

TESTING BAND FERTILIZER DISTRIBUTORS

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Abstract

Tests have been carried out on a range of commercial fertilizer distributors, to determine their relative suitability for use in sugarcane agriculture.

The tests were designed to determine the effect on output rates, of variations in operational speed, machine vibration, ground slope and fertilizer level in the hopper. The distribution of fertilizers along the line of application, and the effect on delivery of a sharp bump, were also studied.

Interesting points brought to light include: the variation in output resulting from changes in ground speed; increased fertilizer output due to vibration; the influence of hopper outlet location on the rate of application when a machine was worked on a range of slopes; the need for field calibration; and the different patterns provided by different machines when fertilizer was applied along a row. These points should be borne in mind by any grower considering the purchase of a fertilizer distributor, especially if the condition of his land is likely to affect the performance of the machine.

Introduction

There are only two fertilizer distributors on the South African market which have been designed specifically to apply banded fertilizer to sugarcane. These machines have achieved a limited degree of success under a range of conditions, but some growers have claimed that they are not suitable for their specific circumstances. However, in addition to these two machines, there are a number of other well proven band distributors which are used successfully to apply fertilizer to other crops. These can quite easily be adapted for use with sugarcane.

It was decided therefore that fairly exhaustive tests should be carried out on a wide range of fertilizer distributors, so that the Experiment Station could advise on the machine which would be most suitable for a given situation.

Objective

(a) To examine as many proprietary models of band fertilizer distributors as possible, and to select for testing those which appear to be most suitable for use in sugarcane agriculture.

(b) To establish in tests the efficiency of the machines as decided by: consistency of application, range of application rate, and performance under different conditions.

(c) To analyse the results of tests and, where necessary, draw up recommendations for mechanical improvements.

Materials and methods

Workshop Tests

A toolbar was designed and built to accommodate the fertilizer distributors so that they could be operated in a workshop at a range of speeds, simulated ground slopes, machine vibrations and hopper contents. Special trays and chutes were made to assist with sampling.

A 3 h.p. electric motor was used to provide the necessary drive, and variations in operational speed were obtained by employing a series of interchangeable sprockets and chains.

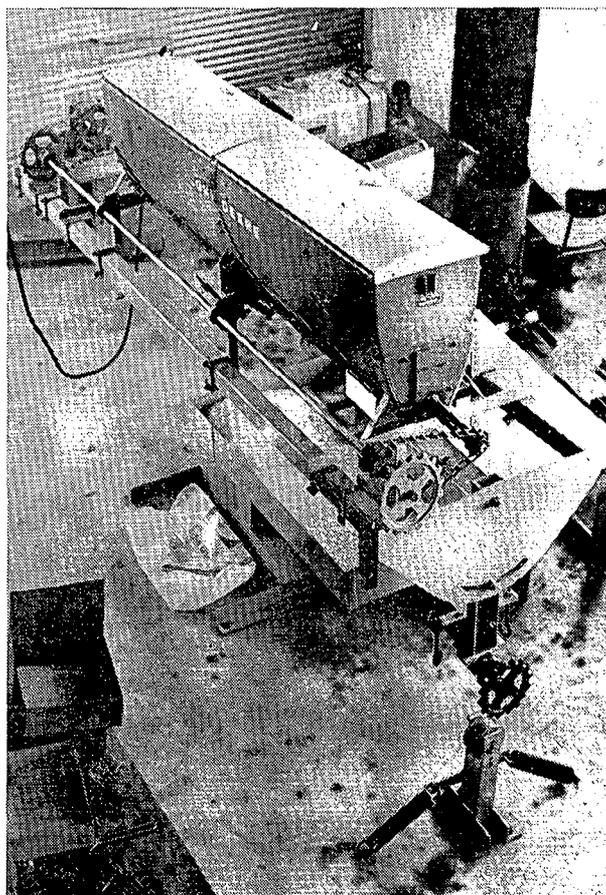


FIGURE 1: The toolbar used in the tests showing the drive shaft and vibration mechanism.

Several fertilizer distributors were tested. Results from five of these are described here. These five, representing five different operational principles, are listed and classified as follows:

- Distributor type S Horizontal multi-toothed wheel
- type T Auger displacement
- type U 2 way auger feed
- type V Reciprocating tray with vane displacement
- type W Horizontal rotating four point star wheel.

Three types of fertilizer were used in the tests. These are:

- (i) 4:1:6 (31)—granular,
- (ii) Sulphate of ammonia (21% N)—crystalline,
- (iii) 1:0:1 (47)—prilled.

They were selected as they are in widespread use by cane growers, and because of their different handling properties, the differences in particle size and shape, and their potentially different reactions under conditions of high humidity.

During the tests, air temperature and humidity were noted and records kept of the qualities of the fertilizers used. These qualities are defined as:

- (i) bulk density,
- (ii) mean weight diameter (MWD)*, and
- (iii) moisture content.

The toolbar tests were carried out at three rates of fertilizer application, namely, 100, 600 and 1,200 lb. per acre. The distributors were calibrated separately for each fertilizer at each rate of application. Calibration was carried out by one or other of the following procedures:

- (a) inter-changing gears on the machine;
- (b) by a slide mechanism, which varies the size of the outlet;
- (c) by varying the length of stroke applied to the feed mechanism.

Field Tests

Each of the distributors in turn was attached to a tractor and calibrated so that each fertilizer was delivered at a rate of 600 lb. per acre. The calibration was carried out on a concrete floor in order to eliminate the variation which can occur in the field.

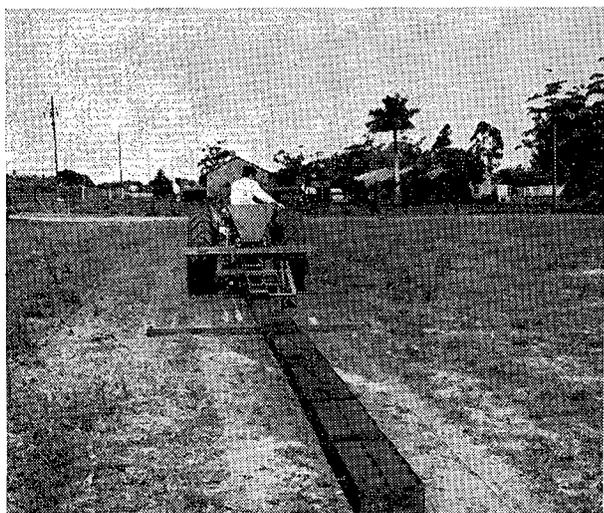


FIGURE 2: A tractor-mounted fertilizer distributor being operated over the longitudinal and bump test run. Note the bump situated approximately half-way along the length of the trough.

