S O U T H   A F R I C A N   S U G A R   I N D U S T R Y

A G R O N O M I S T S'   A S S O C I A T I O N

NOTICE OF ANNUAL MEETING

The Annual Meeting of the Association will be held at Illovo Sugar Estates at 10 a.m. on Tuesday, 26th September, 1967. The following programme has been prepared:

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11:00 a.m.	:	Cotton production - Mr. J. Burton.
11:40 a.m.	:	Mechanization - Mr. G.S. Bartlett.
12:20 p.m.	:	Herbicides - Mr. C. Wardle.
1:00 p.m.	:	Lunch.
2:00 p.m.	:	Frost damage - Mr. E. Browne.
2:40 p.m.	:	General nutrition - Mr. P.K. Moberly.
3:20 p.m.	:	Fertilizer advisory methods 1. Mr. R.T. Bishop. 2. Mr. M. Stewart. 3. Dr. J.N.S. Hill
4:00 p.m.	:	General discussion.

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clean yield: 2650#/ac.

C O T T O N.

INTRODUCTION:

Cotton makes up about 56% of the fibre used by man. (6)
The lint which is approximately one third of the total weight of the seed cotton (the remaining two thirds is made up by the seeds) is sold to the spinning mills, and from there to the weaving industry.
The by-products, e.g. the fuzz or linters (the short fibres remaining on the seed) are ginned off and used by the upholstery and chemical industry.
The Cotton seed is used by the oil seeds expressing industry, where about 16% oil is extracted.
The residue (cotton seed cake) is a valuable protein rich cattle feed. It is not suitable for poultry or pigs until an alkaloid, gossypol has been removed from it.

HISTORY:

Cotton is thought to have originated in Indo-China, Tropical Africa, and South and Central America.
Cotton has been known to have been grown in India for the manufacture of clothing more than 2,000 years ago.
Columbus reported seeing cotton growing in the West Indies, and cotton fabric 800 years old has been found in Indian ruins in Arizona.
Large scale production of cotton began after the invention of the cotton gin in 1794. (6).

BOTANICAL DESCRIPTION:

Cotton belongs to the family Malvaceae. The most important species of cotton are
1) American upland cotton (Gossypium Hirsutum) probably the most widely commercially grown cotton in the world. (95% of cotton grown in the United States of America is upland cotton.) (3)
Upland cotton is of medium quality with staple lengths varying from $\frac{3}{4}$ to $1\frac{1}{4}$ inches.
The flowers are a creamy yellow turning to pink after a day.
The bolls contain 4 to 5 locules.
2) Sea Island and American Egyptian cottons (Gossypium Barbadense). These are long staple ($1\frac{1}{2}$ to 2 inches) high quality cottons.
The flowers are yellow with a purple spot, and the bolls usually have three locules.
3) The Asiatic cottons (Gossypuim Arboreum and Gossypium Herbaceum) are short staple ($\frac{1}{2}$ to $\frac{7}{8}$ inches) low quality cottons. (6)

The cotton plant for Agricultural purposes is treated as an annual, although in its natural state it is a long lived perennial. It is herbaceous, growing to a height of 30 to 60 inches depending on variety, soil fertility and availability of moisture.

VARIETIES GROWN IN RHODESIA:

Two varieties are grown commercially in Rhodesia. They are Albar 65F and Delta pine, smooth leaf, both upland cottons.
Albar (Allen Blackarm Resistant) was bred at Namulonge in Uganda, and was selected as a well adapted variety to the needs of Central Africa, where it has been grown commercially since 1960.
Albar is resistant to bacterial blight. It is an indeterminate bloomer and produces fruit over a long period of time, which results in a long picking season, which rules out the possibility of planting winter wheat.
Albar has glabrous leaves which impart a certain amount of jassid resistants into the variety. However with the insecticide programme generally conducted throughout Rhodesia.; this characteristic is of no real value.
Under optimum conditions of temperature, fertilizer and water, Albar tends to grow rank and lodge. Albar produces about 110 to 120 bolls to the pound, and has a fairly low ginning out turn (percentage lint) 31 to 33%. However the staple length and spinning qualities are good compared with the average American middling cottons.
Deltapine smooth leaft was bred in the United States of America, in the Mississippi Delta, and was grown commercially in Rhodesia for the first time during 1966.

Bolls mature over a shorter period of time, the plant is not inclined to grow vegetative as readily as Albar, and the trash from the smooth leaves is more easily separated from the seed cotton than from the glabrous leaves of Albar. Deltapine produces about 90 bolls to the pound and has a ginning out-turn of between 36 and 38%.
The staple length is as good as that of Albar, however, the spinning qualities are apparently not as good as those of Albar. Deltapine is suitable for machine harvesting.
Other good quality cottons tested are the American varieties, the Acalas 442 and 1517C and Del Cerro. These unfortunately are susceptible to bacterial blight, but otherwise are excellent varieties.
The long staple American Egyptian cottons (Pima varieties) have been tested with most disappointing results. Both low yields and poor quality being produced.

THE MAIN STAGES IN PLANT DEVELOPMENT:

1) From planting to emergence of the seedlings takes 5 to 10 days, depending on depth of planting and soil temperature.
2) From emergence to first buds about 4 weeks.
3) From first buds to first flowers about 3 weeks.
4) From first flowers to main boll development takes a further 3 weeks.
5) Finally, from main boll development to initial split boll development takes 5 weeks.

The main flowering period which is a most important stage of the crop development, particularly from the aspect of insect pest control and supplying the plant with sufficient water, starts about 11 weeks after planting and lasts for a period of 5 to 6 weeks.
The main boll splitting period occurs between the 18th and 23rd week after planting.

CLIMATIC REQUIREMENTS:

The mean temperature of the summer months should not be less than 77% F with a mean annual temperature of about 50 to 60°F.
It is considered that air temperatures below 60°F contribute little if anything to the growth of the cotton plant, and that air temperatures in excess of 100°F can be detrimental to the plant. (3)
Excessively high temperatures can cause an increase in internode length and excessive shedding of buds (squares) and young bolls, all of which result in reduced yields and larger plants which are undesirable.
A frostless season of 180 days with a minimum rainfall of 20 inches to a maximum of 60 to 75 inches provided the distribution is favourable.
Sunny weather is essential for the production of good yields.
Areas recording 50% cloudiness have too little sunshine to be satisfactory, and areas which record 60% cloudiness are unsuitable. (3)
Prolonged rainy weather with excessive cloudiness causes shedding of young fruiting buds, inhibits flower production, retards boll development and maturity and causes boll rot, with the resultant deterioration of cotton quality.

SOILS:

Cotton yields well on soils of average fertility with pH values ranging from 4.8 to 8.0
The best cotton soils are deep well drained sandy to sandy clay loams, with moderate amounts of available Nitrogen, Phosphorus and Potash.
The heavy fertile soils with an abundance of available moisture result in excessive vegetative growth, with lodging, delayed maturity of bolls and boll rots.
Cotton seed germination and the early development of seedlings is sensitive to soil temperature.
The soil temperature range suitable for the germination and development upland cotton is a minimum of 60°F and a maximum of 102°F. The optimum temperature being 93°F. (3)

LAND PREPARATION:

A firm uniform seed bed of good tilth is desirable in order to establish a good stand.
Stubble from a previous crop, clods and unevenness in the land are undesirable, as it effects the flow of seed from the planter and also the depth control which is a particularly important factor.

SEED PLANTING AND SPACING:

The seed rate recommended for machine planted cotton is generally 18 to 25 lbs. of acid delinted seed per acre, which should ensure a good stand.
When hand planting, 3 to 4 seeds should be planted per planting station or alternatively the seed may be dribbled into a shallow furrow at approximately inch intervals.
Depth of planting is critical. It is important not to plant the cotton seed too deep.
Seed should be planted at a depth of ½ inch to 1½ inches. Deep planting i.e. 3 to 4 inches can result in poor stands as demonstrated in the following table.

TABLE 1: Results of a depth of planting Trial conducted at Gatooma Research Station. (Burton 1963)

Depth of planting in inches.	1"	2"	3"	4"
Percentage Stand:	98%	91%	73%	23%
Yields lbs. seed cotton/Ac.	2,800	2,600	2,300	1,100

SPACING:

Spacing Trials conducted under optimum conditions of soil fertility and moisture have shown no statistically significant differences in yield with between row spacings varying from 3 feet to 4½ feet and in row spacings ~~from 4~~ from 4 to 18 inches.
Under dryland conditions where rainfall distribution is erratic spacings of 2½ to 3 feet between rows and 6 to 12 inches in the row have been found to be optimum.
The trend in the United States of America is towards higher plant populations, rather than a reduction in the number of plants per acre.
Broadcasting cotton seed to produce plant populations of up to 200,000 plants per acre is being investigated in the State of Arizona.
The standard practice in the United States of America however, is to plant to populations of between 29,000 and 50,000 plants per acre with rows spaced 38 to 40 inches apart.
The higher plant populations show a trend to producing better yields than the lower populations and also produce a more desirable type of plant.
The advantages of closer spacing are as follows:
1) Reduced number of vegetative branches.
2) Shorter fruiting branches, producing only 2 to 3 bolls each.
3) Bolls ripen over a shorter period of time.
4) Reduction of plant stand by soil borne diseases or termite damage is less serious than where plant populations are already low through wider spacing.
Although there are fewer bolls per plant than on the wider spaced plants, there are collectively more bolls per acre.

The disadvantages of close spacing are:-
1) Close spacing e.g. (3' x 1" - 3") results in tall spindly plants, which bear their bolls near the top of the plant which can result in lodging.
2) Production of barren plants which compete with productive plants in the same way as weeds do.

TIME OF PLANTING: [illegible] mid - November

The optimum time for planting cotton is from mid-October to the end of November.
However, in a wet season the early planted cotton tends to grow more rank than the later planted cotton, particularly in well fertilized soils.
The early planted cotton generally has a greater percentage of weathered cotton than the later planted cotton.
Early planted cotton has a higher yield potential than late planted cotton, however, unfavourable weather conditions can effect the early planted cotton to such an extent, that frequently the early planted cotton yields less than the late planted cotton.

THINNING:

Cotton is planted to a much higher plant population than is required, and then thinned at the "second pair of true leaves" stage to the required with-in-the-row spacing.
The optimum time for thinning i.e. the "second pair of true leaves" stage occurs about three weeks after planting.
Thinning, if done too late, can result in tall, spindly, weak plants, especially if the seeding rate at planting has been high.

FILLING-IN AND REPLANTING:

Gap-filling is considered by some, to be a waste of time.
As a result of work done by MacDonald, Fielding and Ruston 1947 at Barberton it was found that gap filling was not worthwhile, and was found to actually reduce the yield of seed cotton per acre.
It was concluded that the refills inhibited plants of the original planting from benefiting from the extra space available to them, and the refills were not able to compete with the larger, earlier planted plants for light, water and nutrients.
However, there are times when plant stands are such, that replanting must be considered.
Plant population and distribution must be assessed, and also the soil fertility and available moisture known.
The loss of potential yield must be weighed against the cost of replanting and sacrificing a more suitable time of planting.
Planting to the generally recommended spacing in Rhodesia of 3' x 6" (population 29,040 plants/Ac.) under optimum conditions for growth, plant stands as low as 40 to 50% of the theoretical stand are able to produce economically worthwhile yields, provided the distribution of the gaps is reasonable.
The cotton plant is remarkable in the way it is able to adjust its growth habit in relation to the space it has available to grow in. In fact, it is a striking example of plant adaptation to its environment.

CULTIVATION AND WEED CONTROL:

Cotton must be kept free of weeds as lack of weed control results in tall, spindly plants and reduced yields.
Cotoran (C-2059) and Treflan (Trifluralin) are possibly the most promising of the chemical weed killers used in Rhodesia, for chemical weed control in cotton.
When cultivating, care should be taken to avoid cutting or damaging the cotton plants lateral roots and the stem of the plant, as apart from mechanical damage, the plant becomes more susceptible to attack by termites.
Termites chew their way into the plant, the point of entry being the damaged area, and the end result is the whole plant wilts and dies.
Cultivation should stop when flowering starts.

FERTILIZER REQUIREMENTS:

Nitrogen has the greatest effect on yield and plant growth habit of the fertilizers used.
Excessively high rates of Nitrogen, together with a more than adequate moisture supply must be avoided as it can result in :-

1. Rank vegetative growth and lodging of the plants.
2. Boll rots.
3. Delayed maturation of the bolls.

The approximate Nitrogen requirements of the cotton crop can be estimated by means of soil analysis (mineral Nitrogen after incubation determination) and at a later stage from Petiole analysis.

The following table is an extract from a water and Nitrogen Trial on Cotton conducted at Triangle. (Burton 1966)

Table 2.

lbs. N/Ac (Urea)	0	40	80	120	Least sign Diff. 0.05%	Min.N. after incubation (ppm N)	Total Water
Yield lbs.seed cotton per acre.	2,060	3,060	3,683	3,952	424 lbs. seedcotton per acre	23 (low)	31.0"

The above table demonstrates the huge responses to Nitrogen which can be obtained.
The 120 lbs. N/Ac. although producing the highest yield (not statistically significant) also produced rank vegetative cotton, which was difficult to manage, especially the insect pest control and harvesting operations. Similar cotton on a commercial scale would have been subject to considerable field losses.
Symptoms of Nitrogen deficiency are as follows:

1. The young cotton leaves are a pale yellow green, fading to yellow as they age, often becoming red, and finally brown as they senesce and are shed prematurely.
2. Plants are short and stunted with leaves reduced in size and number.
3. The fruiting branches are few and short with a reduced number. The number of vegetative branches are reduced and often there are none at all.
4. Reduction in flower and subsequent boll production resulting in a lower yield per acre.
5. Plants deficient in Nitrogen produce few seeds per boll, and seeds produced under conditions of Nitrogen shortage have been found to produce as little as 17% protein compared with 27% from well nourished plants. (5)

Time of Nitrogen application is not critical provided that it is not applied later than 2 months after planting.
However, the general recommendation is that ⅓ or ½ of the total amount of N to be used, be applied as an initial application before or at planting, and the balance be applied as a topdressing at first buds i.e. 5 to 6 weeks after planting.
Most of the Nitrogen uptake is between 4 and 10 weeks after planting. (5)
Soils with a medium Nitrogen status require 40 to 70 lbs. N/Ac. for cotton and soils which are low in Nitrogen require 70 to 90 lbs. N/Ac.

PHOSPHATE:

The responses to phosphate are not as spectacular as those of Nitrogen, unless the soil is extremely deficient in this nutrient.
Phosphate is necessary for adequate root and top development, promotes earliness and is necessary for the production of maximum fibre length. (5)

DEFICIENCY SYMPTOMS:

1. Stunted growth with delayed fruiting and maturity exposing the cotton bolls for longer than necessary, to insect pest damage.
2. The leaves become dark green, followed by diffuse yellowing and rust coloured areas near the margins. (5)

Phosphate recommendations for soils low in available phosphate are 40 to 70 lbs. P_2O_5/Ac., and for soils with a medium status 30 to 40 lbs. P_2O_5/Ac.

POTASH:

Potash is necessary for maximum flower production, fibre length, seed weight, oil content of seed and finally raises the quality and the production of lint. It is also claimed that the K Content of the plant induces resistance to damage caused by insect pests, by promoting a quick regeneration of the plant.(5) (5)
Soils deficient in potash require 50 to 70 lbs. of K_2O/Ac. and those soils which are marginal require 20 to 40 lbs. K_2O/Ac.

