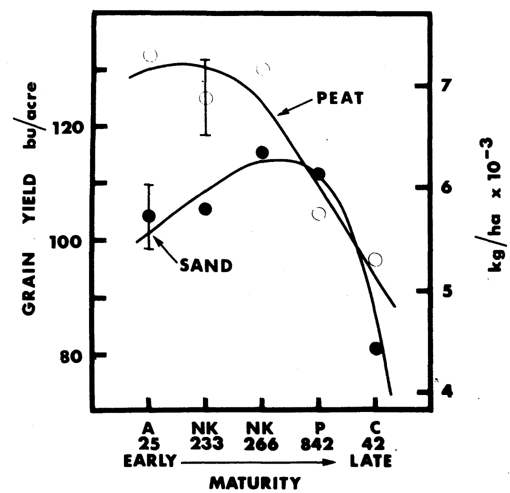

Figure 1. Interaction of varietal maturity of grain sorghums on grain yield at two contrasting sites. SE's are varietal means.

potentially higher and more profitable. Grain, however, is a major component of the sorghum plant as used for silage and its high starch content is especially important in animal nutrition (Ward and Smith, 1968). Grain yield is also the most sensitive parameter of site/plant interaction, so it is a useful yield component to consider first.

The grain yield from specialist dwarf grain sorghums on the Sweetwater peat site and the Cape View sand site are shown in Figure 1. Sorghum hybrids are ranked on the lower axis in order of maturity. Two features are immediately obvious; firstly, yields on the peat generally exceed those on the sand, and secondly, rather early maturing varieties are best on the peat, while mid-season varieties yield best on the sand.

There are several factors which contribute to these relationships. On the wet peat, soil temperatures early in the season were cool, and the meristem of a sorghum remains virtually at ground level until floral initiation takes place. This cooling, especially of the growing point, slowed the rate of crop growth (Menalda and Kerr, 1973) "changing" early season hybrids into "mid" season types, and late season types into very late. It also slowed the first stages of floral differentiation so that more floral primordia were formed. This showed up in increased grain number per head and reduced grain size in A25 on peat, compared with sand. A similar effect was noted in other hybrids but with decreasing emphasis as maturity ranking increased. Yield of the later maturing types was probably reduced on the peat, because although they formed sufficient floral primordia, low night temperatures later in the season reduced grain set (Taylor, 1973) and water/nutrient uptake from the peat became progressively more difficult as its water table lowered during summer.

On the warmer sand site, initial stages of development took place more rapidly, so total crop maturity was accelerated. Normally, the later maturing the variety, the greater the number of grains per head and the longer the grain filling period and hence the greater the yield (Doggett, 1970). This greater yield potential can only be expressed, however, if sufficient water is available. Water is essential for plant growth, especially for cell enlargement (Boyer, 1973) which takes place largely during vegetative growth. Leaves also lose water vapour as they take up CO_2 for photosynthesis, so water use is roughly proportional to the amount of plant growth, especially leaf growth. During the summer, water is lost from the leaves of the crop, from weeds and from the soil surface, so that available soil moisture generally decreases during crop development. Later maturing types generally have thicker stems and more leaves, so they use more water before they even commence grain filling, and they are attempting to fill grain when soil reserves are lower than they were for earlier maturing types. This means that the yield of later maturing types such as C42 is lowest in a drought year, but in a summer with good rainfall, C42 could well yield best on a sand site.

It can be seen that choice of the best hybrid for any site will depend on many factors, but especially early season soil temperatures and general soil water availability.

An additional trial containing a further range of grain sorghum hybrids was laid down on the Cape View site only. Yields of these are given below in parentheses as bu/acre (56 lb/bu at 14% moisture).

A26 (111), B36 (100), C42a (111), C42y (129), P1434 (106), P8048 (126), P451 (132), P9663 (133).

Total DM yield

The main use envisaged for sorghums in Northland is the production of stored feed as silage rather than for grain. Total dry matter yields obtained at Sweetwater and even Cape View were most encouraging considering the very dry 73-74 summer.

On the peat site at Sweetwater, dry matter yield of the grain hybrids followed the same trend with maturity as grain yield, namely, that early maturing hybrids produced better yields than later maturing hybrids (Table 1). As would be expected, much of this variation

TABLE 1: Total warm season silage D.M. yields 73-74 (kg/ha) using direct drilling techniques.

Plant type	Sweetwater peat [1]	Cape View sand
Hybrid grain sorghums		
De Kalb A 25	17,020 a	12,070 b
Northrup King 233	17,290 a	12,840 b
Northrup King 266	16,500 a	14,250 a
Pioneer 842	14,770 b	13,180 ab
De Kalb C 42	13,280 c	12,750 b
Hybrid forage sorghums		
Northrup King 300F	16,490 d (156)[2]	9,840 b
De Kalb FS 1A	24,740 b (182)	8,560 b
De Kalb FS 26	23,940 b (215)	8,560 b
De Kalb FS 4	27,980 a (226)	12,800 a
Open Pollinated sorgho Sugar Drip	20,480 c (219)	11,800 ab
Hybrid maizes		
De Kalb XL 45	23,050 a	10,670 a
Northrup King PX 610	21,540 a	12,440 a

(1) Grain yields averaged 41% (grain sorghums) and 34% (forage sorghums) of total silage dry matter at Sweetwater.
(2) Plant height in parentheses in cm.

Means with letters in common do not differ at the five percent level of significance.

in total yield came from the grain component, although stover yields of C42 were markedly lower than the other hybrids.