*MWD is equal to the sum of products of the mean diameter of each size fraction and the proportion of the total sample weight occurring in the corresponding size fraction.

The field test was designed to detect the consistency of application along a row. This was measured by operating the distributor over a 30 ft length of trough. The trough, which was 1 ft wide, was divided longitudinally into 6 inch divisions so that the amount of fertilizer discharged could be measured every 6 inches of machine travel. Just over half-way along the line of travel represented by the trough, a bump, 2½ inches high and 6 inches long was set up in the path of the tractor wheels.

Experiments and results

Machine shop tests

Toolbar tests were carried out in the sequence shown in Table 1.

TABLE I
Toolbar tests—Plan of the test sequence

Type of test	Description of test (Distributor calibrated at 4 mph)	Number of samples	Time for each sample
A	Run machine at 4 mph	3	15 sec.
B	Run machine at 2 mph . . . .	..	..
C	Run machine at 6 mph . . . .	..	..
D	Vibration test . . . . .	..	..
E	Control run . . . . .	..	..
F	Run machine with hopper full	..	..
G	Run machine with hopper ¾ full	..	..
H	Control run . . . . .	..	..
I	Tilt machine right . . . . .	..	..
J	Tilt machine left . . . . .	..	..
K	Tilt machine uphill . . . . .	..	..
L	Tilt machine downhill . . . . .	..	..
M	Control run . . . . .	..	..
N	Run machine with hopper ¼ full	..	..

Test A—Control

The fertilizer distributor operating at 4 mph was first calibrated to apply a specific fertilizer at a given rate. Once this had been done, three samples were taken to provide a MEAN rate which could be used as a standard for comparison with results from tests B to N. This control sampling is referred to as Test A.

Test B—Ground speed 2 mph

This test was designed to determine whether delivery remained proportional when the machine's forward speed was reduced by half. Very few non-positive displacement feed machines in fact achieved this, most of them delivering more than the amount required by a considerable margin, as illustrated for one machine in Fig. 3. This finding seems to indicate that slowing operating speeds to less than the calibration speed may result in a drastic increase in output.

Test C—Ground speed 6 mph

This test was designed to determine the effect of operating the distributor at greater than calibrated speed, and as in Test B it was again found that output was not proportional to speed. This too is illustrated in Fig. 3, where it can be seen that the output of the same machine falls short of the required amount by about 23%.

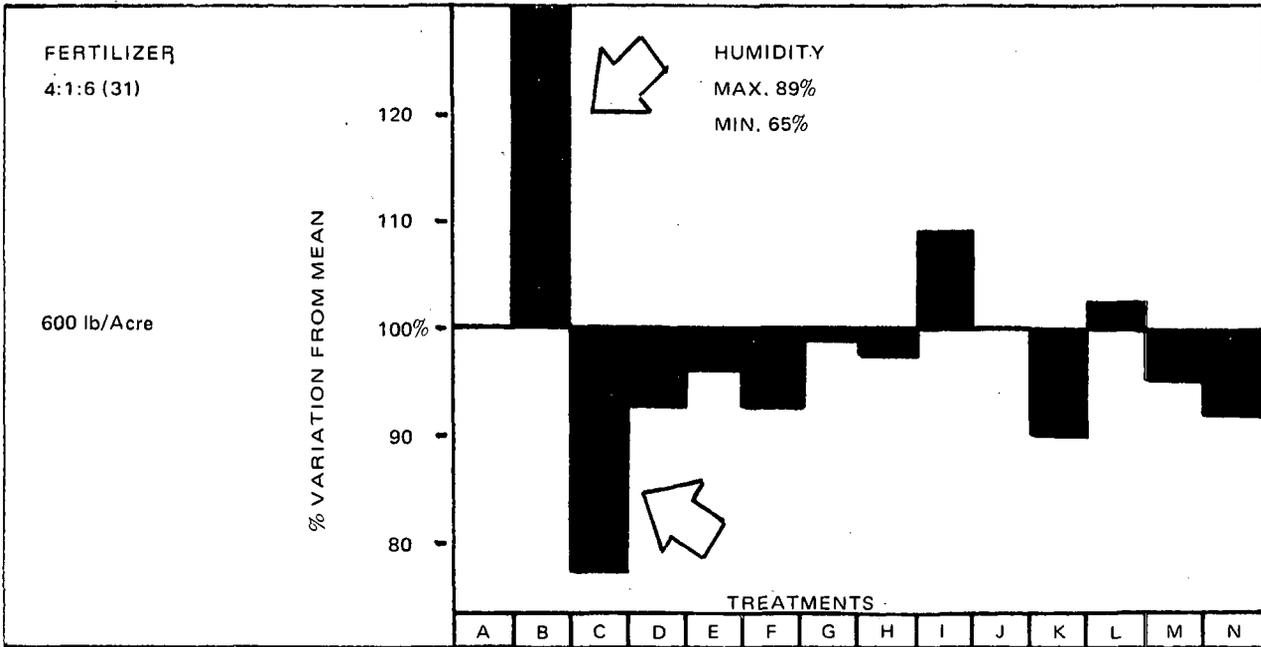


FIGURE 3: Distributor type S (Fig. 4). Percentage variation in distribution of fertilizer from a mean, represented by treatment A (calibrated at 4 mph). The arrows pinpoint the results obtained when testing distributor S for the effects of speed.