DEFICIENCY SYMPTOMS:

1. Yellowish white mottling of the leaf, yellow spots appear between the veins. The centres of these spots die and numerous brown spots occur at the tip, around the margin and between the veins of the leaf. The tip and margin break down first, resulting in downward curling.
2. The leaf finally becomes reddish brown in colour, dries and is shed prematurely, thus preventing proper development of the bolls, and bolls may fail to open. (5)

MINOR NUTRIENTS:

Other nutrients required by the plant are Boron, Calcium, Sulphur, Magnesium, Manganese and Zinc.
Boron deficiency is the most commonly found trace element deficiency in cotton in Rhodesia.
Boron is necessary for the development of flower buds, and young growing tissue of the plant.

DEFICIENCY SYMPTOMS:

1. Excessive shedding or failure of flower buds to develop.
2. A break-down and blackening of the softer tissue, and death of the growing point in severe cases.
3. Distorted terminal growth.

Boron should be applied 2 to 3 weeks before flowering.
Boron may be mixed in with the insecticides and sprayed on the plant at a concentration of between 0.5% and 1% - no higher than 1% as this will injure the plant. (7)
The total amount of Boron required as a foliar spray is 1.6 to 2.4 lbs. per acre, applied over 4 to 6 applications.
If applied by hand to the soil, the application rate is 4 lbs./acre. (7)

IRRIGATION REQUIREMENTS:

The consumptive use of water by cotton in the Rhodesian lowveld is about 30"
Controlled irrigation is the key to high yielding good quality Cotton production. It is the water, nitrogen balance which is probably the most critical factor in cotton growing under irrigation.

AIDS TO IRRIGATION CONTROL:

Cotton water requirements vary through the plants different stages of development.
The water requirements at the different stages of plant development were determined by Meteler Kamp and Cackett 1962-63 and 1963-64 using gravimetric techniques to measure the consumptive use of cotton under an adequate moisture regime.
Evapo-transpiration to Class A pan-evaporation ratios (Et/Eo) were related to the age of the crop, percentage ground cover, effective root depth and leaf area index.

Peak Et/Eo ratios of 0.97 and 1.03 were obtained during flowering and boll setting when both ground cover and leaf area were at a maximum.
Mean ratios of 0.75 and 0.77 were determined for the period between planting and maturity for both crops. (4)
The relationship between Et/Eo ratio, percentage cover, leaf area and root depth have been plotted. See Fig.1. (4)
The Et/Eo ratio related to the age of the plant and percentage cover can be used to good effect for determination of irrigation frequency.
Meierkamp and Cackett compiled a table showing the approximate irrigation frequency and amount of irrigation required by the cotton plant at its various stages of development on the different soil types, which are found in the Rhodesian lowveld.
The table can be used as a simple quide for the cotton farmers irrigation requirements.

Table giving approximate irrigation frequency and amount of water required by the cotton plant.

Soil Depth (Feet)	Avail. water inches	0 - 5 Weeks		5 - 9 weeks		9 - 15 weeks		15 weeks - maturity	
		Days betw. Irrig.	Ins. Appl.	Days betw. Irrig.	Ins. Appl.	Days betw. Irrig.	Ins. Appl	Days bet. Irrig.	Ins. Appl.
Paragneiss									
1	1.5"	6	1"	4	1"	4	1"	5	1"
2	3.0"	12	1.5"	8	2"	7	2"	9	2"
3	4.5"	18	2.5"	12	2.7"	10	3"	13	3"
Alluvium									
6	7.5"	21	2.8"	18	4.2"	17	5.2"	22	5.2"
Basalt									
3.5	10.0"	36	4.9"	27	6.3"	23	7.0"	30	7.C"

The Et/Eo data in Fig.1. the data in table 3, together with the use of a soil augur are an extremely useful guide to the irrigation requirements for a cotton crop.

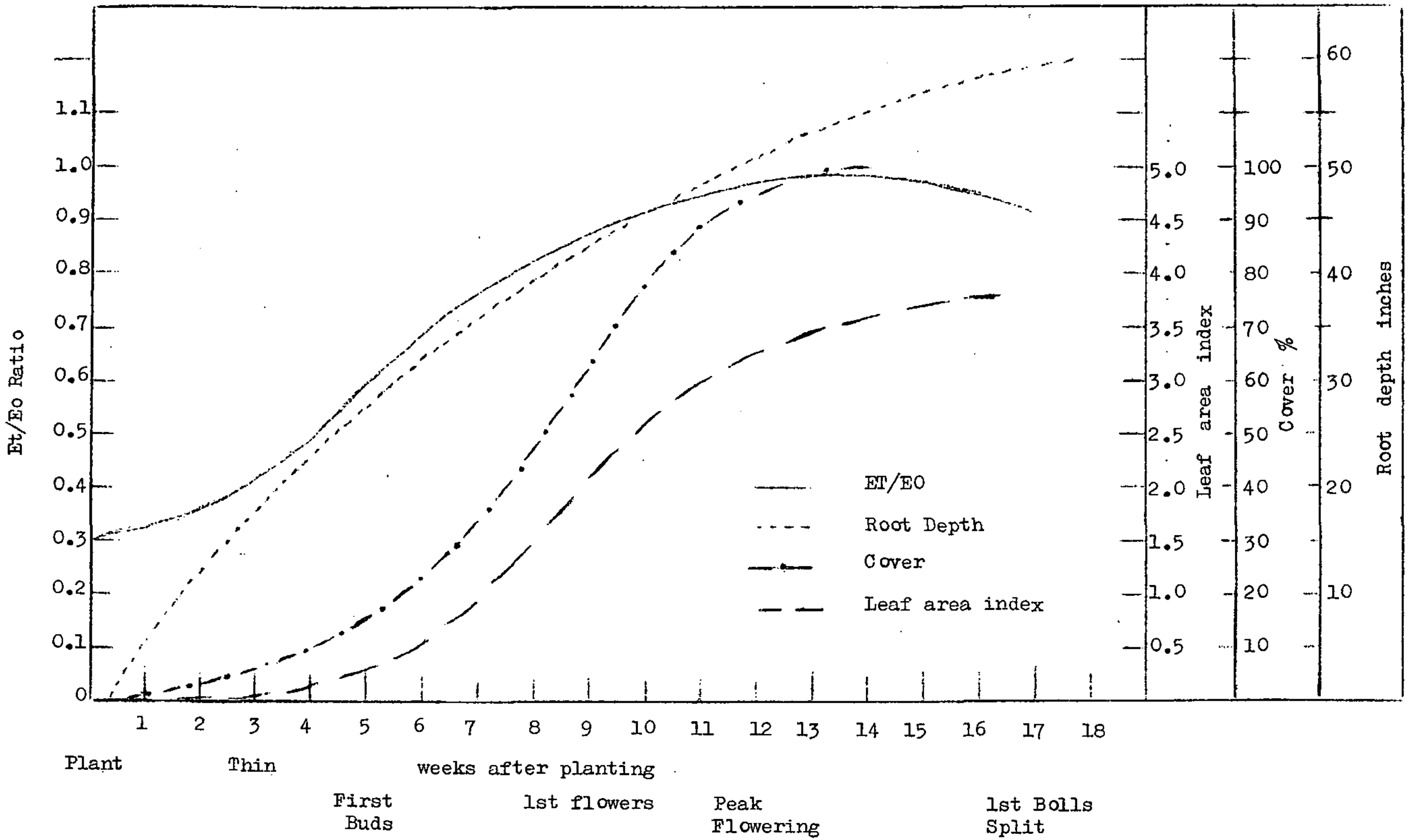
PRE-IRRIGATION

It is advisable to bring the land to field capacity before planting.
Roots of the cotton plant should be in contact with the readily available moisture.
Roots will not grow into dry soil, nor into a saturated soil which lacks oxygen necessary for root development.
Pre-irrigation allows for a lighter application of water at the first post planting irrigation, when a lengthy wet period should be avoided.
It allows for earlier germination of weeds and thus the first cultivation will serve a more useful purpose.

DRY PLANTING

Dry planting has been done with a fair amount of sucess, and has the advantage that one may plant immediately after the land has been prepared, and not have to delay planting while the field is being irrigated, and then dried out sufficiently to allow a planter in without it becoming bogged down.
However, a post planting irrigation can cause a crusting problem on certain soils, resulting in a poor germination.
Light, frequent irrigations should be avoided. Sufficient water should be applied at each irrigation to replenish moisture in the entire root zone, allowing the plant to make full use of the nutrients from a larger mass. It also reduces the degree of injury to the plant if irrigations are unavoidably delayed.
Subjecting the plant to some moisture stress particularly in the stage between germination and first flowers, is likely to assist in restricting the rate of vegetative growth and in increasing the amount of boll set.

FIG 1.



RELATIONSHIP BETWEEN Et/Eo RATIO COVER, LEAF AREA AND ROOT DEPTH

SYMPTOMS INDICATING WATER SHORTAGE:

1. Profuse flowering - (a flower garden effect)
2. Young top bolls die and dry out.
3. Excessive shedding of buds and young bolls.
4. Shortly before wilting the plant turns a darker green or has a slightly bluish tinge. Drier spots in the field turn a dark colour, an advance warning to irrigate.

SYMPTOMS INDICATING EXCESSIVE MOISTURE:

1. Absence of flowers amongst the top growth.
2. Excessive vegetative growth and lodging.

SYMPTOMS OF OPTIMUM MOISTURE:

1. Young fruit buds (squares) at the top of the plant should be prominent.
2. A few flowers should be observed among the growth.

HARVESTING:

Cotton picking commences about $4\frac{1}{2}$ to 5 months after planting.
Cotton should not be picked wet, otherwise when packed in bales it turns grey with a subsequent deterioration in quality.
The greyness is caused by a fungus, Aspergillus Flavus. Lint from grey cotton cannot be used in unbleached yarn and it is also weakened by the fungus.
Good quality cotton should be harvested first, and the poor quality seed cotton harvested at the last pick.
In Rhodesia, seed cotton is graded according to its appearance and its quality characteristics. Seed cotton grade is penalised for trash content, soil and burr stain, immaturity, insect pest damage, weak staple and short staple.
In the United States of America grading is done after ginning, on the lint quality and appearance, and since the American gins are well equipped with cleaning equipment and people who know how to use it (75% of the gin consists of cleaning equipment), the trash content is not generally a serious problem. This enables pickers to pick as much as 300 to 400 lbs. of trashy seed cotton per day. The Rhodesian picker picking trash free cotton picks about 1/5 th of what the American picker picks. This approach to picking by Rhodesian officials is creating an artificial shortage of cotton pickers in Rhodesia.

COTTON INSECT PESTS AND THEIR CONTROL:

Efficient control of insect pests is a pre-requisite to producing a good yield of seed cotton.
Scouting for insect pests and their identification is essential in cotton production.
The main cotton pests are as follows:-

AMERICAN BOLLWORM: (Heliothis Armigera)

The egg is a creamy white colour changing to dark brown just before hatching. The eggs are layed mostly on the upper half of the plant.
The larvae vary in colour from almost black or brown green to pale yellow, having a dark band down each side. The larvae normally feed on young buds, flowers and green bolls, one larvae being able to destroy a large number of buds and bolls.
Heavy attacks by the American bollworm occur particularly over the flowering period of the crop.
Young buds (before flowering) and small bolls up to 10 days after flowering; if damaged by insects are normally shed by the plant.

SPINY BOLLWORM: (Earias Sp.)

The eggs are extremely small and difficult to see by naked eye. The eggs are a blue green colour, darkening before the larvae hatches.
The larvae has characteristic spines along its back. The over-all colour is

often brown or grey with darker markings and some orange spots.
The damage caused to the cotton fruit is similar to that of the American boll worm.
The Spiny bollworm often bores in the growing points of young plants, causing the tops to wilt and die. (tip boring)

RED BOLLWORM: (Diparopsis Castanea)

The egg about the size of a pinhead is pale blue in colour, changing to grey before hatching. The eggs can be found on the lower and upper regions of the plant.
Unlike the American bollworm and Spiny bollworm, the Red bollworm feeds only on cotton plants.
The larvae feeds on the inside of the buds and bolls and generally feeds on fewer buds and bolls than the American bollworm, as it eats out a boll before moving to the next one.

SUCKING INSECTS.

RED SPIDER MITE (Tetranychus Sp.)

One of the most dangerous and insidious of the insect pests.
Mites feed on the under-side of the leaves, and to the naked eye appear as small red or reddish brown dots on the leaf.
Leaves which have been fed on by red spider show a mottling effect on the upper surface, especially near the junction of the main veins at the base of the leaf.
The infected leaf then dries out and is shed prematurely.
Red spider mite, if unchecked, can defoliate an entire cotton crop, resulting in the shedding of young buds and the premature opening of young bolls, causing a considerable drop in yield.
Other sucking insects to be reckoned with are Aphid, Jassid and Stainers.

LEAF EATERS:

Leaf eaters are normally fairly easily controlled and do not present much of a threat to the cotton industry.
These pests, if unchecked however, can cause serious defoliation.
The leaf eating insects are primarily the cotton semi-loopers, Cosmophila, Xanthodes, plusia sp. and grasshoppers.

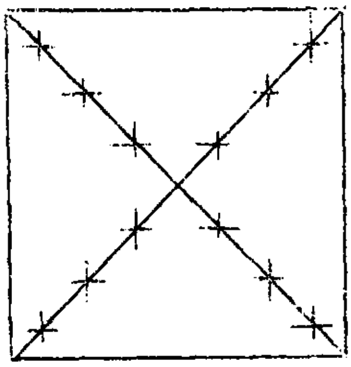
SCOUTING TECHNIQUES AND TIMING OF SPARY APPLICATIONS:

In order to obtain effective insect pest control, the right insecticides must be applied at the correct time.
The choice and timing of insecticides can only be determined accurately if the cotton is inspected regularly and systematically for insect pests and their eggs, and also for plant and boll damage.

SCOUTING TECHNIQUES:

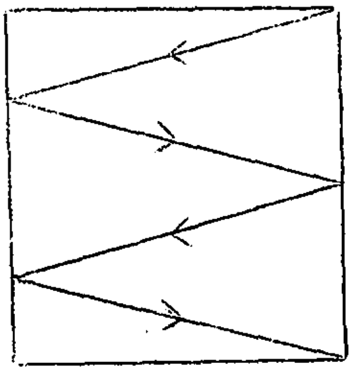
Diagrams 1 and 2 illustrate the two methods used in scouting for insect pests, and damage done by them.

DIAGRAM 1



Scouting positions spaced at approximately equal intervals along the diagonals of a field, for the purpose of making counts of the different insect pests present.

DIAGRAM 2.



A zig-zag path for general scouting of a cotton field, where only the presence or absence of the different insect pests will be noted.

DIAGRAM 1.

At Triangle it is recommended that each scouting position should consist of two plants. The number of stations per diagonal will vary according to the size of the field e.g.

30 to 60 acre field - 24 stations per diagonal.
15 to 30 acre field - 18 stations per diagonal.
1 to 15 acre field - 12 stations per diagonal.

