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SILPHIUM: PRELIMINARY RESEARCH ON A POSSIBLE NEW FORAGE CROP FOR NEW ZEALAND

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ABSTRACT

Silphium perfoliatum seed was introduced from China in 1984 and plants were grown in the Waikato. Preliminary measurements showed that the yield in early summer averaged 11t/ha DM (8-16 t/ha) with a recut recording 10 t/ha DM. The silphium was fed to caged sheep to determine the digestibility of both fresh and ensiled material. The *in vivo* digestibility for preflowering material was 66% which was in agreement with information from overseas. The digestibility of the silage was very low and this was thought to be related to the inability to make acceptable silage out of the low dry matter silphium without additives or wilting. Silphium as cold hardy perennial forage plant a longetivity of 10-15 years could possibly be used as a high yielding specialised forage crop in the cooler areas of New Zealand. These present results are superficial but when they are interpreted with information from overseas they suggest that further research on silphium is warranted so that the feed value and agronomic qualities of the crop are better defined.

INTRODUCTION

The silphium genus contains about 25 species. They are coarse perennial herbs of the Helianthus tribe of the Asteraceae (Compositae) family, native to eastern North America.Five of the species are used as garden plants in North America and in Europe.

In its native state *Silphium perfoliatum* or "cup-plant" is found from Ontario to Mississippi and plants are capable of living over 30 years (Dickson, 1979). The plant develops a crown up to 40cm wide and in the vegetative state the large leaves (25cm x 35cm) form a rosette. The plant is cold hardy and under the harsh winter conditions of continental Europe the rosette leaves die off and regrowth begins from buds on the crown. Growth begins when temperatures are above 5°C (Sokolov and Gritsak, 1972) and the plant elongates in summer reaching over 2m in height with 75mm diameter flowers in a corymb (Bailey and Bailey, 1976).

Russian research workers carried out considerable research on the use of silphium as a forage and silage crop in the 1950's and 1960's (Sokolov and Gritsak, 1972) and found silphium similar in biochemical and nutritive value to other forage crops (Vavilov *et al.* 1978). Since this initial research was undertaken, work on silphium has spread into Western Europe, China and Japan.

Silphium can be established in rows 70cm apart at a sowing rate of 15-20 kg/ha by autumn sowing fresh seed or spring sowing seed which has been stratified for two months (Sokolov and Gritsak, 1972). Neumerkel and Martin (1982) obtained best results when silphium was sown at 10 kg/ha in rows 50cm apart but Filatov et al. (1986) used sowing rates of 18 kg/ha (or 14 kg/ha where the crop was drilled in both directions). Weeds were controlled during establishment by using trifluralin applied presowing (Vavilov *et al.*, 1972, Filatov *et al.*, 1986). Once established silphium is expected to be productive for at least 10-15 years. There is little comment in the literature about pests and diseases although Troxler and Daccord (1982) found silphium in Switzerland was vulnerable to *Sclerotinia*.

Date presented by Sokolov & Gritsak (1972) showed that as silphium grows in the spring the leaf dry matter and protein percentage change (Table 1). Early in the spring the major portion of the dry matter of the plant is in leaves but at flowering in summer the stem may account for 50-60% of the dry matter. The dry matter content of the plant ranges between 10-16% with the stems having lower percentage dry matter than the leaves. As the plant matures the dry matter percentage rises and the concentration of the plant crude protein levels fall from above 20% to about 13%. The protein concentration of the leaves is more than double that of the stems (Sokolov and Gritsak, 1972).

In Europe and Russia, silphium is generally cut twice a year for silage with the first cut taken in June or July at budding or early flowering and the second about two months later. Yields of 26 t DM/ha have been recorded in Russia under highly fertilised conditions (Sokolov and Gritsak, 1972) but more recent trials in Western Europe would suggest the yield more frequently ranges between 13-19 tDM/ha (Niqueux, 1981, Neumerkel and Martin 1982, Troxler and Daccord 1982). One comparison with lucerne found that silphium gave a yield of 191 DM/ha and lucerne 9.9 t DM/ha (Sokolov and Gritsak, 1972). Silphium responds markedly to compound fertiliser or farm yard manure and gives best yields under conditions of high fertility and adequate water (Sokolov and Gritsak, 1972, Niqueux, 1981). Troxler and Daccord (1982) considered silphium was vulnerable to water stress but Neumerkel and Martin (1982) did not obtain any increase in yield when irrigation was applied. Vavilov *et al* (1978) found silphium did not yield well on acid soils.

Silphium in the vegetative stage has an *in vitro* digestibility of 70-90% (Neumerkel and Martin, 1982) but as the plant matures and flowers the digestibility drops. Demarquilly and Niqueux (1978) found the digestibility of the organic matter dropped from 72% to 62% as the plant matured. Voluntary intake of silphium by stock is high but this also drops if the crop is fed to stock at flowering.

Silphium does not ensile well because of low concentrations of soluble carbohydrate and low dry matter content but where silage is made using formic acid or the material is wilted, the quality is improved considerably (Demarquilly and Niqueux, 1978, Kawahara *et al*, 1977). In a comparison of silages made from maize or silphium, daily milk yield per cow was 12% higher where cows were fed siliphium silage (Sokolov and Gritsak, 1972) although the milk yields were low by New Zealand standards (A.M. Bryant, *pers comm*).