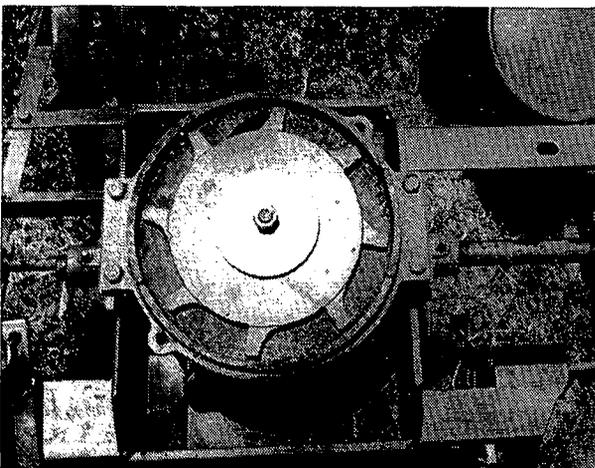


FIGURE 4: Distributor type S. The fertilizer feed mechanism employed in the distributor yielded the results shown in Fig. 3.

Explanations for the poor association of speed and application rate are as follows. On a horizontal rotating, non-positive, displacement machine, the feed mechanism revolves at a certain rate to produce a given output. As the mechanism revolves, some material escapes beneath and over the teeth, and as a result the space between the teeth is not completely filled with fertilizer. As the speed of rotation is reduced, so the rate of escape from the teeth is also reduced. Because the 'pockets' between the teeth are now being more completely filled, the displacement properties of the machine improve. Thus at 2 mph the output increases out of proportion to the reduction in speed (top arrow in Fig. 3)—giving a higher than mean reading.

If the speed of rotation of the feed mechanism is increased, the positive displacement properties are

reduced because the amount of fertilizer between each tooth is now less than it was at 4 mph. This is due to the faster movement of the teeth through the material in the hopper, which creates greater particle disturbance. This in turn reduces the amount of fertilizer collected between the teeth and deposited in the outlet, and results in reduced output at high speed, as shown by the lower arrow in Fig. 3. Some machines, however, are fitted with a cover or shield over their outlet and these actually produce an increased rate of discharge as the speed of rotation of the feeding mechanism is increased. Although these are non-positive feed machines the shield acts as a compressor. Because the shield covers the outlet above the rotating auger, as shown in Fig. 5, any fertilizer forced into the space cannot escape and is therefore forced out of the outlet. Arrow (1) in Fig. 6 shows the results obtained.

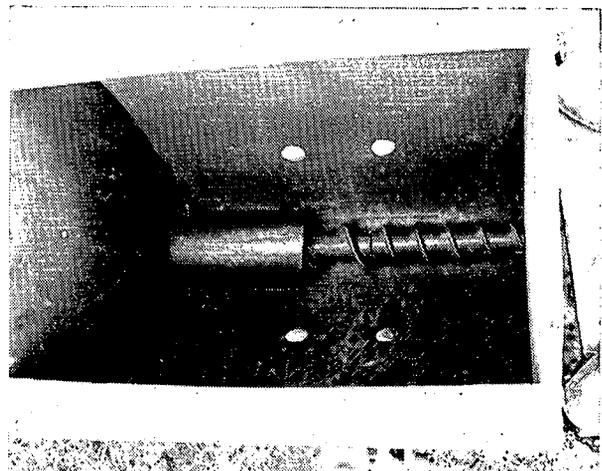


FIGURE 5: Distributor type T. Rotating auger feed mechanism. Note the cover over the outlet.

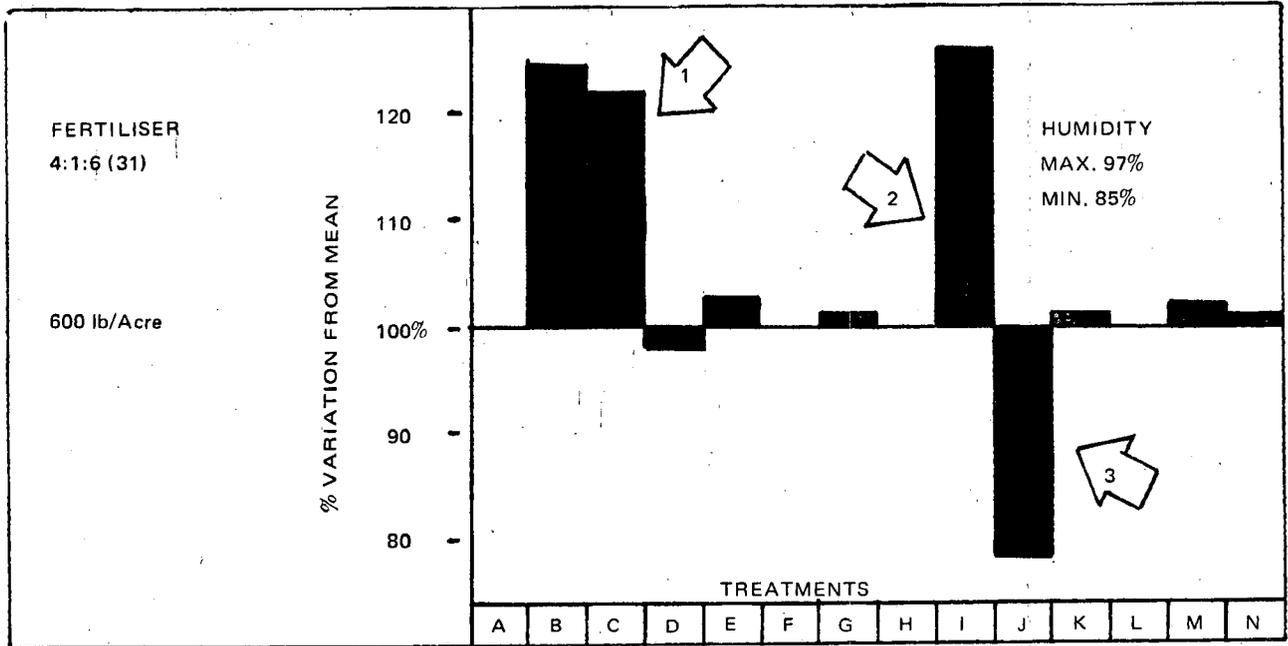


FIGURE 6: Distributor type T (Fig. 13). Percentage variation in distribution of fertilizer from a mean, represented by treatment A (calibrated at 4 mph). Arrow 1 indicates the rise in output when the ground speed is increased to 6 mph. Arrow 2 shows the increase due to the effect of a right-hand slope on the machine in Fig. 13. Arrow 3 shows the decrease in output due to the effect of a left-hand slope on the same machine.