Counts should be made at least once weekly (preferably twice) from soon after the crop is thinned up until boll maturity.
At each scouting exercise it is desirable to take a new set of plants, as continuous sampling of the same plants may cause damage and make the plant unattractive to egg laying moths, thus giving an unreliable count.
The actual scouting operation involves inspecting the cotton plants thoroughly for the following:-

1. American bollworm: Eggs and larval count
2. Red bollworm: Eggs and larval count
3. Spiny bollworm: Larval counts only.
4. Aphid: the degree of infestation recorded
   e.g. None - no aphids present.
   Very Light - one or two aphids found on a few plants.
   Light - a colony of Aphids found on a few plants.
   Medium - Aphids are present on numerous plants.
   Heavy - Aphids are numerous on most plants and the leaves show considerable crinkling and curling.
5. Red Spider Mite
   None - no red spider mites found.
   Light - a few red spider mites found on one or two leaves.
   Medium - Spider mites readily found.
   Heavy - upper surface of leaf mottled yellow and on the under surface fine webbing is apparent. (2)

Finally the numbers of Cotton Stainers, Elegant grasshoppers, Pink Bollworm, Jassid Adults, various leafeaters, Cotton Bugs and Termite damaged plants are recorded.
The bract of a bud flares after being damaged by a bollworm, and the number of flared buds are easily and quickly observed, and can give a good indication of a bollworm in festation.

DIAGRAM 2.

Once a week a general examination of the field should be made by taking a zig-zag course across it and examining plants at intervals.

At this examination the presence or absence of the various insect pests are noted, and the degree of infestation estimated.
It is recommended that general scouting commence soon after germination, in order to inspect the crop for cutworm and leaf eaters.

THE INTERPRETATION OF SCOUTING RECORDS AND THE TIMING OF SPARY APPLICATIONS:

The commencement of the spraying and the type of spray used will depend on when and which insect pests invade the crop.
Once the first spray has been applied, applications are normally continued at weekly intervals for as long as the insect infestation persists, although an initial early spray may be separated from the main spray programme by up to three weeks.
The American Bollworm comes in early and persists practically throughout the season.
DDT at a 0.5% concentration should be applied when the egg counts show a distinct rise in number, or attain an average of 0.25 eggs per plant.
Spiny Bollworm should be sprayed with 0.5% Sevin (Carbaryl) when the number of larval per plant average 0.25%
Red Bollworm should be sprayed with 0.5% Carbaryl as soon as eggs are seen on the plant.
Red Spider: An acaricide should be applied as soon as red spider mites are found, even though the infestation may be considered light.
Delay in control will make it difficult to contain the attack, as the cotton senesces and does not absorb the systemic insecticides which are usually applied for red spider control.
Recently, organic phosphorus resistant mites have appeared in the cotton and the insecticide generally recommended for their control, Dimethoate (Rogor) has not been effective.
However, Asodrin (Shell chemicals) or Nuvacron (Ciba) (both the same chemical) have shown up well on red spider.
There are several excellent contact type acaricides available, these are however, not suitable where aerial spraying is concerned, as aerial spraying provides little, if any, under leaf cover.
Red Spider is probably the most difficult of the insect pests to control.
Red Spider infestations are linked with the constant use of DDT which, it is claimed, destroys the predators of the Red Spider, thus reducing biological control to a minimum.
Aphid: If scouting indicates a "very light" attack, no control measures are necessary, but as soon as the Aphid population reaches the level of "light attack" an Aphicide should be applied.
Leafeaters and Jassid are controlled by either Carbaryl or DDT. (2)

DISEASES:

One of the most important diseases is Bacterial Blight (Xanthomonas Malvacearum) which occurs throughout the world where cotton is grown.
This disease may cause reduced yields as a result of shedding infected leaves, boll rotting and damage to the vegetative and fruiting branches, which can result in both mechanical and physiological damage to the plant.
The disease manifests itself in three ways on the cotton plant:-

1. Leaf lesions, which are black to brown and angular, known as angular leaf spot.
2. Small water soaked lesions on the bolls which turn black and are often coated with a sugar like film known as bacterial blight.
3. Lesions on the stem which are black to brown being elongated and sunken, commonly known as blackarm.

The most effective control measure is the use of resistant varieties.

BOLL ROTS:

These are more serious where cotton growth is rank and rains are frequent during the period of boll development and opening.
Boll rots can be reduced by avoiding the application of excessive quantities of Nitrogen.

Correct irrigation control, effective insect pest control, bottom defoliation and freedom from weeds
Secondry fungi which attack bolls include the following:-
Alternaria Spp., Fusarium Spp., Rhizopus Spp.

VERTICILLIUM WILT (Verticillium Alboatrum)

Verticillium, although not a serious disease at present in Rhodesia, is one of the most serious diseases in the U.S.A.

The incidence of verticillium wilt increases over cool wet periods and lessens when conditions are warm and dry.

Infected plants may die almost immediately whilst others may survive for most of the season, shedding their leaves and most of their bolls.

Losses can be reduced by growing resistant varieties, and by rotation with crops such as maize, sorghum, lucerne, soya beans, wheat and ground nuts.

Cotton should not be grown continuously for more than three years.

ROTATIONS

Cotton is an excellent crop to include in rotations with maize, soya beans, sugar cane and other summer crops.

However in an area where winter cropping is ~~im~~possible, cotton requires too long a period, to enable a farmer to produce a summer cotton crop, as well as a winter crop, (eg.,wheat) without sacrificing yield from one of the two crops. Seed beans are possibly an exception.

It is claimed that maize following cotton produces better yields than maize following maize, and that cotton is a soil improver.

The sugar cane, cotton rotation is an interesting one with possibilities.

Cotton following cane will enable the farmer to eradicate volunteer cane from the previous crop, and possibly reduce smut infection in the soil, as well as the nematode population, as cotton is not parasitised by most of the nematode species.

Hand harvesting is generally practiced in both cotton and sugar cane .

Labour normally used for cane cutting , could be used for cotton picking, during March, April and May, a period when the sucrose percent cane is probably at its lowest.

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PONGOLA FIELD STATION

COTTON CROP 1966-67 · 122 ACRES

The crop was planted late (1st to 10th December) as the irrigation installations were not complete, and no useful rain fell prior to this date. Consequently picking was a drawn out process and was not complete until August. Higher yields would have been obtained by earlier planting.

The last operation of land clearing has been charged to the crop (Roam harrowing at R5-25/acre) in lieu of ploughing. A ploughing charge would have been considerably cheaper. Several other operations could have been more economical, e.g. cutworm bait, where half the amount of maize would have been adequate, but these were not apparent at the time.

The two varieties used were Cape Acala and Acala 442. About 60 acres each. The former was superior to the latter especially in yield and storm resistance.

Breakdown of costs.

	Total Cost	Cost/Acre
Virgin land already stumped and ripped	R.	R.
Roam Harrowing on contract		5-25
Harrowing MF 175 200 hours x R1.01 (including driver)	202-00	1-66
Drilling Seed MF 175 83 hours x R1.01 (" ")	83-83	-69
Labour	25-00	-20
Seed @ 3 cents/lb. 24 lbs./acre		-72
Seed dressing Brassicap 8oz./100 lbs.	15-00	-12
Fertilizer 55,000 lbs. 2-3-2 (22) 450 lbs./acre	1352-45	11-09
Gap Filling Labour	60-00	-49
Cutworm Bait Maize 40 lbs./acre	93-00)	
Dieldrin 2 oz./acre	18-27)	1-40
Labour	60-00)	
Weeding 8.4 Units/acre	512-40	4-20
Spraying 14 applications Motor knapsack sprayers. Labour	180-00)	
Depreciation on sprayers 20% on R429	85-80)	
Thiodan 63 gallons (93 ct./pint)	470-35)	8-90
Sevin 400 lbs. (84 cts./lb.)	334-80)	
Rogor 1 gallon	14-80)	
Irrigation 14 inches/acre @ R1/acre inch		14-00
Harvesting Picking 2000 lbs. @ ½ ct./lb.		10-00
String and hire of bales	134-78	1-10
Labour for packing	115-00	-94

	Revenue	60-76
Sales 240145 lbs. @ 6 cts./lb.	14,408-70	
4037 lbs. @ 4 cts./lb.	161-48	
	14,570-18	119-43
Expected agterskot .3 cts./lb.	732-55	6-00
	Gross Return/acre	125-43
	Net Profit/acre	64-67

SOUTH AFRICAN SUGAR ASSOCIATION

INDUSTRIAL FIELD MECHANISATION AND LABOUR SAVING COMMITTEE

BULK SUGAR TERMINAL. MAYDON WHARF ROAD
DURBAN

TELEPHONE 313994 TELEGRAMS "COMPTAC" DURBAN POST OFFICE BOX 507 TELEX: DX 292

AGRONOMISTS' ASSOCIATION ANNUAL MEETING 1967.

Field Mechanisation in the Sugar Industry

George S. Bartlett
Field Mechanisation Engineer
South African Sugar Association.

Introduction:

The roles of the Agronomist and the Engineer in any form of Agriculture are inextricably intertwined, since the Engineer is largely dependent upon the Agronomist for the terms of reference and standards of performance expected of the tool or machine to be designed, while the Agronomist is largely dependent upon the Engineer to provide the means by which the job envisaged can in fact be performed. In other words, there must be a merging of known facts, interests, standards, limitations and ideas from both the Engineer and the Agronomist, so that the resultant compromise machine is able to perform the task in the most efficient manner for all concerned.

The rate of growth of the Research facilities of the South African Sugar Industry during the past years has indeed been noteworthy, and the findings and recommendations emanating therefrom are now finding their way amongst the grower population. There is little doubt in the minds of the Research workers that the implementation of their recommendations will result in considerable benefits to cane growers. It is also generally accepted that it is essential for their recommendations to be implemented if the research organisations expect to retain the goodwill of their sponsors.

In examining these sentiments and the general practice in the Sugar Industry however, it does become quite clear that many Research workers are faced with two major obstacles which are retarding the rate at which this information is being implemented. The first is the resistance on the part of the grower to change his existing proven methods, and the second is the lack of suitable equipment which will enable the grower to carry out the operation as recommended. Each of these tends to frustrate the other in that, because the suitable proven equipment is not available, the grower is reluctant to change his methods and similarly, because the growers as an Industry present a very limited market for the manufacturer, the latter is reluctant to invest in the development and manufacture of equipment for a questionable market.

This situation is not new, since when one examines the developments in the Natal Sugar Industry over the past twenty years, one finds that there has been very little really significant change in farming practice apart from loading and transport equipment. This is borne out by the following extract which appeared fifty years ago in the South African Sugar Journal dated 15th August, 1917.

> "The average price at which cutting and loading of cane is undertaken in the North Coast and in Zululand is about 2s 6d. a ton, and some planters harvesting their own cane reckon to do it at 1s 6d to 2s. A good average for cutting and loading is a ton per man per day."

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Today, the cost of cutting and loading has not nearly increased proportionately with the rising cost of living over the last fifty years, yet these operations are still performed manually in nearly 95% of all cases. The only change has been that a good cane cutter now averages 4 to 5 tons per day which results in him earning a higher daily income to meet the rising cost of living. Basically his lot has improved very little over the years.

These facts are quoted to illustrate that in spite of all the recent research developments, especially during the past decade, there has not been a proportionately significant change in farming practice. This statement applies less to practices such as primary tillage, fertilising and the use of new cane varieties than most others, and possibly the advances in these fields over the past few years have been the major causes for the Industry's rising yield per acre-month. One might immediately ask therefore, what the resultant benefits would be if advanced Technology could be applied to all the operations involved in sugar cane production and what the resultant economies would be.

It is this problem of "putting into practice what one preaches" which must now be considered by all concerned as being of major importance to the South African Sugar Industry. Without significant changes in farming practice, enthusiasm will wane, and initiative will be allowed to stagnate, conditions which cannot be allowed to infiltrate an Industry looking forward to a prosperous and expansive future.

It is felt that these are the views of the Agricultural Engineer whose main task is to endeavour to perform the recommendation made by the Agronomists attending this Annual Meeting. These views must be expressed since all indications point to an urgent need for a major change in cane growing practice, if the results which the Research workers promise are to be achieved at all.

The Limits of Mechanisation:

It is essential that some consideration be given to the various limits placed on mechanisation at the present time since without this, discussion on this subject tends to verge on the theoretical without any true relationship with existing realities.

Broadly speaking, these limits can be divided into three categories, namely, mechanical, economic and human.

The mechanical problems involved in growing sugar cane in South Africa are considerable since the Industry has to face formidable terrain, long haulage distances, and in many areas, a growth pattern which presents mechanical harvesting with badly lodged crops running in excess of 60 tons to the acre.

In the case of terrain, it is inevitable that in the long run, much of the really steep land must eventually be taken out of cane production. Exactly when this will take place cannot be foreseen at this stage since the variables in technology, infield operating technique, and the relative economic values of land, labour and crop cannot be correlated and projected with any degree of accuracy. It can be noted that this eventuality has been forecast for many years, yet still a major portion of the Industry's cane is grown on steeply sloping land.

What is known, however, is that the mechanisation research and development to date, and the economics of its use at current cost and price levels, indicate that attempts to completely mechanise extremely steep slopes at this time will prove to be unprofitable for the cane grower. In view of these difficulties a more realistic approach must be taken in making a more determined effort to completely mechanise the lesser slopes and flat terrain wherever possible since this can now be

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done both easily and profitably. Specialist equipment resulting in partial mechanisation of the slopes at economic limits is in the offing, however field trials still have to be carried out in order to obtain more accurate operational and economic data.

There are other mechanical limits facing the use of presently available planting and crop maintenance equipment due to inadequate attention being paid to the soil requirements of these tools. All too often the operations of ploughing out and preparing the seed-bed are carried out with little consideration being given to the subsequent operations since it is assumed that these are to be performed in the main by hand labour. Consequently, where these practices persist, the Design Engineer is often asked to design a weed control device which must have the capabilities of a rotary slasher, rotary tiller, clod breaker, electronic crop sensing device and mountain goat all rolled into one. If one is to learn at all from the experience of other forms of agriculture where mechanisation is fast approaching the success achieved in industrial operations, then one must accept that the first consideration is to endeavour to bring the field conditions into line with the requirements and limitations of the tools to be used.

This also applies to harvesting equipment, since the mechanical problem of separating tangled rows of cane, lifting lodged crops and cleanly pushpiling and loading the cut cane, depends to a very large extent on the thought and organisation which has gone into the pre-planning of such operations.

The economic limits which face mechanisation can be determined by standard costing procedure, however it does appear in some instances that, to many growers, these limits are more illusionary than real, due to a disproportionate emphasis being placed on the relative values of the various items making up the entire cost structure and the accepted way of life. Much of this is due to the over-emphasis on the so-called "cheapness" of farm labour and the generally accepted ease with which this labour will perform certain tasks and can be managed, when compared at this stage with the requirements of a mechanised system of cane production.

All too often, the "spare gang" is called in to assist with certain operations without its actual cost being charged directly to those operations, but rather written against general overheads. On the other hand, the high cost resulting from the low utilisation of many tractors and self-loading trailers in the cane belt is ignored, or accepted as unavoidable, since it is felt that this equipment is "essential". This is borne out by the fact that many growers have invested in self-loading trailers so as to introduce a one-man, one-stack method of tasking in order to keep labour contented, whereas a similar investment in some other form of mechanisation such as a spray outfit or infield loader which would save considerably more labour and probably reduce costs, is looked upon as unnecessary, probably because the successful use of this equipment is more demanding upon the available time of the grower. The problem is often compounded during good financial years when excess income is sometimes siphoned off to pay for non-income earning items, such as labour compounds, in order to save on taxes, whereas in the long run this money would be better invested in income-earning mechanisation.