Dry matter yield of forage hybrids on the peat was roughly proportional to height (Table 1). The average amount of grain on these silage types was slightly above that of the grain hybrids, but stover contributed an increasing proportion of dry matter as height increased. The open pollinated sugar sorgho line "Sugar Drip" showed somewhat reduced yields compared to high-sugar hybrids of comparable height and also some tendency to lodge. Although weed control and seed germination were not good, tillering by the sorghums partially corrected most of the plant spacing deficiencies and yields on this peat site could be considered as reasonably close to the maximum obtainable.

On sand at Cape View, lack of soil moisture frequently more than halved yields of forage sorghums and maize compared with those on the peat, while grain sorghum yields were reduced much less (Table 1). Yield of the forage sorghums FS 1A and FS 26 were particularly low, but this may have been caused by plant population. Normally, yield will increase as plant population is increased until a point is reached when soil moisture becomes limiting. After this further increases in plant population will decrease yield, especially that of grain (Doggett, 1970). Plant populations of FS 1A and FS 26 which established at Cape View were 30 to 40% higher than those of other forage types; and this may have been the reason for their low yield. Total dry matter yield of the grain types followed the same pattern as that of grain yield, and as would be expected, much of the variation in total yield was caused by variation in the grain component.

Interactions of maturity on grain yield in relation to early season soil temperatures and mid-late season water availability have been discussed earlier. Differences in available soil moisture on the sand and on the peat can also be seen to cause major differences in the relative DM yields of the three main forage classes used in these trials, namely, grain sorghums, forage sorghums and maize. When adequate or almost adequate moisture is available, as on the Sweetwater peat, then ultimate yield potentials are approached and the tallest forage sorghum yields best and the short grain sorghums yield least. On the Te Kopuru sand at Cape View there was less water reserve in the soil and short grain sorghums yielded best. Maize and the tall forage sorghums use more water during vegetative growth than small grain types, so less soil moisture remains for grain filling which is a large and important component of yield. For example, grain yield of the forage sorghums averaged only 64% of that of the grain sorghums at Cape View, while they averaged 120% at Sweetwater. Lack of water reduced the dry matter yields of forage sorghums and maize to approximately half those on the peat, so it can be seen that the strategic use of irrigation on this sand country could have substantial benefits.

Sorghums vary widely in their maturity and amount of vegetative growth, and it can be seen from the results presented that the best forage type for any area will be chosen on much the same basis as the best grain hybrid, with the added proviso that potentially higher stover producers must have more water or their grain yield will suffer.

Chemical composition of plant parts:

Sorghums produce a starch rich grain and frequently store soluble sugar in their stems. Some types, known as sugar sorghos, store considerable quantities of sucrose and reducing sugars and have been used in the USA for commercial sugar and syrup production. Garrett and Worker (1965) have reported that silage from "sweet" high sugar types produces comparable or better animal performance than silage made from high grain "dual purpose" types such as FS 1A. Storage of sugar proceeds late in the season, and a three-fold (Doggett, 1970) increase occurs from early flowering until storage is complete at around the same time as physiologic grain maturity is reached (Eastin, 1972).

Sorghums on the Northland sites were harvested together in late March for comparative purposes. At this stage the grain and short forage hybrids had all reached physiologic maturity as judged by black layer development, while grain on the tall forage types was at the mid-dough stage. Analysis of the stover of the forage sorghums from the Sweetwater trial showed a considerable variation in sugar content, viz. FS 1A 26.7%, Sugar Drip 23.0%, FS 26 20.5%, NK 300F 19.4%, and FS 4 15.4%. Forage types on the Cape View sand site showed similar trends in sugar accumulation. Commercial publicity data would imply that the tall forage types with substantial sugar sorgho parentage (viz. FS 4 and FS 26) should be highest in soluble sugars. It may be that we harvested them a week or so before they were able to achieve full accumulation. The surprise to us was the high sugar level achieved by NK 300F and especially FS 1A, both of which are advertised as high grain producers, not stem sugar accumulators.

TABLE 2: Composition and yield of forage sorghums. Data are means from all forage types grown on the Sweetwater peat site.

	Stover yield [1] 14,930 kg/ha	Grain yield 7,796 kg/ha	Total silage DM 22,726 kg/ha
Protein	3.0%	12.3% [2]	6.7%
Soluble sugar	21.0%		13.8%
Starch	0.3%	75.8% [2]	29.1%

(1) Leaf material averaged 25% of total stover.

(2) Data from Doggett (1970).

Stover protein and starch contents were also measured for all forage sorghums and data means are shown in Table 2. Total soluble carbohydrates (sugar and starch) were high at 42.9% while protein at 6.7% was low. Sorghum silage is similar in composition to maize silage and US reports (Browning and Lusk, 1966) have also shown them to be similar in terms of animal production.

Silage rations:

Animal requirements for protein vary between 9% of feed intake for beef cattle (Preston, 1970) to 13% for lacating dairy cows (Bath, 1971), and protein in sorghum silage is well below those requirements. One way of achieving a more balanced ration would be to add non-protein nitrogen as urea and/or to blend sorghum silage with wilted fine chopped silage made from spring flush pasture. If this pasture silage was made at an early flowering stage and it was wilted and fine chopped, it should have a protein content of around 15 to 20% and would also have good intake and handling characteristics.

The dual use of silage from these two sources has several other advantages, namely, many areas of Northland have a good spring flush of pasture; secondly, machinery for the manufacture and feed-out of sorghum silage can serve equally well in the manufacture and feed-out of wilted, fine-chop pasture silage. Finally, good forage conservation schemes should be infallible and the use of silage from two sources made at different times of this year, allows two decision making steps and so better ensures adequate supply.

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