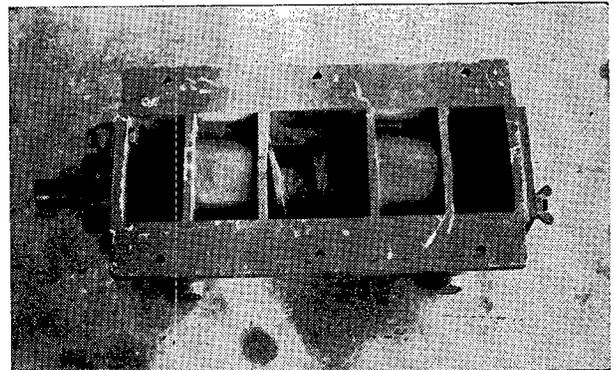


FIGURE 7: Distributor type U. A positive displacement feed mechanism. The auger receives the fertilizer through the centre opening only.

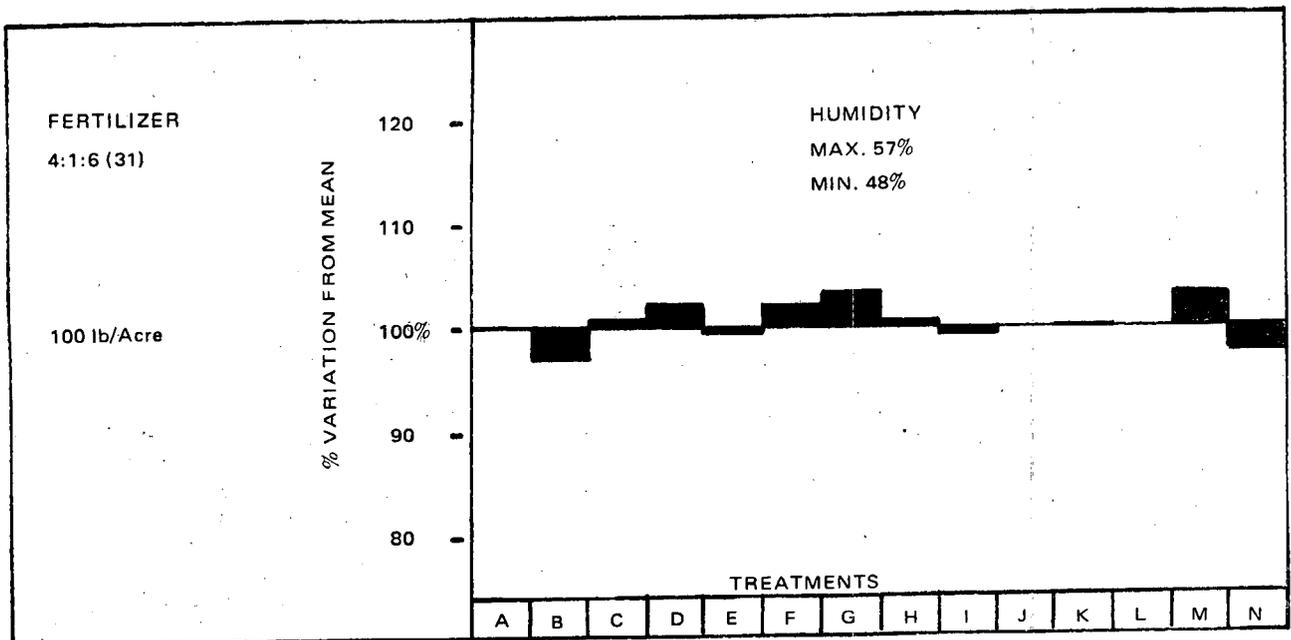


FIGURE 8: Distributor type U (Fig. 7). Percentage variation in distribution of fertilizer from a mean represented by treatment A (calibrated at 4 mph). This is the pattern produced by a positive displacement feed machine. Note the evenness of the columns B and C compared with those in Fig. 3.

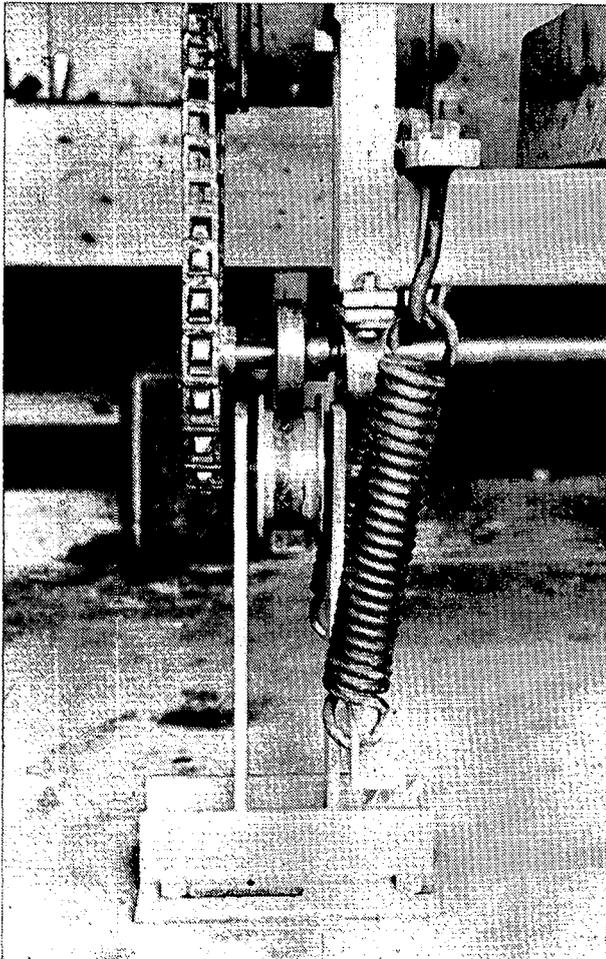


FIGURE 9: A close-up of the vibration mechanism.

With positive displacement machines (Fig. 7), one is able to increase or decrease forward speed, producing a proportional output in each case. This is illustrated in Fig. 8. At very high speeds, however, a sticky fertilizer could cause a slight drop in output due to the fact that the material cannot effectively recharge the auger. In these circumstances the material does not flow down onto the auger fast enough to recharge it between meterings.