The third broad limit facing mechanisation is a human one. If it is accepted that certain changes are necessary in the relationship between grower, labour, machines and methods in order to break through from a manual system to a mechanised system, then it follows that this break through will be entirely due to the adaptability of the persons concerned to these changes. While there may be many who are willing to change, the main problem lies in them and their labour not being suitably prepared technically and administratively to ensure a smooth evolution into mechanisation. It cannot be denied that the prospect of a machine breaking down miles from the nearest repair shop, with no one on the farm

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who can do the job while cane is left to deteriorate in the field, is not a very pleasant one. Similarly, the successful use of equipment such as fertiliser distributors and herbicide sprayers relies very heavily on an informed and interested party supervising the operation and adjusting and cleaning the equipment to meet the variables which arise during the performance of the operation.

It must be accepted therefore that the average grower cannot be expected, among all his other duties, to also be a fully qualified mechanic and for this reason it would seem that there is an urgent need for properly trained agricultural mechanics on sugar farms and more farm workshops to be established by the trade throughout the cane belt.

The Present Scope for Mechanisation:

It has already been stated that there has been very little real progress or change in cane growing methods over the past years. What changes have occurred have been mainly in the ploughing out, transporting and transhipment operations.

There is, however, a very wide and promising scope for increased mechanisation at the present time. This starts at the planting operation and goes right through to the harvesting operation.

It is known, for instance, that many growers use anywhere from 8 to 20 units of labour to plant an acre of cane. One of the main reasons for this very wide variance is terrain. Yet a little simple mechanisation and organisation on lands which can be worked with a wheel tractor will reduce this to 4 to 5 units per acre, including the actual cutting of the seed cane, trashing, dipping etc. This is achieved by mechanising the fertilising operation and eliminating the carrying of cane setts into the field by using a "planting trailer" or "platform". In addition, the covering is done mechanically, while a pre-emergent herbicide application is performed simultaneously. While final cost figures have not yet been calculated, indications are that this form of mechanisation will not only save considerable numbers of labourers, but will do so at a much lower cost. In addition, the fertiliser and herbicide applications will be uniform throughout the field, something which is impossible to achieve manually.

Some of the greatest economies, however, can be made by eliminating hand labour from the weed control operations. Recent investigations by the Mechanisation Committee showed that it costs an average of R1-00 per acre to cultivate with mules; from R1-16 to R7-26 per acre to weed by hand; 40 cents per acre to cultivate by tractor, and from R1-15 to R2-50 for a pre-emergent 2-4-D application depending on whether it is row only or full cover.

If a figure of R3-00 is accepted as a good average to manually weed an acre of land, then this means that a grower could tractor cultivate his fields seven and a half times for the price of one hand weeding. There is little doubt that a weed control programme, combining cultivators and herbicides, will eliminate the need for hand weeding. This, however, first of all requires that management is fully aware of the requirements and organisational standards involved, and secondly, has the equipment and tractor available to do the job when it is required. All too often the grower has to wait until a tractor is free from doing other jobs such as haulage, before it can get on with the cultivation programme. It must be accepted throughout the Sugar Industry, that successful and complete mechanisation resulting in a considerable reduction in labour, can only be achieved by a corresponding increase in available tractor horse-power.

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Tongaat Knapsack sprays 60c per acre
Cage boom - tractor spray < 20c per acre.

Other operations, such as lining cane trash, applying fertiliser, mowing cane breaks etc., can be very efficiently and economically performed by using equipment already available and in use in the Cane Industry.

It is with the harvesting, however, that one most often hears the call for further mechanisation. This is understandable since, unlike most other forms of agriculture, the cane cutting season extends for eight or more months and unless this is well organised, it can result in many heartaches and headaches for the grower. For this reason, labour shortages often result in cries for mechanical cane cutters as a possible solution to the problem. Experience and research has shown however, that the actual cutting of the cane should be one of the last operations to be mechanised. This is due to the complexity of operation under the variety of field and cane conditions encountered.

It has been found however, that the present labour force can be reduced by at least 50% by introducing infield mechanical loaders and thereby leaving the cane cutter to cut the cane only. Cost studies show that the correct selection of loader to meet the particular circumstances will result in no additional cost to the harvesting operation, while in some cases this can actually be reduced.

This form of mechanisation, combined with the use of the long-handled cane knife with a curved blade, and the three row, windrow cutting method, can result in a major step forward in reducing both the labour requirements and the production costs in the Sugar Industry.

Summary:

The wealth of research data which has been accumulated over the years, especially during the past decade, places the Sugar Industry on the threshold of major advances in increased production at more efficient and economic levels. These advances, however, are going to be largely dependent on the successful introduction of machines to carry out each particular task.

It is necessary, therefore, for the Agronomist and the Engineer to collaborate to a far greater degree in order that these advances can be achieved in the most efficient manner. To do this requires that consideration be given to the mechanical, economic and human limits which exist at the present time, but which will change with time, so that a more realistic approach can be taken to apply the results of the various forms of research.

Once a major breakthrough in altering existing farm practice can be achieved through mechanisation, the Sugar Industry will in time be able to reduce its labour force by at least 60% by first accepting that the so-called "spare-gang" is obsolete; by introducing a more efficient utilisation of labour through partial mechanisation of the planting operation; by completely eliminating labour from the weeding operation through the correct planning and use of mechanical and chemical weed control methods, and by reducing the harvesting labour force by at least 50% and probably 65% by introducing infield cane loaders and the long-handled, curved bladed cane knife and 3 row windrow cutting technique.

To do this means that a far greater emphasis must be placed on Grower Extension by the Sugar Industry's institutions, and that both Agronomists and Agricultural Engineers must combine to have a far greater say in what practice must be carried out on the larger estates, who so often are in a far better position to institute changes than is the average cane grower.

20th September, 1967.

HERBICIDE ACTION AND HERBICIDE

DAMAGE WITH SPECIFIC

REFERENCE TO 2,4-D

Prepared by :
G. J. F. WARDLE.

7th September, 1967.
ISE No. 1702.

Herbicide action and herbicide damage with Specific Reference to 2, 4-D.

Introduction :

The practice of selective control of weeds is relatively modern yet in its brief and meteoric lifetime it has transformed many aspects of plant husbandry and has promoted the rise of a vast chemical industry all over the world. Although chemicals were used to kill weeds as early as the end of the last century, the full potential of this new approach was not realised until the chance discovery, during the Second World War, that certain analogues of natural plant hormones could be extremely toxic to plants. This, and the disclosure that different species exhibited differing sensitivities, set the new science upon its dazzling career.

As it has developed so tremendously rapidly, there are many unknowns in herbicide chemistry, their mode of action and the general physiological disorders which they promote. It must be appreciated, therefore, that the tremendous amount of literature, often conflicting, makes comprehensive cover impossible in a paper of this type. Instead, the writer has endeavoured to present a general summary of the latest thinking in this field of study, with specific reference to the widely used "hormone - type" herbicides.

There are approximately 71 generally accepted herbicides in commercial use throughout the world at present. However, in actual practice, about seventy five percent of all chemical weed control is achieved with 3 chemicals and their homologues and analogues. These chemicals are 2, 4-D (by far the most widely used herbicide), simazine and diuron.

Herbicide Penetration :

Most selective herbicides and all general contact herbicides are applied to the foliage, and to enter the plant they must pass through the cuticle and epidermal walls or, in the case of stomatal penetration, the walls of the sub-stomatal chambers.

When herbicidal solutions are properly formulated so that they dry down to liquid films of high wetting and penetrating power, the toxic molecules of many compounds are able to enter and move in leaves regardless of the presence of stomata. Such cuticular penetration is common with the heavy ester and emulsifiable acid formulations of the chlorophenoxy compounds, especially 2, 4-D and 2, 4, 5-T. In this regard, recent evidence has shown that surfactants, incorporated in formulations of these chemicals may have chemical and physical effects upon the cuticle as well as lowering the surface tension of the herbicide, all of which greatly enhances the penetration of herbicide molecules.

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There is considerable controversy as to the relative importance of cuticular and stomatal entry of herbicides into leaves. There is, however, growing evidence of the involvement of stomata in penetration processes. An interesting suggestion is that 2, 4-D enters primarily through a number of specific sites, probably the guard cells and accessory cells but not through the stomatal pores. There is other evidence that the area surrounding the stomata is distinctive in ways which may favour penetration. Another pointer in this direction is that, although wax deposits are remarkably uniform over most leaf surfaces, they are notably sparse in the vicinity of stomata. It has also been demonstrated that ectodesmata, which form a direct connection between epidermal cells and the external surface, and are covered only by the cuticle, are present in large numbers in certain areas of the leaf viz. around the larger leaf veins, leaf hairs and guard cells. Furthermore, some workers have obtained differential rates of penetration through the upper and lower leaf surfaces which closely paralleled the density of stomata at each surface.

The importance of stomatal penetration is yet to be clearly defined but if it occurs at all it would be of some advantage. It would enlarge the absorbing surface, the internal cuticle may be thinner and more easily penetrable and the risk of spray solution drying down on the surface would be reduced.

The effect of light on herbicide absorption and penetration is another factor which has not been clearly defined. Some workers have concluded that light does not influence the penetration of herbicides. Others have concluded that penetration is uninfluenced but that subsequent translocation is light dependent. Still other workers consider that light promotes absorption by causing stomata to open and by causing an increase in the export of carbohydrates with which growth - regulators appear to be associated during translocation from the leaf. Light effect on stomatal behaviour, however, is not entirely responsible for the improved penetration under conditions of high light intensity. The influence of light on penetration is due to some more complex phenomenon which can also differ from species to species.

That light does influence 2, 4-D action is not disputed, and is borne out by the fact that the action of 2, 4-D sprayed at night is not as rapid or effective as when the chemical is applied in daylight or conditions of high light intensity. However, how light influences herbicidal action appears to remain a mystery at this stage.

Regardless of the factors which appear to influence herbicide absorption and penetration, it has been established that it is a steady and gradual process and in the case of 2, 4-D has been known to continue for fifty-six hours after application. This fact would stress the need for formulations of 2, 4-D to be stable and as little affected as possible by external factors such as rain if best results are to be obtained.

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The penetration of soil - borne herbicides into plant roots is even less clearly understood than leaf penetration. It has been established that 2, 4-D is fairly rapidly absorbed into the roots but then the movement slows down considerably. Furthermore, root penetration appears to have definite advantages in that, soil-borne 2, 4-D can be toxic to plants which are resistant to it when foliar applied e. g. grasses.

The penetration of soil-borne herbicides is influenced by a number of clearly established factors such as, chemical destruction of the herbicide before penetration, removal by a resistant crop, deep-leaching or loss by evaporation from the soil surface. The latter phenomenon together with adsorption of the herbicide onto the soil colloid are the two most important factors influencing the efficacy of soil-borne herbicide penetration into the root. Soil organic matter is very important in reducing activity by adsorption.

Translocation and Mode of Action :

Generally, herbicides are translocated in the symplast of the plant and in the sieve tube and tracheary systems. There are the two tissue systems by which herbicide molecules may move rapidly in plants, the phloem and the xylem. Much evidence during the past 15 years has shown that most of the export of herbicides from the leaves takes place via the phloem along with normal food transportation. In the case of a molecule such as 2, 4-D which is strongly bound in living cells, extensive movement is dependent on rapid food movement (active plant growth). If food movement is slow the compound is hindered in its movement and hence the herbicide action will be very slow as is the case in fields sprayed with herbicide in winter in South Africa.

For suitable herbicide action effective end points i. e. new shoots and actively growing roots where food is being used are essential, hence adequate soil moisture availability is also important. In plants having sluggish food movement, 2, 4-D may scarcely move beyond the treated foilage. In plants with active food movement, differential accumulation by active parenchyma from the sieve tubes of the phloem may be the reason why 2, 4-D can kill root meristems before an appreciable reaction occurs in the mature and much less sensitive sieve tubes through which it has moved passively to the root tip.

The above considerations introduce the important question of mode of action of the auxin - like herbicides. It is an established fact that 2, 4-D is an auxin and thus it causes growth reactions very similar to the naturally occurring indole-auxins except that it is far more active and persists for a far longer period of time. Clearly, the introduction into plant tissue of an artificial auxin which is highly persistent will saturate the cells and prevent the normal auxin fluctuation necessary for orderly growth and differentiation. Cell division is affected, young leaves do not expand properly and have low chlorophyll, and photosynthesis is thus

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reduced, roots lose their ability to take up salts and water, and phloem tissue can no longer transport food material to the plant.

In time 2,4-D has a plugging action on the sieve tubes and tracer studies show that application of 2,4-D, 24 to 48 hours ahead of amitrole application, may materially restrict the movement of the amitrole. The sieve tubes, being enucleate and lacking in endoplasm, may be relatively passive to the presence of so toxic a substance but, in time, changes in the sieve tubes are accelerated so that premature obliteration sets in. This might well be a factor in the lethal action of 2,4-D because sieve-tube destruction stops movement not only of 2,4-D itself but of food, auxins and all other substances conducted by the phloem.

This disturbance, depicted at cellular level, can also be traced at intra-cellular level where cytoplasmic activity is disrupted. At the biochemical level abnormalities also occur with the increase in R. N. A.

The above discussion might explain the actual mechanism by which plants are killed, especially those destroyed as a result of the systemic action of 2,4-D, but what actually sets in motion the cell divisions and tissue proliferations that cause the disruptions ? It might be suggested that the increase in R. N. A. is the crucial factor involved. Alternatively, the level of ascorbic acid may be the factor involved in the initiation of this process of destruction. One worker has found that plants suffering from toxic amounts of 2,4-D have a reduced level of ascorbic acid in their leaves while those stimulated to grow above normal have a greater than normal content of this acid. It is hypothesized that this causes a disturbance of the oxidation - reduction balance in the cells which in turn triggers cell division, cell proliferation, root primordial development etc. It is suggested that this is a reasonable hypothesis by which an insight can be gained into the total action of this very effective growth regulator and herbicide.

Other herbicides such as M. C. P. A., 2,4,5-T and the chlorinated phenyl and benzoic acids act, fundamentally, in the same way as 2,4 -D with differences in herbicidal activity between them being due to their chemical stability, persistence and mobility within the plant.

It is obvious therefore, that the herbicidal activity of a compound arises from a complex chain of events and many of the factors which operate are associated with the make-up of the plant itself.

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Selectivity of Herbicides :

Since plant species differ not only in their morphology but also in their chemistry, it is not surprising that they often respond differently to the same chemical treatment, thus providing a basis for herbicidal selectivity. However, there are numerous other factors which influence the selectivity of herbicides.

1. Gross mechanical selectivity which arises mainly due to time and space variation between the weed flush and the crop growth. This type of selectivity can also arise due to variation in the position of the roots in relation to the location and availability of the herbicide in the soil.

2. Differences in uptake from the soil can cause selectivity. If ordinary soil-acting herbicides are applied to the soil surface many factors operate to determine their subsequent distribution within the soil and their availability to crop and weeds. First the degree of adsorption of the herbicide onto clay and organic matter affects both subsequent mobility and direct availability to the plant. There is wide variation in adsorption between compounds and between soil types. This variation in degree of adsorption is the most important single reason for the differences in performances of soil-acting herbicides from one soil type to another.