New Zealand Trials

In 1984 a single seedline of silphium was obtained from the Institue of Animal Science, Chinese Academy of Agricultural Sciences, Beijing. Seedlings were raised in glasshouse conditions at Ruakura and later planted out in rows 1m apart at Rukuhia Horticultural Research Station. Seedlings planted at Wairakei Research Station in early April were killed by severe frosts (-9.2°C) as the plants had not been sufficiently well hardened off from the glasshouse conditions. General observations made at Rukuhia the season after planting indicated the plants were healthy and grew vigorously where weeds were controlled and the plants kept well watered on fertile soil. In the 1986-87 season the rainfall in November and December was only 40% (74mm) of the long term average and in early December 100mm of water was applied with spray irrigation. Just prior to this 2 t/ha superphosphate and 1 t/ha sulphate of ammonia was applied. The 122mm of rain which fell in January was 40% above the long term average although only 25mm fell in February which was considerably drier than normal. No further irrigation was applied.

Table 1. Silphium Composition (Sokolov and Gritsak, 1972)

	Height	%Leaf		%DM	Protein
Vegetative	76 cm	69	Leaf	15	24
			Stalk	8	14
Budding	207 cm	50	Leaf	21	20
			Stalk	18	8

Table 2. The crude protein gross energy, and *in vitro* and *in vivo* digestibilities of fresh and ensiled Silphium grown in the Waikato and harvested at the preflowering stage.

	Crude Protein	Gross Energy	Digestibility	
	%	MJ/kg	*invitro*	*invivo*
Silphium (Fresh)	11.0	17.1	67.8	66.1
(Silage)	11.8	18.3	-	52.1

Trial 1

Silphium in a pre-flowering state was cut daily over the period 25.11.86 to 15.12.86 to supply sufficient feed for the digestibility trial. The area was harvested daily (3-9 metres of row) and the crop green and dry weight were recorded to enable the crop yield to be calculated. The silphium was chopped into 1cm lengths and fed to four caged mature crossbred wethers of an average weight of 51kg. Preliminary feeding was carried out for 15 days before the digestibility trial which ran for 7 days. The sheep ate the silphium readily and, during the trial period, completely ate the 5kg/day offered. Faecal output was measured daily and samples kept for dry matter, organic matter, nitrogen determination by the Kjeldahl procedure and energy determinations using an adiabatic bomb calorimeter. Similar measurements were made on the fresh silphium.

Trial 2

Silphium was cut at the preflowering stage on 23.12.86, chopped into 1cm lengths and packed tightly and ensiled in a sealed black plastic bag until 14.5.87. This silage was fed to four caged mature crossbred wethers of an average weight of 62kg. The silage of 15.8% dry matter was fed at 5 kg/sheep/day with no refusals. Faecal output was measured daily and samples kept for determinations similar to those in trial 1.

RESULTS AND DISCUSSION

The dry matter yield calculated from the 12 samples taken daily in Trial 1 for the feeding studies averaged 11.09 t DM/ha (range 8.0-16 t/ha) with a dry matter content of 11-15%. On 26.2.87 the regrowth of the crop was 10.5 t DM.ha at 16.6% dry matter. Growth made after the cut in February was not measured. Twenty-one t DM/ha was obtained when the early summer cut and the regrowth were combined and this was at least equivalent to the yields of 16-19 t DM/ha recorded overseas (Niqueux, 1981; Neumerkel and Martin, 1982). Longer term trials need to be conducted to obtain a better idea of the annual variability in yield but nevertheless the initial result indicate that silphium is one of the higher yielding crops in New Zealand (Douglas, 1980).

At 11% the concentration of crude protein (Table 2) is similar to figures for crops grown overseas and reflects the maturity of the crop at harvest and amount of stem in the crop. Neumerkel and Martin (1982) found the crude protein content of leaves varied from 14-17% and stems from 4-6% although Sokolov and Gritsak (1972) recorded higher levels. A leafy silphium crop in late spring might be expected to have crude protein levels of 15-24% crude protein and consequently the change in nutritive value needs to be considered depending on whether the crop is targeted for grazing or conservation. The gross energy content of fresh silphium is low (Table 1) but values for silage were similar to silage made from grass or clover (Ministry of Agriculture, Fisheries and Food, 1975).

The *in vitro* and *in vivo* digestibilities of fresh silphium were lower than found by Neumerkel and Martin (1982) but are similar to those of Demarquilly and Niqueux (1978) for a crop approaching flowering. The pen fed sheep readily ate the silphium but the maturity of the crop was more appropriate to making silage and it would be expected that a more leafy crop would have been more digestible. The low *in vivo* digestibility of the silage was unexpected and it is unexplainable since the expectation would be that the digestibility of the silage would be comparable to that of the fresh material. This discrepancy is probable related to the difficulty of making silphium into good silage without additives or drying (Kawahara *et al.* 1977, Demarquilly and Niqueux, 1978, Neumerkel and Martin, 1982, Troxler and Daccord, 1982). Even so, the penned sheep ate all the silage which was offered.

This preliminary work with silphium and the review of overseas results indicates that silphium has the potential to be a useful crop in New Zealand. In many respects silphium might be looked upon as a cool season equivalent to forage maize for summer grazing or conservation. Its perennial growth and longevity may give it a specialised place in local farm systems. More research is needed before silphium can be totally accepted as a forage crop suitable for New Zealand but the initial results indicate further research is warranted.

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