Test D—Vibration

Vibration tests were carried out, using the standard toolbar, by attaching a cam and spring mechanism to one end which 'bumped' the toolbar once every second. The cam and spring mechanism are illustrated in Fig. 9.

Variations in fertilizer delivery were obtained mainly in machines employing gravity feed or with slow moving mechanisms. Results from the latter, namely a machine with a reciprocating feed mechanism (Fig. 11) are shown in Fig. 10. In this case the action is slow enough for vibration to affect output between passes of the reciprocating blades.

When the distributor is bumped sharply, fertilizer is forced through the ports in the top plate and drops onto the lower tray. Supply to the lower tray is normally by gravity feed, but the bump increases the load and this in turn increases output. When output is deliberately raised beyond a rate of 100 lb./acre, the increased delivery caused by vibration alone becomes proportionately less, as the bump increases output by the same amount regardless of the setting.

The effect of vibration is similar with all three fertilizers but the output increases according to the weight per unit volume of material. Thus, vibration increased output of the 4:1:6 and 1:0:1 fertilizers more than the sulphate of ammonia, the flow properties of the latter being poorer.

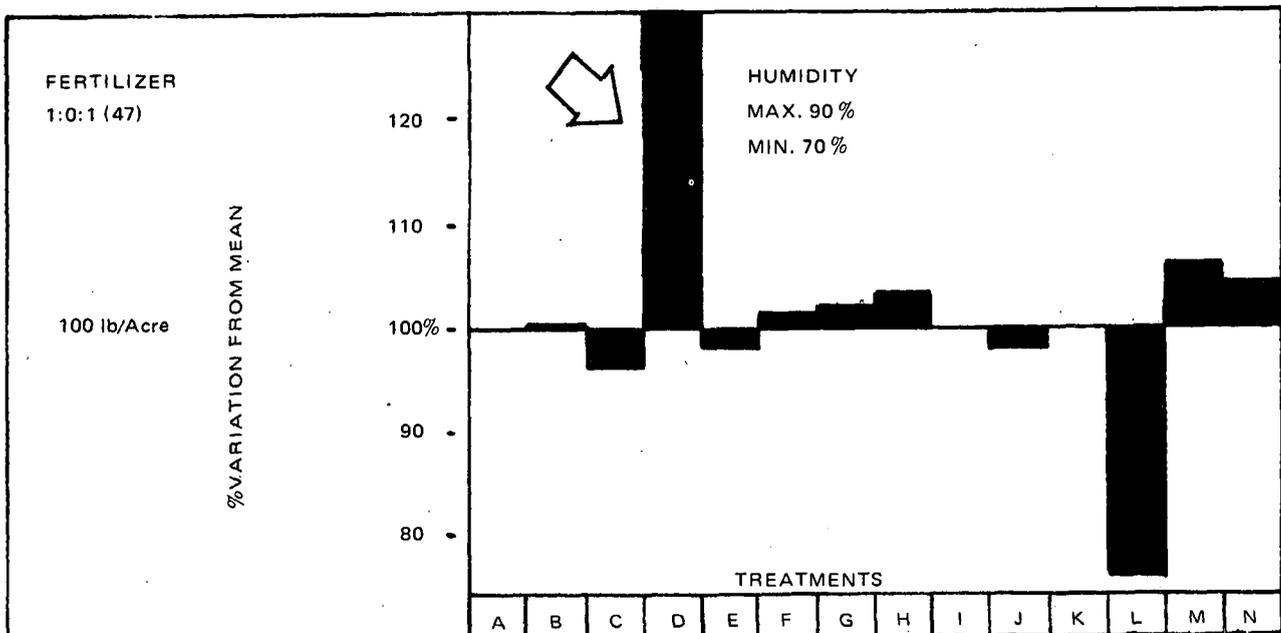


FIGURE 10: Distributor type V (Fig. 11). Percentage variation in distribution of fertilizer from a mean, represented by treatment A (calibrated at 4 mph). The arrow indicates the sharp increase due to vibration.

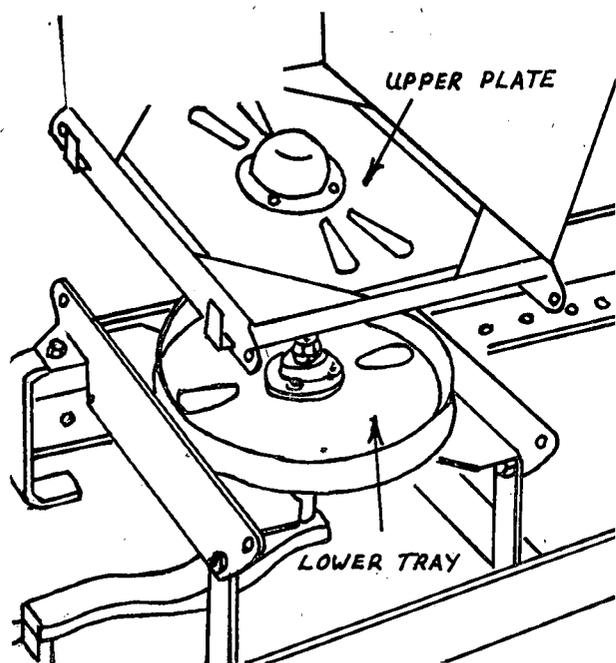


FIGURE 11: Distributor type V. The layout of the machine which produced the results in Fig. 10. A typical gravity feed machine.

Tests F, G. and N—Quantity of fertilizer in the hopper

These tests were designed to detect whether the quantity of fertilizer in the hopper had any effect on output consistency. The results showed that the amount of fertilizer in the hopper had no detectable effect on output.

A noticeable fault in most machines was lack of agitation in the hopper. Agitation is needed to keep fertilizer flowing and to avoid cavitation and tunnelling.

Cavitation occurred in machines with a horizontal rotating or reciprocating feed. Because the fertilizer is tacky, it tends to adhere to the sides of the hopper. The feed mechanism inevitably draws material from the line of least resistance and in consequence this can lead to cavitation. Cavitation, illustrated in Fig. 12 usually starts directly above the centre of the rotating or reciprocating feed, and vibration caused by tractor movement does not always dislodge the fertilizer banked against the hopper sides.