   Movement downwards within the soil is by diffusion in soil moisture over short distances or by a leaching process over greater distances unless the herbicide is volatile and vapour movement can occur.

   The selectivity of a soil-acting herbicide is often regarded as due to so-called "depth-protection" of the crop. If the weeds germinate near the soil surface and the crop is deep-sown it is thought that the herbicide will reach the roots of the weeds but not those of the crop. However, if selectivity rests on this basis then it will be dependent on conditions not favouring extensive leaching. As might be expected, rainfall can have a considerable effect on leaching. Some experiments have shown that the equivalent of one inch of rainfall will not disturb the herbicide from the top one inch of soil, but 3 inches of rain caused an initial movement into the second inch of soil and appreciable amounts reached beyond this after 24 hours and further downward movement occurred thereafter. A considerable reduction in selectivity could therefore be expected under high rainfall conditions. Of course, herbicides can be formulated to reduce leaching and hence to improve their selectivity.

A common example is the use of ester formulations of 2, 4-D for pre-emergence weed control.

3. Differential translocation, absorption, detoxication, metabolism of inactive to active compounds and by selectivity in their effects on metabolic systems at the site of action can all influence herbicide selectivity. This statement disproves the popular conception that differences in absorption and translocation between susceptible and resistant plants is the complete answer to selectivity. Oxidative destruction of the carboxyl and methylene carbons from the side chain of 2, 4-D in certain tolerant plants partially explains the selectivity of 2, 4-D. Another possible explanation of selectivity is based on the specificity of enzymes. However, this all leads to the conclusion that there is much to be learnt and defined regarding the physiological selectivity of the chlorophenoxy compounds, and herbicides in general.

Damage to Herbicides and by Herbicides :

1. Soil-Microbial Balance :

Although the damage which soil micro-organisms do to herbicides is very important e. g. certain micro-organisms break down herbicides very rapidly, thus reducing their selectivity and longevity, the converse is equally important. The delicate equilibrium of the soil population may be altered in a variety of ways but fortunately, at present, most herbicides in use appear to make no permanent alteration to this equilibrium. Regarding the phenoxy herbicides, in particular, there is no evidence to show that they have any adverse effects on the total number of micro-organisms in the soil at normal practical rates of application.

2. Weather Conditions :

Hail and wind have been known to cause damage (physical) to leaves by disturbing their wax deposits thus enhancing the possibility of herbicide damage to crops. Frosts can also enhance 2, 4 -D damage to crops.

As stated earlier, heavy rains soon after herbicide application can also cause damage by altering the selectivity of the herbicide. Heavy rains can also have the opposite effect by destroying herbicidal effects in certain instances. The recent spate of instances where 2, 4-D damage to sugarcane in Natal has occurred is probably due to heavy rains altering the selectivity of the herbicide, especially as the amine formulation of 2, 4-D is now widely used in our industry. This form of 2, 4-D is more easily leached in the soil.

Post on cane

Severe evaporative conditions can also cause damage to the herbicidal action of certain chemicals.

The Choice of 2, 4-D Formulations :

In recent years the tendency in the Natal cane belt has been to select the amine formulation of 2, 4-D in preference to the ester formulations. This has been motivated by the fact that amines are slightly cheaper than esters, are non-volatile, and the belief that there is little, if any, difference in the respective efficacies of the two types of formulation.

Although the cost and non-volatility factors are undoubtedly valid, and worthy of consideration, the writer is of the opinion that the slightly greater cost of esters and their volatility is outweighed by the advantage of their superior safety margin and the wider spectrum of conditions under which they can be used. These latter factors become particularly significant when large scale commercial operations are being carried out. Volatility under such conditions does not present a serious hazard especially if the low-volatile long chain esters are used.

The fact that there are differences between the amine and ester formulations and even between different formulations of esters is borne out by the earlier statements regarding rainfall effects (Selectivity of Herbicides) and by the following quotations : -

"There was a time after the introduction of 2, 4-D when users were convinced that all formulations were alike when compared on an acid equivalent basis and that the dosage in ounces per acre was the only basis for judging performance." "However, when the low volatile ester formulations were introduced it soon became evident that certain of these were much more effective on perennial weeds than were the light alkyl esters. The reasons being that the heavier slower acting molecules of these esters enter the leaves in an ordered manner causing less contact injury. Furthermore, the formulations remain in a liquid state on the leaves and the active molecules continue to move into the plant for a much longer period. Obviously, the 2, 4-D ester molecules of these formulations are carried deeper into the roots of weeds and hence are more effective."

"2, 4-D as a pre-emergence weed killer has become widely used. However, this practice is fraught with difficulties. Because rainfall, which cannot be predicted nor controlled, is critical to the success of the treatment, with no rain the chemical will not be leached into the zone of germinating weed seeds ; with excessive flooding the chemical may be leached past the zone where weed seeds are germinating. Under such conditions, the suspended 2, 4-D acid lasts somewhat longer in the top soil and hence may prove more effective than the water-soluble salts."

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Quotations from :

"The Chemistry and mode of action of herbicides"
A. S. CRAFTS. Interscience Publishers, New York and London (1961).

G. J. F. WARDLE.

7th September, 1967.

NOODSBERG SUGAR COMPANY LIMITED

NOTES ON FROST IN SUGAR CANE

1. Background to Frost Occurrence.

1.1 Incoming radiation decreases rapidly from March to June due to shorter days and lower sun altitude.

1.2 Outgoing radiation increases due to longer nights and drier conditions.

1.3 Nett results : lower air temperature, especially at night.

1.4. Further depression of nocturnal temperatures are caused by

1.4.1 Cloudy days
1.4.2 Rain
1.4.3 Snow
1.4.4 Influx of cold dry air.

1.5. Two types of frost are known to occur in the Natal Midlands -

1.5.1 Advective frosts occur when a strong wind blows over snow covered mountains and impinges on other areas causing freezing conditions to develop in the other area.

1.5.2. Radiation frosts occur with the following sequence of events: the soil or radiative surface loses heat by back radiation. During the night this loss is not countered by incoming radiation and if this loss of heat is permitted to continue at a rapid rate, there comes a time when the air temperature falls to below freezing. Cold air is denser than warm air and thus the cold air flows down valleys and collects in topographical dams and if air at 0° C is allowed to persist in an area for long enough it will cause the water on the soil and in vegetation to freeze - and thus frost is formed.

2. Occurrence of Frost in Sugar Areas.

2.1. The South African Sugar Industry is not unique in having to manage with frosts and the following industries are cited by Barnes (1) as having a frost problem: Argentina, Louisiana, Florida, Egypt, Southern Rhodesia, Mexico, West Pakistan and New South Wales.

2.2. Lauden (2) reported temperatures of -5°C lasting for 9 hours at Houma in the heart of the sugar district of Louisiana during 1966.

2.3. M.T. Chen (3) has reported on studies at Taichung Sugarcane Improvement Station, which investigated relationships between frost resistance and morphological structures, obviously since frost is a problem in this area as well.

2.4. In the South African industry frost has been noted in certain valleys on the coast but occurs mainly in the Midlands area. Frost is by no means general in the Natal Midlands and occurs in small pockets on most farms. Very few farms are completely free from frost and by the same token very few are completely frost prone.

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3. Frost damage to Sugar Cane.

3.1. The degree of frost damage is dependent on three main factors :

3.1.1. Temperature (4)
3.1.2. Duration of low temperature (4)
3.1.3. State of vigour of cane prior to frosting.

3.2 Assessment of degree of frosting is made by observing damage to the plant and was categorised by Wilson in 1960 (5). Here the categories are briefly noted :

3.2.1. Only exposed leaves damaged
3.2.2. Spindle and exposed leaves damaged.
3.2.3. Meristematic tissue, spindle and exposed leaves damaged.
3.2.4. 3.2.3 and lateral buds on stalk damaged.

3.3. Damage has also been assessed by observing an experiment which was frosted and frosted plots were given ratings as follows :

Very light frost	(3.2.1 above)	= 0
Light frost	(3.2.2 above)	= 1
Severe frost	(3.2.3 above)	= 3

The frost damage (although not demonstrated statistically significantly) was estimated at minus 2.7 $\pm$ 1.64 tons per acre per unit increase in rating (6).

4. Management of frost damaged cane.

4.1 Management of frost damaged cane is dependent on the degree of damage and the millability of the cane, classified as follows·

4.1.1. Cane with 1-2 ft. of stalk and low sucrose.
4.1.2. Cane with 2-4 ft. of stalk and reasonable sucrose.
4.1.3. Cane with 2-4 ft. of stalk and poor sucrose.
4.1.4 Cane with plus 4 ft. of stalk and reasonable sucrose.

4.2. Action taken as follows:

4.2.1 All cane damaged to the extent 3.2.1 and 3.2.2 is treated as normal cane.
4.2.2 With 3.2.3. level of damage the following action is taken with each of the millability classes as follows:

4.1.1 - leave cane
4.1.2 - harvest for milling
4.1.3 - leave cane to side shoot
4.1.4 - harvest for milling.

4.2.3. With 3.2.4 degree of damage. As above in 4.2.2 except class 4.1.3, where economics become important.

5. Frost abatement.

5.1 Methods of combating frosts by heat, smoke screens and direct irrigation as used in other spheres of agriculture are not practical in sugar cane culture.

5.2. Practical measures of frost abatement can be listed as follows:

5.2.1. Removal of obstacles from valleys which trap and hold cold air.

5.2.2. Breedin of varieties which are either

(a) fast growing and early maturing so as to escape frosting.

or (b) frost tolerant.

5.3. Methods of reducing the damage done by frost are:

5.3.1. Selecting planting areas.
5.3.2. Good general husbandry which will lead to healthy cane which seems to induce frost tolerance.

5.3.3. The correct and timely handling of cane which is frosted according to the principals set out above.

E.L. BROWNE.
AGRONOMIST.

14th September 1967.

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SOUTH AFRICAN SUGAR INDUSTRY

AGRONOMISTS' ASSOCIATION

SOME ASPECTS OF PLANT NUTRITION

Ratoon chlorosis

To determine the effect on cane growth and ultimate yield of foliar applications of iron solutions to chlorotic cane, two experiments have recently been conducted on Cornubia section of Natal Estates.

Soil analysis pH 8.5, Ca 2-3000

In experiment I, a 6 x 6 Latin Square design, ferrous sulphate and ferric chloride were used, each at 3 lb. and 6 lb. per acre row only. Two control treatments were included in the design. The iron compounds were applied by means of a knapsack sprayer using approximately 50 gallons of water per acre. A wetter was added at 0.1%.

The treatments, applied in November, five weeks after cutting the first ratoon crop, were most dramatic in their 'greening up' effects on the foliage; ferrous sulphate appeared to be the quicker acting in this respect. Shoot counts and stalk height measurements were made during the growth of the crop and the experiment was harvested at 19 months old.

Results.

Both the sulphate and chloride proved equally effective. Three pounds per acre of chemical was shown to be as effective as six pounds per acre. The mean yield of the four iron treatments proved to be considerably greater than that of the two control treatments. The average response to iron (compared with control) is given in Table 1.

Table 1 The average response to iron

	I. Response	I. S.E.	II. Response	II. S.E.
Tons cane per acre	8.9 *	± 3.87	7.1	± 3.41
Stalk count per acre (10^{-3})	0.0	± 2.33	6.2 *	± 2.20
Stalk length (inches)	0.47 *	± 0.206	0.40	± 0.196
Stalk diameter (inches)	0.4	± 0.38	0.5	± 0.40
Stalk weight (lb.)	0.36 **	± 0.108	0.11	± 0.091
Sucrose % cane	0.31	± 0.185	0.42 *	± 0.181
Tons sucrose per acre	1.49 *	± 0.565	1.23 *	± 0.545

Yield increase is seen to be due primarily to an increase in weight of stalk as a result of longer stalks.

Experiment II, established on second ratoon cane and sprayed in November 1966, six weeks after cutting, has not yet been harvested. The object of this experiment was to determine whether split applications of an iron solution would be preferble, and whether higher rates of iron than those used in experiment I are worthwhile. The treatments used were: 6 lb. and 12 lb. applied in two spray applications at an interval of one month, a single application of 6 lb. per acre, and two unsprayed control treatments, in a 5 x 5 Latin Square design. Ferrous sulphate was used with a wetter in approximately 50 gallons of water per acre. The effects of spraying were even more dramatic than in experiment I due it is thought, to a better plant population and consequently a greater leaf area.

Shoot count and stalk height measurements have been made since the start of this experiment. The mean stalk heights just prior to harvesting experiment I, and the most recent stalk heights from the 6 lb.

Mention also the level of Fe on leaves (Alexander) sprayed & unsprayed

and 12 lb. rates in experiment II are given, together with the data from the control treatments, in Table 2.

Table 2 Response to iron in terms of mean stalk height (inches)

	Experiment I (April 1967)	Experiment II (August 1967)	
Control	71"	42"	30.2
6 lb.	never more than 8"	52"	37.0
12 lb.	-	55"	38.8
3 and 6 lb. means	78"	-	
3+3			36.4

The response to split applications of iron was no greater than the single application, and therefore these results have been meaned in table 2. In this table it can be seen that the response is slightly greater in experiment II than it was in experiment I; also, the response to the 12 lb. rate appears to be slightly larger than at the 6 lb. rate.

In both experiments the number of shoots per acre was increased by the iron sprays, but this effect on population was comparatively small and persisted for a short time only.

Finally Probable that on a field scale the response to iron would be lower, as the experimental site was comparatively severely affected.

Costs

The price per pound of the commercial grade of ferrous sulphate in quantities >100 lb. is 3.3 cents and ferric chloride 20.0 cents.

@ 6 lb. cost is only 20.0 cents + say 50.0 for tractor costs.

2

Placement of superphosphate in ratoons crops

An experiment to determine where superphosphate should be applied in the field to effect the best uptake of P by ratoon cane, has been established on a virgin Inanda soil. Pre-plant soil analysis indicated only a trace (< 1 ppm) of P present.

In the plant crop (planted January 1966) only one treatment (8 plots) received superphosphate at 1,000 lb. per acre applied in the furrow at planting. The rest of the experiment was planted with no phosphate but all plots received a top-dressing of N and K. The plant crop was cut prematurely in November 1966 at 10 months old. Cane growth in the plots which received no phosphate was poor and showed distinct symptoms of P deficiency. Third leaf analysis, at ten months old, confirmed this P deficiency: Control 0.15% P and supers in the furrow 0.20% P.

The treatments for the ratoon crop were applied in mid-December, one month after cutting, and were as follows:

a) Control, no phosphate.
b) 1,000 lb. supers (8.3% P) per acre broadcast
c) 1,000 lb. supers banded on the surface one one side of the cane row in the half-row position. half way between the row & the centre of the inter-row
d) 1,000 lb. supers placed 9" - 12" deep on one side of the cane row in the half-row position. Furrows were drawn with a single tine, & this was drawn alongside the row in all plots.
e) No further supers applied to the 1,000 lb. applied in the furrow in the plant crop., so any response could be termed a residual response

Trash versus no trash was a comparison included in the experiment and comprised the whole plot treatments, whilst methods of P application comprised the sub-plot treatments. The superphosphate in treatments B and C was applied on top of the trash, whilst in treatment D the trash was replaced after the deep placement of supers.