Tunnelling is similar to cavitation except that it usually occurs in machines with horizontal revolving augers. It is caused by the formation of a hardened surface around the flights as the auger revolves through the fertilizer, and it prevents further material moving down to the feed auger. This occurred most frequently with sulphate of ammonia, and on some occasions with prilled 1:0:1.

Cavitation and tunnelling can happen at any time and not necessarily after hours of use. To help the distributors to deal with different fertilizers, agitators should be fitted. Steep sided hoppers are not always practical and could be bulky and awkward, especially for refilling.



FIGURE 12: Cavitation occurring in a fertilizer distributor hopper due to the lack of agitation.

Tests I, J, K and L—The effect of slope

Slope affects the operational efficiency of fertilizer distributors which have:

- i single, off centre outlets, with horizontal rotating feeds,
- ii auger feeds, housing an offset outlet, or
- iii two opposing outlets, if a full application is required from each.

Slope does not affect machines which have:

- i positive displacement feed, or
- ii a centrally placed outlet or outlets, presuming the hoppers are not less than $\frac{1}{4}$ full.

Left- and right-hand slopes.

The machine illustrated in Fig. 13 is fitted with an auger which conveys the fertilizer to the right (Fig. 5). Tilted to the right therefore it is discharging downhill. Because the clearance between the auger flights and the sleeve is fairly large, excess material will flow downhill towards the opening. As a result, the space between each flight will carry a greater charge than it does when the machine is on the level. This increases output (arrow 2, Fig. 6).

The opposite or left-hand slope will have the reverse effect, as fertilizer will tend to flow away from the spinning auger. This means that the flights will not carry a full charge and output will drop. The effects are well illustrated in Fig. 6 (arrow 3).

Uphill and downhill slopes.

These have a similar effect on machines with outlets placed in the fore or rear of the hopper base plate.

If a distributor with the type of mechanism illustrated in Fig. 14 was to work uphill, the opening would be uppermost and the fertilizer would have to be 'pushed' uphill. As this is not a positive displacement machine, a decrease in output will inevitably result (arrow 1, Fig. 15). On a downhill slope the fertilizer would be swept downwards into the outlet, assisted by gravity, and this will give a higher feed rate (arrow 2, Fig. 15).

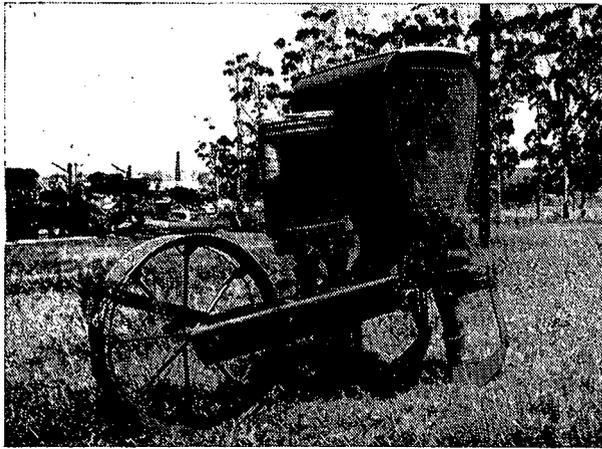


FIGURE 13: Distributor type T. Distributor with its outlet located on the right-hand side, just behind the chain drive.

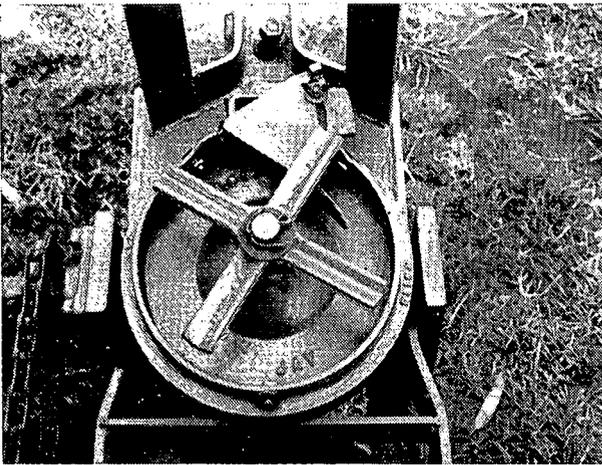


FIGURE 14: Distributor type W. Distributor with its outlet under a triangular shaped cover..

Field Tests

When all the machines had been tested on the toolbar, each in turn was mounted on a tractor and re-calibrated to give a fertilizer output of approximately 600 lb./acre. They were then submitted to the longitudinal and bump test previously described. As the machine was driven over the length of trough, the fertilizer deposited in each division was weighed separately and recorded on a chart. Inconsistencies in application, surge tendencies, and the influence of the bumps, were clearly shown using this method. Recordings indicate that outputs from all machines were affected by the sharp bump. This was true whether there were three points of contact or just one. (A mounted machine with landwheel would have three points of contact with the bump, whilst a trailed machine would be affected only once.)

Three factors have been taken into account:

- i the surge pattern,
- ii the variation along the row, over:
 - (a) area x, or even section. (See Fig. 16.)
 - (b) area y or uneven section. (See Fig. 16.)
- iii fall off from the calibrated feed rate.

Surge Pattern

The distributor, type U which is illustrated in Fig. 7, has a strong tendency to surge. This is shown in Fig. 16, where a series of surges can be seen occurring approximately once every four feet and continuing over the bump affected area "y". This surging is due to the fact that at the given rate of application, and at a ground speed of four miles per hour, the one start auger does a complete revolution for every four feet of travel. It follows therefore that there should be approximately seven to eight surges within the measured distance of 30 ft. We can in

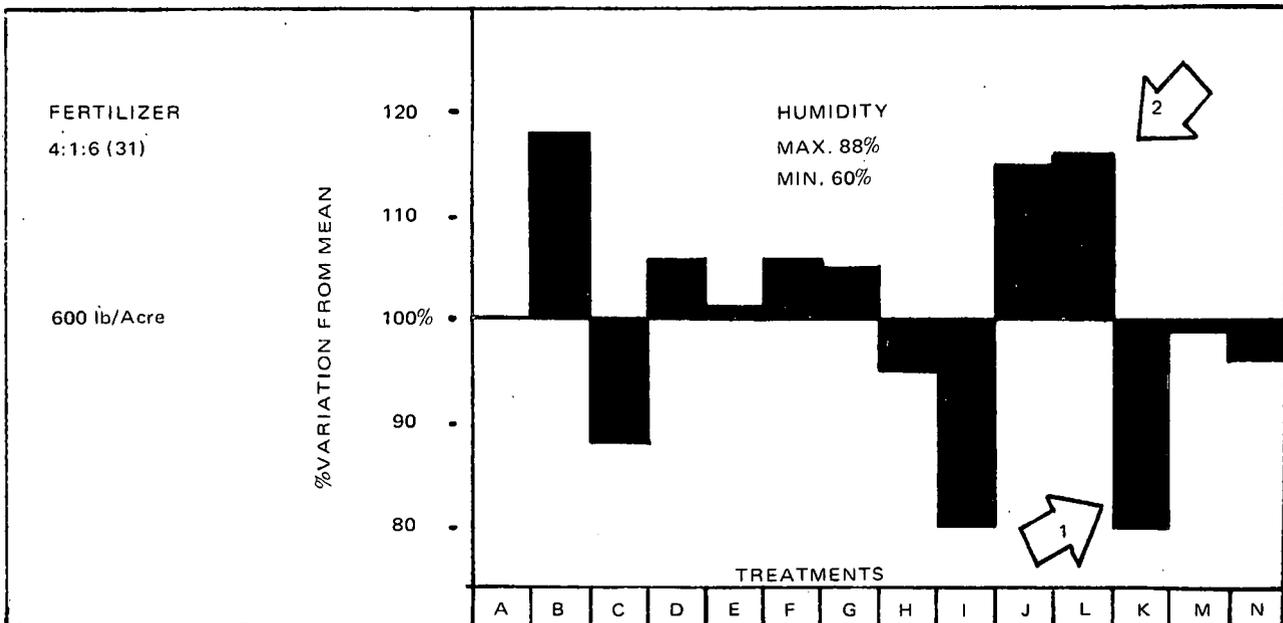


FIGURE 15: Distributor type W (Fig. 14). Percentage variation in distribution of fertilizer from a mean, represented by treatment A (calibrated at 4 m.p.h.). Arrow 1 shows the increase in output due to the effects of an uphill slope on the machine in Fig. 14. Arrow 2 shows the effect of a downhill slope on the same machine.

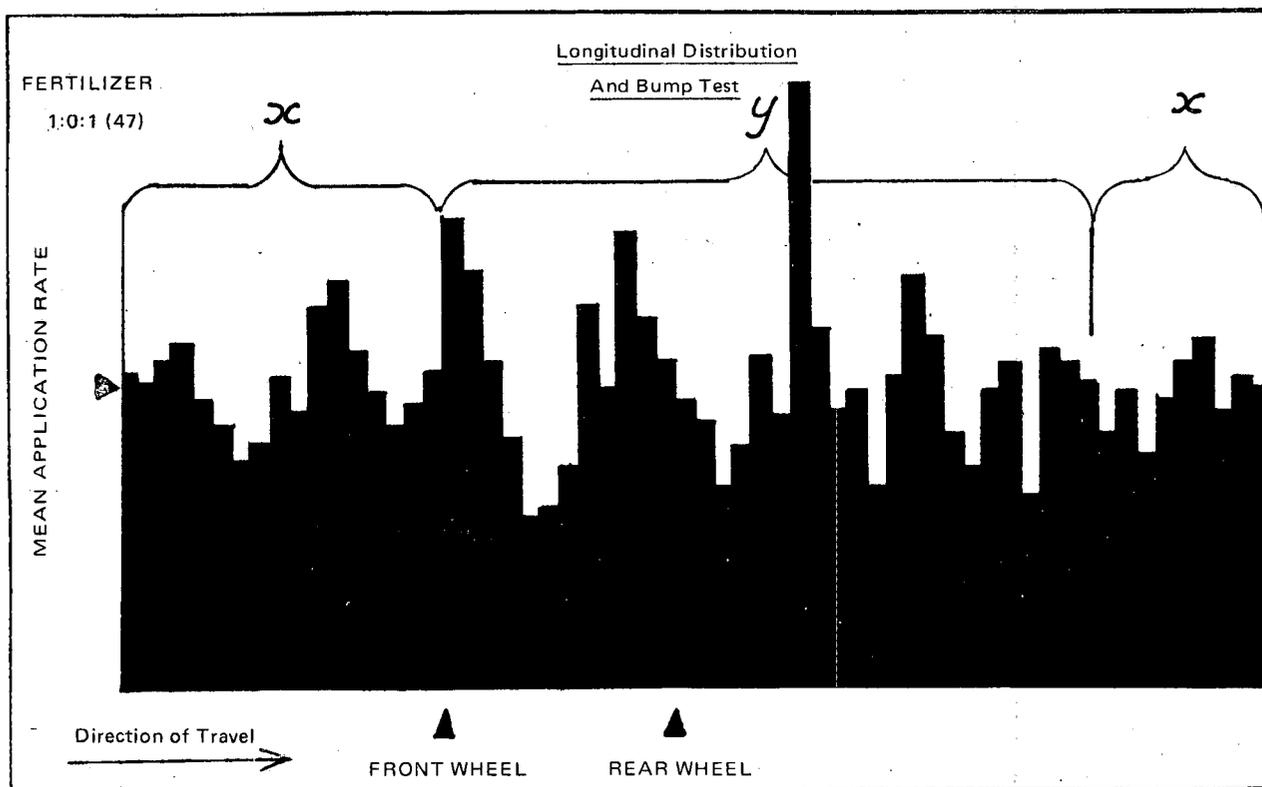


FIGURE 16: Distributor type U (Fig. 7). The amount of fertilizer in grams, measured every 6 inches of travel along a trough 30 ft. in length. The readings inside the area marked "y" are affected by the bump. The arrows above "FRONT WHEEL" and "REAR WHEEL" indicate the position of the hopper when the named wheel contacts the bump.

fact say, that the smaller the amount applied per acre, the greater the distance will be between surges. This is because the auger speed is used to control the feed rate, and it is therefore altered in relation to the forward speed.