3.3

Within each sub-plot of treatments B, C and D (4 replications) is a micro-plot (4' x 5') where P-32 labelled superphosphate was applied in the same way and at the same rate as the ordinary commercial superphosphate was applied to the rest of the plots.

The ratoon crop will not be harvested until mid 1968 but some of the already available data are of interest.

Results

Mean stalk heights at two and eight months after the application of superphosphate to the ratoon crop are given in table 3.

Table 3 Mean stalk height of ratoon crop in inches

Treatments		Control	Broadcast	Surface banding	Deep Placement	in furrow application
2 months (February)	Bare ground	12.7	15.7	15.0	14.5	24.5
	Trash blanket	13.3	14.5	14.5	15.2	24.2
	Mean	13.0	15.1	14.8	14.8	24.3
8 months (August)	Bare ground	45.2	59.0	55.1	58.8	72.4
	Trash blanket	45.5	59.8	56.8	54.8	72.7
	Mean	45.3	59.4	56.0	56.8	72.6

Treatment effects on shoot count are still evident at the present time; in 10^{-3} per acre the mean shoot counts for treatments A, B, C, D and E are respectively 38, 49, 46, 44 and 55.

These measured growth characteristics indicate:

i) the vast superiority of supers applied in the furrow.

ii) that the three methods of phosphate application are apparently equally effective with a slight trend in favour of the broadcast method.

iii) the application of phosphate on to either bare ground or a trash blanket has had no measurable effect on cane growth.

Analyses of third leaf lamina, sampled 2½ and 3½ months after treatment applications, show the following mean phosphate content in per cent P:-

Table 4 % P in third leaf lamina at 2½ and 3½ months after superphosphate application

	Control	Broadcast	Surface banded	Deep placement	Furrow application
After 2½ m	0.14	0.20	0.19	0.18	0.20
After 3½ m	0.15	0.17	0.16	0.15	0.17

The percentage P in third leaf lamina from the broadcast and surface banded treatments are given separately for the trash and bare soil plots in Table 5.

Although data in Table 3 indicate that supers only affecting the trash or on bare soil did not affect stalk height, leaf analysis indicated an advantage from application to trash. Although this does not show up in the later analysis.

Table 5 % P in third leaf lamina from trash and bare soil plots

		Broadcast	Surface Banded
after 2½ M	Trash	0.22	0.20
	Bare soil	0.19	0.18
after 3½ M	Trash	0.17	0.16
	Bare soil	0.17	0.15

These results illustrate the severe P deficiency in the control plots. The uptake of P is slightly greater where supers was broadcast and is lowest where supers was banded at a depth of 9" - 12". Where supers was applied on top of trash the uptake of P tends to be greater than where it was applied to bare ground. Some of the results obtained from the P-32 micro-plots are given in Table 6. These data represent the fraction of P derived from the tagged superphosphate, at different time intervals after fertilizer application.

Table 6 The amount of P derived from fertilizer expressed as a percentage of the whole

		Weeks after P-32 application					
		2½	4½	7½	11	14½	18
Trash	Broadcast	1.88	14.50	32.9	43.8	36.9	33.4
	Banded	1.03	4.89	16.0	26.6	23.5	20.9
	Deep	1.38	4.22	9.5	13.4	12.6	11.7
Bare soil	Broadcast	0.52	4.70	21.9	32.5	28.9	28.4
	Banded	0.91	3.79	9.4	14.7	13.2	16.1
	Deep	1.28	4.98	10.9	15.9	14.3	14.4

It is seen that from 4½ weeks onwards a significantly (P = 0.05) greater amount of fertilizer P was taken up in the broadcast treatment than in the other treatments; and that this amount reached a peak at 11 weeks from the time of application. The uptake of P in both the surface applications (broadcast and banded) was superior in the presence of a trash blanket. However, the broadcast method of application effected a greater uptake of P than did the other methods in the presence and absence of a trash blanket. Why this result with trash? Shallow rooting roots growing into trash good rainfall.

Conclusions

It would be premature to draw conclusions from this experiment before harvesting, but there are indications that top-dressing of superphosphate on ratoons can be carried out by means of a fertilizer spinner on the top of trash or bare soil, on any soil type, without fear of decreasing uptake efficiency. This method should facilitate rapid application and good distribution. As Inanda is considered a soil with the highest capacity for fixation of P-supplies, there is good reason to believe that broadcasting could safely be carried out on any other soil type.

Time of nitrogen application to the plant crop

A number of experiments have been carried out recently to determine the optimum time of nitrogen application to the plant crop.

Experiment I, on an Inanda series soil, was planted in November 1964 and harvested at 18½ months old in June 1965. The crop received 63" of rain. 100 lb. N was applied in two ways, half in the furrow and half top-dressed, compared with all the N top-dressed. The results are given in Table 7.

Table 7 Yields of sugarcane from a split application of N compared with a single top-dressing

	T.C.A.	S.%C.	T.S.A.
Split	71.5	15.16*	10.83
Top-dressed	75.3*	14.65	11.02

The significant ($P < 0.05$) increase in Tons Cane per acre from the single application was due to a significant increase ($P < 0.05$) in stalk count, but this effect was offset by a significant ($P < 0.05$) reduction in sucrose % cane.

Experiment II was established on a Waldene series soil in September 1965. One hundred pounds of N was applied in three ways, all in the furrow at planting, all as a top-dressing 11 weeks after planting, and as a split application with half in the furrow and half top-dressed. The experiment was irrigated with 1" at an estimated soil moisture deficit of 1.5". Half the experiment was harvested in November 1966 at 13½ months old, and half was harvested in May 1967 as a 20 month old crop. The results are shown in table 8.

Table 8 Yields of cane at two ages and with three different times of N application

	T.C.A.	S.%C.	T.S.A.	
Control No N	24.9	14.50	3.60	September - November (13½ M)
In furrow	37.8	14.30	5.39	
Split	35.8	14.52	5.19	
Top dressed	37.5	14.46	5.42	
S.E. Treatment means	1.64	0.099	0.234	
Control No N	54.4	14.51	7.84	September - May (20 M)
In furrow	67.6	14.67	9.89	
Split	62.1	14.82	9.18	
Top dressed	68.4	14.34	9.76	
S.E. Treatment means	2.23	0.190	0.296	

The response to nitrogen is due to an increase in stalk length primarily and to population to a lesser extent.

The above data illustrate that there is no difference in yield of sucrose between the single application of N in the furrow or top dressed. However, there is a trend, albeit it not statistically significant, for the split applications to be slightly less efficient.

Experiment III, established in November 1965 on a virgin mistbelt dwyka soil, compares split applications of 100 lb. N with a single top-dressing. This experiment has not yet been harvested, but the crop growth measurements indicate a slight advantage from the split application of N. These data are presented in Table 9.

Table 9 The effect of times of N application on shoot counts and stalk height in inches

	Shoot Counts		Stalk height	
	January 1965	August 1967	March 1965	August 1967
Split	30,200	51,000	11.9	67.7
Top-dressed	22,900	51,300	10.5	64.2

It is seen that there is an apparent advantage from the split application of N, in that population is slightly increased in the early stages, and a small increase in stalk height is effected.

Experiment IV established on a Trevanian series soil in November 1966 also compares the split application of N with a single top-dressing 9 weeks after planting. The crop growth characteristics again indicate a small advantage from the split application of N. These data are presented in Table 10.

Table 10 The effect of times of N application on shoot counts and stalk height in inches

	Shoot counts		Stalk height	
	December 1966	August 1967	January 1966	August 1967
Split	41,600	59,000	8.3	44.5
Top-dressed	35,100	61,700	7.9	40.7

The advantage of the split application is reflected in the large population in the early stages only, and in a slight increase in stalk height.

Conclusions

Results obtained to date tend to be inconsistent. However, in regard to ultimate yield of sucrose, the time at which N is applied to plant cane would seem to be immaterial. But there are indications that enhanced growth in the early stages and consequently a quicker canopy of cane can be obtained where nitrogen is applied in the furrow. This may be of more importance on the acid soils with a high organic matter content.

If nitrogen can be applied in the furrow with satisfactory results, as the somewhat limited data does indicate, then the extra cost of top-dressing nitrogen would be avoided. A shorter time to canopy might, in addition, save an extra weeding operation.

A MEASURE OF THE RELIABILITY OF PREDICTING YIELD RESPONSES TO APPLIED FERTILIZER

The techniques of soil analysis and the method used by the Fertilizer Advisory Service for N when predicting yield responses to applied fertilizer in a number of field experiments were investigated. The Exploratory Fertilizer Trials (Ex's) or 3 x 3 x 3's and the Regional Fertilizer Trials (R.F.T.'s) or 4 x 2 x 3's were used. The levels of N, P and K in the former series were 0, 100 and 200 lb/ac of N, P_2O_5 and K_2O and in the latter series were 100, 200, 300 and 400 lb/ac N, N 100 and 200 lb/ac P_2O_5 and 0, 150 and 300 lb/ac of K_2O. Although levels were adjusted from time to time in these trials the basic procedure was adhered to. Yield responses used were those of the maximum fertilized treatments minus the minimum fertilized treatments. See table 1. In the R.F.T.'s the yield of the N1 treatments was subtracted from the N2 treatments and are presented in table 2. Plant cane crops and the mean ratoon yields are treated separately.

The value of leaf analysis is not included in the present study as the Ex trials were started before foliar diagnostic techniques were established in South Africa.

(1) Nitrogen.

(a) Plant cane

1.5 lb N/ton of cane expected except on T.M.S. (ordinary) and Dwyka soil groups but 2.6 lb N/ton on these two soils. 2.0 lb/ton of N for irrigated cane and T.M.S. (mistbelt).

(b) Ratoons

2.5 lb N/ton of cane expected - 3.0 lb N/ton for Pongola and Eastern Transvaal.

The recommendations indicate that a better response to applied N in the ratoons than in the plant crop is expected. Using the data in tables 1 and 2 the number of experiments confirming this assumption are listed in table 3. Since fertilizer treatments were changed from time to time the yield results of this table, and tables 4, 5, 6 and 7, represent the percentage increase of the maximum fertilized plots over the minimum fertilized plots. If this increase was greater than 10% when a response was predicted the result is considered correct (+), less than 10% as doubtful (+*) and if no response, or if no response was predicted but one was obtained, the prediction was incorrect(-).

Table 3

Predictions that yield response in ratoon cane is better than in plant cane.

	3 x 3 x 3	4 x 2 x 3
Grey sand		--
Red sand	+-+	+-+++
T.M.S. (mist)	+	-+-
T.M.S. (ord)	+-+	--+-+---++++-
Black dolerite	+	
Red dolerite	++	++
Granite	-+	+
Dwyka	+	+-+
Ecca shale	-+	++++-
Aluminium	+	+-
Tugela schist		++

In 65% of the experiments a better response to N was obtained in the ratoon as compared to the plant crop.

For T.M.S. (ordinary), Dwyka and T.M.S. (mistbelt) a significant response (greater than 10% over controls) in plant cane is predicted.

Table 4

Predictions that a yield response to N in the plant crop will occur

Soil group	3 x 3 x 3
T.M.S. (ordinary)	+++
T.M.S. (mistbelt)	-
Dwyka	-

For the remaining soil groups no great response to N in the plant crop is predicted.

Table 5

Predictions that no yield response in the plant crop will occur

	3 x 3 x 3	4 x 2 x 3
Grey sand		+-
Red sand	+-+	++--+
Black dolerite	+	
Red dolerite	++	++
Granite	-+	+
Ecca shale	++	++++-
Alluvium	+	--
Tugela schist		++

In 73% of cases it is true to say that no significant response to N occurs in plant crops on soils other than T.M.S. (ordinary), T.M.S. (mistbelt) and Dwyka. Although it is unfair to include the 4 x 2 x 3's in this exercise, as 100 N was the lowest level applied, it is indicated that in some cases responses to N at the 400 lb/ac level can occur in the plant crop.

Thus for N it can be said very generally that (i) a better response to N occurs in ratoons than in plant crops and (ii) that responses to N in plant crops are not significant. There is, however, little evidence for suggesting that different soils respond differently to applied N. It appears that some factor, other than soil group, dictates whether or not a response to N in the plant crop occurs. Only the red dolerite and Tugela Schist soil groups gave no responses to N in the plant crop. For other soils, including T.M.S. (ordinary), Dwyka and T.M.S. (mistbelt) some experiments indicate a response to N in the plant crop while others do not. These observations coupled with the fact that variation in yield response, not only between experiments but also between crops in the same experiment, was large indicates the unreliability of predicting responses to applied N.

(2) Phosphorus (Threshold values are 750 lb and 250 lb/ac of superphosphate for plant and ratoon crops respectively).

Since no control plots for P were included in the 4 x 2 x 3 trials only the 3 x 3 x 3's are considered in testing the reliability of soil analysis of predicting yield responses to applied P. The soil P values are compared to the percentage increase in yield.

Table 6

Predictions of yield response to applied P

Soil Group	
Red sand	++++++
T.M.S. (mistbelt)	+-
T.M.S. (ordinary)	+*+*+-+-
Black dolerite	++
Red dolerite	+++*-
Granite	+++-
Dwyka	+*+
Ecca shale	++++
Alluvium	++

Predictions of yield were correct in 72%, incorrect in 16% and doubtful in 12% of cases.

In all experiments (Ex.'s and R.F.T.'s) it was possible to distinguish the different P treatments from soil analysis. This fact, plus the observed variability of the P content of the soil at different sites indicates that it is not so much the method of extraction that accounts for the 16% incorrect predictions but rather sampling variability.

(3) Potassium (Threshold value is 500 lb/ac of muriate of potash).

Table 7

Predictions of yield response to applied K

Soil group	3 x 3 x 3	4 x 2 x 3
Grey sand		++++
Red sand	-+*+++*+	+++*+++*++++
T.M.S. (mistbelt)	+*+	++++++
T.M.S. (ordinary)	++---+	++--+++++*+*+*+*++++++++++++
Black dolerite	++	
Red dolerite	++++	++++
Granite	--++	++
Dwyka	+*+	++--++
Ecca shale	++--	-+++++----
Alluvium	++	++++
Tugela schist		+++*+

Predictions of yield were correct in 74% of cases, incorrect in 16% and doubtful in 10% of cases.

It was found in almost all experiments that unlike P, no build up of K reserves in the soil could be detected in plots receiving muriate of potash.

It is suggested that the recommendations issued by the Fertilizer Advisory Service will be wrong in approximately 30% of cases for N and 16% of cases for P and K.

Discussion.

It was stated that no change in K content of the soil could be detected after repeated K fertilization. This, coupled with the fact that P applied in the furrow at planting is intended to satisfy the plant crop and at least the first ratoon, indicates that there is little point in taking soil samples after each harvest. In Australia it is believed that errors introduced by the augar not penetrating the placed fertilizer are greater than recommending a standard top dressing for ratoons. We in South Africa could also base our P and K requirements solely on the preplant soil analysis. P can be applied as required in the furrow and nitrogen and potassium top dressings given in the plant crop and first ratoon. Depending on the P status of the soil this could be continued for subsequent ratoons or replaced by a mixture of N, P and K. This would in fact not differ appreciably from recommendations based on repeated soil sampling. Such a change over if accepted, should be conducted with the greatest tack as nothing affects the confidence of the grower more than sudden changes of policy. It should be indicated to him that greater benefit would result from taking more care over his preplant soil and subsequent leaf samples that soil samples after each ratoon.

Tissue analysis is considered to be potentially more reliable than soil analysis as a basis for making effective fertilizer recommendations. Two reasons for this are:-

(i) The coefficients of variation for different nutrients in the third leaf blade are very much less than in the soil. The results of the growth analysis experiment indicate this.

Table 8

Coefficients of variation (between 6 reps) for different nutrients in third leaf blade and soil samples

	C.V. %			
	P	K	Ca	Mg
Third leaf blade	29.5	14.4	27.1	19.2
Soil	43.7	21.8	44.1	37.7

(ii) Leaf analysis can reflect fertilizers applied to the standing crop whereas soil samples cannot. For example, exchangeable K contents from the growth analysis experiment, which received 166 lb/ac of K and showed a mean value of 51 ppm were of the same order as those from the additional block which received no K (48 ppm). The mean K contents of the third leaf blade samples, however, did distinguish between the two K treatments with values of 1.18% and 0.93% K for the main experiment and block receiving no K respectively.

It was stated in the previous paragraph that tissue analysis is a potentially more reliable index of soil fertility than soil analysis.

The word "potentially" is used because unless strict precautions are taken the conclusions drawn from tissue analysis may also be misleading. As for soil sampling, it is felt that more emphasis should be placed on quality of leaf samples rather than on quantity. It is felt that there are three main ways in which leaf samples can assist in fertilizer recommendations.

(i) To establish the fertility characteristics of the field in respect to fertilizers applied i.e. the P fixing power, is the depth of soil sufficient to warrant lower critical levels in the soil? etc.

(ii) To trace the nutrient uptake of a crop since it would appear that each crop will differ in its response to applied N. This is to use the crop log system employed in Hawaii

(iii) To compare poor areas of cane with surrounding crops.

Ideally what is required is a tissue which will indicate the nutritional status of the crop while it is still very young. To date attempts to find, or interpret the results of such a tissue have been unsuccessful. Since number (ii) above would be unpractical under our conditions number (i) is recommended. Thus the main objective of leaf samples will be to add knowledge to field records and thus make adjustments to fertilizer applications based on field history. This would mean that leaf data from past crops would assist in adjusting fertilizer applications in the new crop.

21st September, 1967.

TABLE I

YIELD INCREASES (MAXIMUM FERTILIZED PLOTS - PLOTS RECEIVING NO FERTILIZER) AND SOIL ANALYSES FROM 3x3x3 TRIALS

(results in tons cane per acre)

Soil Type	Location	Yield Responses (increase of highest fert. over controls)	N	P	K	Soil Analysis of control plots P	K
						lb/ac SP	lb/ac MN/P
Red sand	Mwawine Section	Plant	1.26	0.69	-0.41	860	307
	Tongaat Sugar Co.	Ratoons (2 crops)	8.11	0.47	1.52		
Red sand	Loring Rattray	Plant	2.08	9.17	5.04	160	253
	Mposa	Ratoons (2 crops)	2.14	11.13	12.98		
Red sand	Garland	Plant crop	1.70	1.59	3.18	280	350
	Mtunzini	Ratoons (3 crops)	10.33	-1.70	13.15		
T.M.S. (Mist.)	C.R. Butcher	Plant	4.42	7.29	0.64	353	110
	Eshowe	Ratoons (3 crops)	13.53	1.99	10.48		
T.M.S. (Ord.)	J.L. Hulett & Sons	Plant	7.17	1.62	5.25	160	580
		Ratoons (2 crops)	4.82	2.46	3.94		
T.M.S. (Ord.)	Tongaat Sugar Co.	Plant (2 crops Replant)	11.91	2.11	-3.46	360	163
	Sputu Section	Ratoons (1 crop)	10.73	7.69	-0.02		
T.M.S. (Ord.)	Solferino Section	Plant	10.18	10.10	-2.08	370	329
	Reynolds Bros.	Ratoons (3 crops)	11.93	7.83	3.54		
T.M.S. (Ord.)	Tongaat	Plant	2.92	5.57	3.42	200	433
	Frosterley Sect.	Ratoons					
Red Dolerite	Hulett, G. Esq.	Plant	2.46	12.89	3.99	110	1153
	Compensation	Ratoons (3 crops)	12.49	14.66	5.38		
Red Dolerite	Ukulu Prop.	Plant	1.29	3.59	2.27	40	2197
	Empangeni	Ratoon	4.89	-1.35	-5.07		
Black Dolerite	Ukulu Prop.	Plant	-1.18	11.19	5.43	110	830
		Ratoons (3 crops)	-2.13	6.29	4.16		
Granite	G.N. Waller	Plant	4.18	11.92	8.26	140	673
	Umzinto	Ratoons (1 crop)	1.41	6.90	5.12		
Granite	T.D. Archibald	Plant	1.34	6.37	10.93		
	Umzinto	Ratoons (3 crops)	6.34	5.32	13.21	350	417
Dwyka	Expt. Farm	Plant (Replant)	-4.88	1.35	1.10	400	283
	Chaka's Kraal	Ratoons (3 crops)	13.60	0.22	7.32		
Ecca Shale	Illovo Sugar Co.	Plant	.81	-1.15	0.35	960	1277
	Nkwali Section	Ratoons (2 crops)	-1.39	-4.01	0.06		
Ecca Shale	Rowe Turner	Plant	-0.79	-4.35	3.00	1740	1520
	Mandeni	Ratoons (2 crops)	-1.30	-1.09	6.64		
Alluvium	ULOA Agric Co-op (Ltd.)	Plant	-3.02	-3.45	-1.79	970	1627
		Ratoons (3 crops)	-3.47	1.26	1.49		

Table 2

Yield increases (maximum fertilizer plots - minimum fertilizer plots for P and K but 200 lb - 100 lb/ac N) and soil analysis from 4 x 2 x 3 trials (results in tons cane per acre)

SOIL TYPE	LOCATION	YIELD RESPONSES (increase of highest fert. over lowest fert.)	N	P	K	SOIL ANALYSIS of CONTROL PLOTS P	K
						lb/ac of SP & MP	
Grey sand	W.R.B. Davidson	Plant	0.32	2.1	8.0	250	120
	Mposa	Ratoons (mean of 1 crop)	2.40	5.4	15.9		
Grey sand	R.J. Willis	Plant	-2.89	1.90		780	197
	Mtunzini	Rat. (mean of 1 crop)	-4.79	5.48	13.38		
Red sand	M/Doneni Estates	Plant	6.06	7.99	4.21	550	183
	Umhlali	Ratoons					
Red sand	W.J. Ladlau, Esq.	Plant	9.22	4.14	13.52	530	247
	"Beverley Hills" Umhlali	Ratoons (1 crop)	5.69	3.64	12.58		
Red sand	Cornubia, Natal Estates	Plant	2.96	3.74	1.39	2310	323
		Ratoons (1 crop)	15.65	8.16	12.29		
Red sand	E.A. Talmage	Plant	6.40	5.60	5.20	400	257
	Gingindhlovu	Ratoons					
Red sand	F.T. Poynton	Plant	19.14	4.58	5.14	320	163
	Empangeni	Ratoons (1 crop)	27.25	2.77	3.35		
Red sand	Ellingham Estate	Plant	13.90	2.61	8.47	510	253
	Park Rynie	Ratoons (1 crop)	12.11	2.13	7.88		
Red sand	G.F. Balcomb	Plant	-0.39	1.08	3.37	440	240
	Mtunzini	Ratoons (1 crop)	12.57	9.59	13.57		
T.M.S. (mist)	R.J. Mansfield-Sanger	Plant	2.69	1.25	10.06	510	367
		Ratoons (2 crops)	2.25	4.55	19.33		
T.M.S. (mist)	Maurel Investments	Plant	1.66	3.16	7.92	210	443
	Chaka's Kraal	Ratoons (1 crop)	1.44	10.14	13.71		
T.M.S. (mist)	A.C. Toble, "Mvuma"	Plant	6.27	3.09	14.98	220	407
	Upper Tongaat	Ratoons (1 crop)	1.28	1.10	19.43		
T.M.S. (ord.)	W. Meyer, Esq.	Plant	-1.30	-3.30	4.90	670	1247
	Wartburg	Ratoons (2 crops)	2.14	2.38	2.17		
T.M.S. (ord.)	K. Eggers	Plant	-1.8	-1.6	-0.3	No soil analys	
	Dalton	Ratoons (2 crops)	-2.05	0.6	1.51		
T.M.S. (ord.)	Illovo Sugar Estates	Plant	2.63	3.36	12.44	520	573
	Stony Hill section	Ratoons (1 crop)	1.84	1.78	22.53		
T.M.S. (ord.)	R.B. Archibald	Plant	3.6	12.4	27.3	280	343
	Umzinto	Ratoons (2 crops)	7.3	6.0	12.9		
T.M.S. (ord.)	M.E. Addison	Plant	0.39	0.94	6.76	530	483
	Eshowe	Ratoons (1 crop)	-0.24	3.53	12.43		
T.M.S.(ord.)	W.H. Hulett	Plant	3.24	-0.30	6.22	410	327
	Compensation	Ratoons (2 crops)	-0.45	3.43	5.24		
T.M.S. (ord.)	Stone Lodge Estate	Plant	5.98	5.45	3.56	230	320
	Compensation	Ratoons (1 crop)	6.10	4.69	3.49		
T.M.S. (ord.)	K. Eggers	Plant	-0.81	0.49	2.87	1270	1803
	Dalton	Ratoons (2 crops)	2.56	1.66	0.22		
T.M.S. (oed.)	H. Balcomb	Plant	0.54	0.07	10.19	1220	230
	Kearsney	Ratoons (2 crops)	2.69	0.36	17.12		
T.M.S. (ord.)	E.L. Stainbank	Plant	5.28	2.26	6.36	540	367
	Eston	Ratoons (1 crops)	4.45	6.00	9.25		
T.M.S. (ord.)	B.E. Johnson	Plant	-5.30	-0.45	4.22	890	403
	Eshowe	Ratoons (1 crop)	-2.04	0.52	13.59		
T.M.S. (ord.)	O. Livingstone	Plant	0.29	1.57	4.69	220	223
	Ntumeni	Ratoons (1 crop)	6.75	0.80	13.72		
T.M.S. (ord.)	O. Borchers	Plant	2.20	4.4	5.3	190	360
	Port Shepstone	Ratoons (1 crop)	1.32	11.09	16.28		
Red dolerite	Ukulu Properties	Plant	2.99	-6.71	4.42	640	1613
	Empangeni	Ratoons (1 crop)	-1.62	3.35	0		
Red dolerite	P.L.V. Coetzee	Plant	0.52	-0.42	1.47	260	1970
	Pongola	Ratoons (1 crop)	15.42	8.96	1.90		

SOIL TYPE	LOCATION	YIELD RESPONSES (increase of highest fert. over lowest fert.)	N	P	K	SOIL ANALYSIS of CONTROL PLOTS P	K
						lb/ac of SP & MP	
Granite	V.S. Henderson	Plant	-5.57	6.24	2.89	760	720
	Umzinto	Ratoons					
Granite	B.T. Wilson	Plant	5.5	4.3	10.0	310	270
	Glen Echo	Ratoons (2 crops)	9.81	1.72	10.67		
Dwyka	K. Hamlyn Esq.	Plant	8.79	-0.33	-2.44	130	503
	Darnall	Ratoons (2 crops)	12.94	0.88	0.42		
Dwyka	D.L. Hulett	Plant	5.03	0.09	8.29	300	287
	Compensation	Ratoons					
Dwyka	Melville Sugar Company	Plant	0.39	-1.10	4.72	110	627
	Darnall	Ratoons (2 crops)	2.31	-4.0	4.06		
Dwyka	Reynolds Bros.	Plant	3.80	2.80	5.00	320	353
	Glebe Estate	Ratoons (1 crop)	9.30	10.60	7.40		
Dwyka	G. de Pern,	Plant	3.99	-1.05	3.99	270	207
	Inyoni	Ratoons					
Ecca shale	N. Carr	Plant	4.51	3.01	1.69	350	443
	Darnall	Ratoons (1 crop)	6.65	2.27	7.40		
Ecca shale	G.G. Blackbeard	Plant	6.11	-1.39	-4.25	350	793
	Verulam	Ratoons (1 crop)	4.38	-2.11	0.91		
Ecca shale	D. Nightingale	Plant	-0.23	-2.13	6.13	260	273
	Gingindhlovu	Ratoons (1 crop)	5.09	4.88	9.01		
Ecca shale	G.H. Askew	Plant	1.67	4.43	16.38	1730	543
	Umhlali	Ratoons (1 crop)	6.16	1.89	11.18		
Ecca shale	C.L.C. Reynolds,	Plant	2.05	0.84	2.16	350	430
	Chaka's Kraal	Ratoons (2 crops)	6.19	2.46	3.25		
Ecca shale	A. van der Vyver,	Plant	0.6	-0.7	-0.5	220	373
	Gingindhlovu	Ratoons					
Ecca shale	H.O. Johnson	Plant	0.67	4.16	1.26	180	423
	Amatikulu	Ratoons					
Ecca shale	Umzimkulu Sugar Company	Plant	5.17	14.64	7.93	370	453
		Ratoons					
Alluvial	Longacres Estate	Plant	1.83	0.99	2.01	250	797
	Nkwaleni	Ratoons (1 crop)	18.51	6.57	1.45		
Alluvial	Lea Estate	Plant	21.91	8.82	-1.16	2380	733
Alluvial	Handley Wiseman	Plant	16.0	3.0	5.5	2520	733
	Umfolosi	Ratoons (2 crops)	5.2	2.2	1.4		
Tugela schist	Wilton Park Estate	Plant	0.41	0.93	0.88	570	633
	Empangeni	Ratoons (1 crop)	0.33	3.31	-3.66		
Tugela schist	E.S. Mann	Plant	-1.67	0.05	3.84	250	443
	Empangeni	Ratoons (1 crop)	-2.60	3.00	4.50		
Tugela schist	A.H. Lintvelt	Plant	3.44	2.16	0.75	130	380
	Mposa						

SOUTH AFRICAN SUGAR INDUSTRY AGRONOMISTS ASSOCIATION.

FERTILIZER ADVISORY METHODS

F O R

DRY LAND SUGAR CANE.

M.J. STEWART - HULETT'S.

INTRODUCTION:

The economy of dry land cane production is closely associated with seasonal rainfall, temperature and soils, and within these natural limitations any field operation which is neglected or carried to extreme will affect profit margins.

Although this exercise is concerned with fertilizer use, an appreciation of environment and cultural standards is a pre-requisite to the evaluation of fertilizer requirements.

Chemical analysis of the soil and plant material are the primary yardsticks of fertilizer recommendations. However, analysis should not be regarded as a scientific sausage machine, constantly producing the correct answer, for although laboratory methods may be precise, interpretation is subject to limitations and errors occur in sampling and fertilizer application.

This paper presents a case for rationalising advisory methods and fertilizer application in order to achieve an optimum level of accuracy for each stage of the procedure.

SOIL ANALYSIS:

1. Soil Sampling is one of the main sources of error. Within the sugar belt there are a number of soil series, most of which have been cropped for many years. The fertility status of these soils can vary widely due to inherent properties and past fertilizer practice. These variations can be identified, to a certain extent, by sampling in units which account for soil series and the fertility gradient of hillsides. Nevertheless, an appreciable sampling error is likely to occur no matter what reasonable precautions one may take.

2. Chemical Analysis is the most accurate and reproducible step in the procedure. Many methods of extraction are being used in different laboratories throughout the World, but it is not within the scope of this paper to discuss their merits; of importance is their correlation with fertilizer response in controlled trials for different soil types.

   Within the Sugar Belt we are familiar with two routine methods. One is the official F.A.S. method which is relatively time consuming but precise and suited to a well equipped central laboratory. The other is known as Dr. Beater's rapid method suited to a small laboratory, and less skilled technicians. These methods of analysis indicate the relative availability of P; K; Ca and Mg, while N requirements are related to expected yeild.

   Both methods have been correlated with field trials and Dr. Beater has found his method sufficiently reliable for advisory work. In fact time and effort can be wasted in persuing precise and accurate methods when sampling, interpretation and fertilizer application are subject to inevitable errors and limitations.

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Soil acidity tests provide a valuable insight into the general health of the soil, whereas the difference between water and Kcl extraction for p.H. determinations are said to indicate the potential exchange capacity of the soil.

The cation exchange capacity of the soil can be analysed more precisely by ammonium acetate extraction. For those capable of interpreting results, it provides a valuable indication of potential fertility and balance between base elements.

INTERPRETATION:

This phase of advisory work requires a degree of skill and experience in order to provide sound interpretation.

The varying fertility status and yield potential of coastal soils, coupled with our unreliable rainfall, aggravates the task of correlating responses in the field trials with soil analysis. Furthermore, soil sampling errors will also restrict the accuracy of interpretation in routine analysis.

If, however, a soil analysis history is built up for each field over a period of years, a certain trend is likely to develop which will reveal the main nutrient requirements. In this way miscalculation from attempting to prescribe precise treatments for each and every situation can be avoided. Field histories should also include concise reference to:-

1. Soil series, whereas the influence of topography and any special feature will be assessed by personal inspection;

2. Pertinent information on past cultural practices and fertilizer application;

3. Variety planted, yields, and rainfall received by each crop cycle;

4. Reference to any major limiting factor such as disease or frost damage.

This additional information reveals limitations that could influence fertilizer recommendations. Consequently a process of balanced judgement is allowed to evolve which ensures the maintainence of an adequate plant food supply, with due consideration being given to the high nitrogen and potash requirements of sugar cane, and the current economics of crop production.

LEAF ANALYSIS:

The chemical analysis of plant tissue and its interpretation for fertilizer recommendations is the ultimate objective in nutritional studies.

Of the various plant tissues which may be analysed, the third leaf lamina is selected for advisory prupospd in Natal. However, factors affecting the moisture status and physiological age of the plant influence nutrient levels, therefore apparent leaf deficiencies do not automatically signify a faulty fertilizer policy.

Recommendations specify that reliable results can only be obtained from an actively growing crop which requires an arbitrary judgement of "active growth" for each case in question.

Any large scale leaf sampling campaign implies that a team of trained personnel can be made available at short notice, and that fields for sampling are at an acceptable stage of growth and not being influenced by recent fertilizer dressings.

A valuable application of leaf analysis can be made to diagnose problem fields suffering from growth failure. All factors which could possibly inhabit cane growth are investigated by a process of elimination, while an analysis of carefully selected leaf samples may reveal certain deficiencies that could provide a vital link in the investigation.

HANDLING AND APPLICATION OF FERTILIZER:

An advisory procedure should take into consideration the practical difficulties of handling and fertilizer application.

Manual methods of mixing straights in accordance with recommendations for each field are subject to considerable error, depending on the degree of supervision and technique employed. The same criticism will apply to field application where errors in quantity and distribution are difficult to control. Close supervision and simple methods of measurement help to improve the accuracy of manual application, nevertheless, varying rates and textures of fertilizer for different fields make inevitable demands on human judgement.

Mechanical application can offer improvements, but adjustments to rates are usually coarse and must be checked regularly. Quantity and distribution errors from mechanical application are mainly caused by the varying textures of ungranulated mixtures, fine powders and hydroscopic materials.

It would seem pointless to increase the accuracy of sampling, analysis and interpretation if mixing and application errors remain the weakest link in the procedure under discussion.

A RATIONAL APPROACH:

More efficient handling could be achieved by standardising fertilizer mixture ratios. This would necessitate a change in approach to fertilizer procedure whereby a programme is designed for the entire crop cycle. A standard mixture is prescribed for each crop, while deficiencies are supplemented at planting and halfway through the crop cycle.

The more obvious advantages to be obtained from this approach can be summed up as follows:

1. The choice of a factory mix would reduce the errors of Farm mixing and also lessen spillage and transport difficulties experienced with open bags.

2. This approach does not compromise scientific principles, but offers an opportunity to increase the efficiency of fertilizer procedure.

3. Less than half the number of fields harvested each year are sampled, consequently greater care can be taken to reduce sampling error.

4. In the case of manual application, the use of standard mixtures will lead to a more accurate distribution in the field.

5. Free flowing granular mixtures are preferred for mechanical application and so, with any increase in mechanisation, the introduction of "bulk handling" granular fertilizer could offer distinct advantages in labour economy, transport and field control.

Some disadvantages may discourage a ready acceptance of such a scheme, namely:-

1. The charges made by manufacturers for mixing fertilizers are generally much higher than farm costs for the same operation. Granulation will also increase the unit cost of plant food, however, this could be offset partly by economies in "bulk handling".

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2. A fertilizer programme for the crop cycle is designed to cover a period of seven to eight years. Such a long term programme presupposes continuity in supply of a particular mixture and its price stability.

3. The addition of deficient plant foods at planting and halfway through the crop cycle could leat to luxury consumption of potash. Nitrogen requirements would, of course, be supplied as required to each crop with the mixture.

4. Initial Capital outlay on fertilizer would be higher to supply deficient plant foods in advance.

AGRONOMY DEPARTMENT.
DARNALL.
20.9.1967.
MJS/RLS.

THE TONGAAT SUGAR COMPANY, LIMITED

DETAILS OF FERTILIZER ADVISORY SYSTEM FOR COMPANY CANE FIELDS

Shortly after a field has been harvested a trained gang collects soil samples from approximately 10 acre blocks throughout the field. These soil samples are taken over the cane row and approximately 40 cores represent a single sample. These cores are collected together in the soil sample bag, which is then labelled with the details of the block number and field number and is then sent down to the Agronomy Laboratory of The Tongaat Sugar Company. The samples are then dried, crushed to pass a 2 m.m. sieve, and then sub-sampled after thorough mixing for purposes of analysis. The remainder of the sample is then re-bagged, re-labelled, and sent to the Fertilizer Advisory Service at the Experiment Station at Mount Edgecombe, for thorough analysis. The sub-sample collected at the local laboratory is then analysed by Beater's method for available phosphorus and available potassium in parts per million. This information is printed on sheet (A) together with other information pertaining to the previous yields of the field, previous soil analyses, and previous leaf analysis of the cane in the preceding crop. In due course, the Section Manager in charge of a particular section sends in a slip (B) requesting fertilizer recommendations for various fields, and on this slip the Section Manager indicates the variety and the yield in tons cane per acre which has been obtained from the particular field. This information is also entered by the clerk at the Agronomy Department on to the form on which the soil analysis etc. is shown. This form is then sent to the Assistant Field Manager, Dr. Hill, who makes out the fertilizer recommendation (C) for the particular block, using his knowledge of the field in question, together with a set of standards, which are set out below:-

YIELD, TCA	Recommended 1.0.1(47) lb/a	Recommended Double Saaifos (24) lb/a	
		Soil Level	L=Low S=Satisfactory
<35	400	L	100
		S	NIL
35 - 45	500	L	100
		S	50
45 - 60	600	L	200
		S	100
>60	700	L	200
		S	100

It is the policy of The Tongaat Sugar Company to base fertilizer levels on yield performance of the previous crop. In other words, fields that yield highly are given heavier fertilizer dressings for the ensuing crop than would fields that give low yields.

The dressing of Double Saaifos is recommended using a combination of soil analysis and yield performance. It is the policy of the Company to apply total dressings in one application and fertilizer applications to ratoon fields commence from the 1st August or as soon after harvesting as is possible. The top dressings of plant cane, planted during the spring, is carried out within two months of the planting date, whereas the top dressing of March planted cane is held over until the 1st of August, the same year. There has been an

2/.....

attempt to standardise on a single level of fertilizer for the majority of fields so that hand labour, which is used at present to distribute fertilizer, can become accustomed to a certain application rate and thereby achieve uniform distribution by continued practise. During the present season it has been estimated that 79% of the area harvested will receive 500 lb. 1.O.1(47) and 100 lb. Double Saaifos(24) per acre.

To follow up the effects of recommended fertilizer levels on cane growth, fields are leaf sampled when the cane is between the age of three and nine months, only when conditions satisfy active growth of the cane.

Third leaf samples are collected, are oven-dried and are analysed for N.P.K. Whilst no attempt is made to rectify the nutritional status of fields following the results of this foliar analysis, nevertheless, this information is studied and these fields which show nutrient deficiencies are earmarked for the following season as fields on which the crop was not satisfied with a particular level of fertilizer recommended. This is then borne in mind for the following crop and the fertilizer recommendation for this field can be adjusted.

Finally, when the analysis sheet from the Fertilizer Advisory Service is obtained, the analysis as conducted by the technicians at Mount Edgecombe is compared with the local analysis, and in the event of any discrepancies the sample is re-analysed locally. The results of the analysis is then entered into the field history sheet for record purposes.

J.N.S. HILL

Maidstone
11.9.67
JNSH/PLC

(A)

THE TONGAAT SUGAR COMPANY, LIMITED

SOIL SAMPLES

Samples taken .... Results received ....

Section: .... Field: ....

Soils: ....

Area: .... Varieties: ....

Ratoon: ....

PREVIOUS YIELDS:

Year							
Field							
Sucrose							
T.S.P.A./M							
Rainfall							
Irrigation							

PREVIOUS SOIL ANALYSIS

Year	N p.p.m.	P p.p.m.	K p.p.m.	OM%	pH	Ca p.p.m.	Mg p.p.m.

PREVIOUS LEAF ANALYSIS

Year	Age	N%	P_2O_5%	K_2O%

NEW SOIL ANALYSIS

Date	N%	P p.p.m.	K p.p.m.	OM%	pH	Ca p.p.m.	Mg p.p.m.

Special Areas ....

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SOUTH AFRICAN SUGAR ASSOCIATION

CHEMICAL SERVICES LABORATORY

GUIDE TO ADVISORY OFFICER

The following are the standard systems of fertilizer recommendations based on analytical data, to be used for estimating amounts and indicating types of fertilizers to be used.

1. NITROGEN

(a) Plant Cane - 1.5 lb. N per ton of cane expected on all soils except T.M.S. ordinary and Dwyka, but 2.5 lb. per ton expected on these two soils. 2.0 lb. per ton for irrigated and T.M.S. mist belt.

(b) Ratoons - 2.5 lb. per ton of cane expected - 3.0 lb. per ton for Pongola.

NOTE: Recommendations for ratoon cane should never be less than 60 lb. N per acre.

2. PHOSPHATE

(a) Plant Cane

Soil Level		Add lb. S/P (to make up to 1000 lb.)
p.p.m. P	LB. S/P per acre	
34	750	Nil
27	600	300
23	500	400
18	400	500
14	300	600
9	200	700
4.5	100	800

(a) Ratoon

Soil Level		Add lb. S/P (to make up to 400 lb.)
p.p.m. P	lb. S/P per acre	
11	250	Nil
9	200.	200
7	150	250
4.5	100	300

3. POTASH

Plant cane and ratoons

Soil level		Add lb. M.P.
p.p.m. K	lb. M.P. per acre	(to make up to 600 lb.)
125	500	Nil
100	400	200
75	300	300
50	200	400
25	100	500

Note: Make up to 700 lb. where K responses are known to be outstanding. Never add more than 300 lb. M.P. per acre at one time to a sandy soil (clay less than 10 %). Call for a leaf sample at a suitable later stage, and add further potash if the leaf K level during November - April is less than 1.10 % K.

4. CALCIUM

Agricultural limestone should be recommended before planting only when the soil pH is below 4.8, or when the calcium level is below 150 p.p.m. Ca. and at a rate of 1 to 2 tons per acre.

5. MAGNESIUM

Dolomitic limestone should be recommended before planting only when the magnesium level is below 25 p.p.m. Mg., and at the rate of 1 to 2 tons per acre. If there is a magnesium deficiency after the crop has been planted, the recommendation should be for 300 lb. Magnesium Sulphate/acre.

3RD LEAVES (Sampled correctly)

% N	Apply lb./N/acre	% P	Apply lb./Supers/acre
>1.80	Nil	0.20	Nil
1.60 - 1.80	At discretion	0.17 - 0.19	200
1.40 - 1.60	(50 for plant (60 for ratoon	<0.17	300
<1.40	(60 for plant (80 for ratoon		

% K	Apply lb./Muriate/acre
>1.10	Nil
0.95 - 1.10	200
0.80 - 0.95	300
<0.80	400

Critical Values for:

Ca	±	0.12 %
Mg	±	0.08 %
Zn		15 p.p.m.
Mn		15 p.p.m.
Cu		3 p.p.m.

POUNDS OF FERTILIZER TO BE APPLIED TO ROWS 25, 50 AND 100 YARDS LONG WHEN APPLIED AT RATES VARYING FROM 100 - 1,200 LBS PER ACRE

ROWS 4' 0" APART

LBS. FERTILIZER PER ACRE	100	200	300	400	500	600	700	800	900	1000	1100	1200
YARDS OF ROW												
25	0.69	1.38	2.07	2.76	3.45	4.14	4.83	5.52	6.21	6.90	7.59	8.28
50	1.38	2.76	4.14	5.52	6.90	8.28	9.66	11.04	12.42	13.80	15.18	16.56
100	2.76	5.52	8.28	11.04	13.80	16.56	19.32	22.08	24.84	27.60	30.36	33.12

ROWS 4' 6" APART

25	0.78	1.55	2.33	3.10	3.88	4.65	5.43	6.20	6.98	7.75	8.53	9.30
50	1.55	3.10	4.65	6.20	7.75	9.30	10.85	12.40	13.95	15.50	17.05	18.60
100	3.10	6.20	9.30	12.40	15.50	18.60	21.70	24.80	27.90	31.00	34.10	37.20

ROWS 5' 0" APART

25	0.86	1.72	2.58	3.44	4.30	5.16	6.02	6.88	7.44	8.60	9.96	10.32
50	1.72	3.44	5.16	6.88	8.60	10.32	12.04	13.76	15.48	17.20	18.92	20.64
100	3.44	6.88	10.32	13.76	17.20	20.64	24.08	27.52	30.96	34.40	37.84	41.28

(B)

THE TONGAAT SUGAR COMPANY, LIMITED

For Fetiliser Recommendations :

FIELD	BLOCK	YIELD				
		NCo 376	NCo 339	NCo 310	NCo 382	N50/211

(C)

THE TONGAAT SUGAR COMPANY, LIMITED

FERTILIZER RECOMMENDATION

Section: .... Date: ....

Field: .... Area: ....

Soils: ....

Ratoons: .... Variety Performance:

....

....

....

....

....

FERTILIZER RECOMMENDATION:

Block	1.0.1 (47)	Double Saaifos
	Total dressing:	Total dressing:

Remarks: ....

....

Signed: ....