Variation on even and uneven ground

The performance of distributor, type S is shown in Fig. 17. Although the pattern over the areas marked "x" looks comparatively even, the coefficient of variation, expressed as a percentage of the mean, is still quite high. The two "x" areas can be considered together as they are both over even ground. When this has been done, the C.V. over area "x" is 24.1% and over area "y" 31.6%. The difference is relatively small, compared with the C.V. recorded for distributor U (Fig. 16), which is 14.5% over area "x" and 96.9% over area "y".

The differences between the distribution pattern of the two distributors is occasioned by differences in the number of meterings or feedings of the mechanism over a given distance. The greater the number of meterings over a set distance, the greater the control the machine has over output, and the fewer factors there are which can affect the output between meterings. Thus a feed mechanism with six fingers or points will have more control over output than one fitted with four. Comparing the performances of the two machines in Fig. 17 and 16, the smaller difference between readings over areas "x" and "y" is to be found in the machine

which has a multi-toothed feed wheel. The other machine has a one start auger. Compared over a distance of 4 ft, type S (Fig. 17) meters out twenty-four times, while type U (Fig. 16) meters out only once. The reason for the higher C.V. experience by the former machine over area "x" (24.1% compared to 14.5%) is that the total output of distributor S is less than that of distributor U. If both machines had the same total output, namely 600 lb./acre, then the results from distributor S would be expected to have a lower co-efficient of variation than that of distributor U, because it has greater control over output over the same distance.

Fall-off in feed rate

It has been pointed out that for the field tests, each distributor, when attached to a tractor was calibrated on the workshop floor to deliver 600 lb./acre. A small variation of $\pm 10\%$ was allowed. This meant that each machine should give 14.16 g per tray in each of the 60 trays in the test line, or 849.6 g altogether. If we once again compare distributors U (Fig. 16) and S (Fig. 17), the overall mean output of the former proved to be correct, but that of model S, which is operated by a land-wheel was only 6.36 g per tray. The calculated application rate of model S was therefore only 255 lb./acre. This large fall in application rate serves to indicate that a landwheel driven fertilizer distributor MUST be calibrated in the field itself, under the actual conditions in which it will work. If this

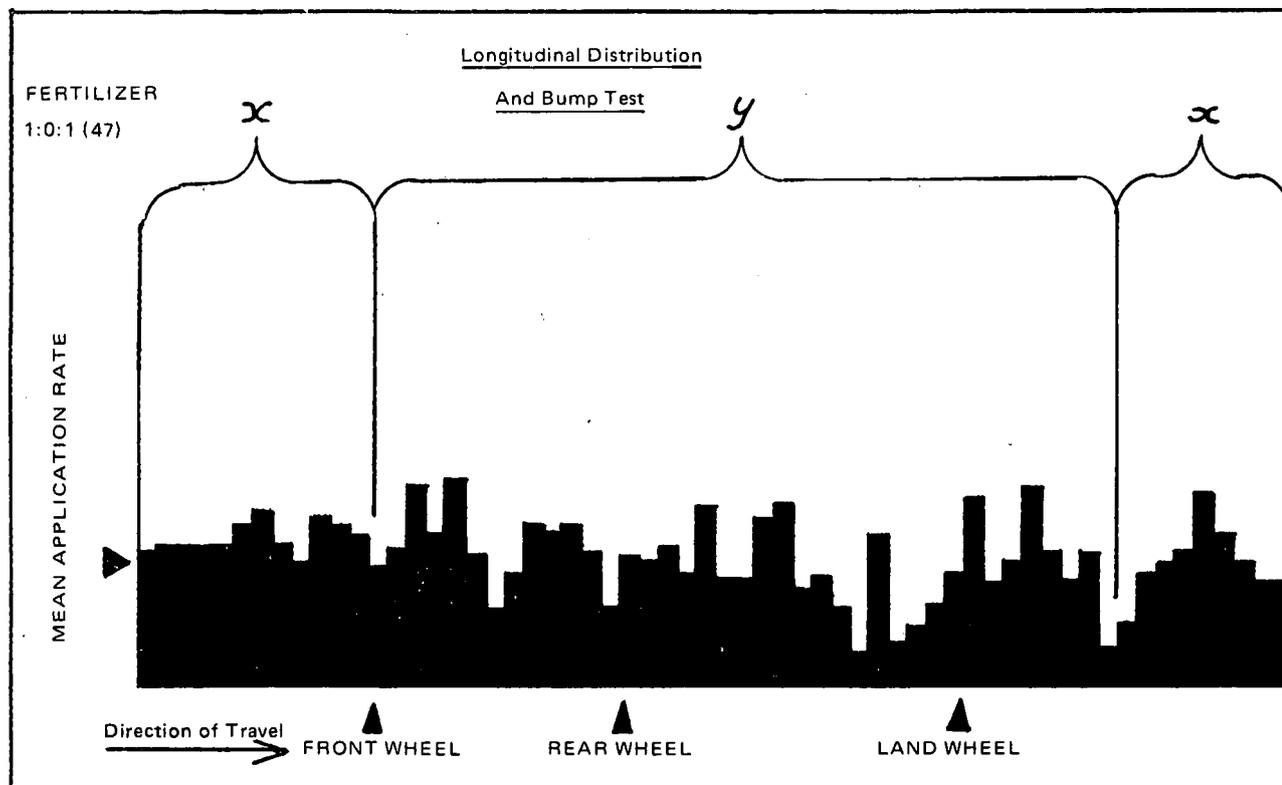


FIGURE 17: Distributor type S (Fig. 4). The amount of fertilizer in grams, measured every 6 inches of travel along a trough 30 ft in length. The readings inside the area marked 'y' are affected by the bump. The arrow marked 'LAND WHEEL' indicates that the machine was land wheel driven.

TABLE II

The co-efficients of variation in the areas marked 'x' in Figs. 17 and 16 for the longitudinal test run

Fig. no.	Mean of areas x	S.E.	C.V. %
Fig. 17	6.59	1.59	24.1%
Fig. 16	14.24	2.06	14.5%

is not done, the results obtained are likely to be similar to those in Fig. 17. Calibration in a workshop or shed fails to take into account a number of factors which effect a machine in the field. Thus workshop calibration:

- (1) does not allow for wheelslip,
- (2) fails to allow for ground conditions,
- (3) does not allow for field speed; (the wheel being turned slowly by hand),
- (4) fails to allow for slopes.

Fertilizer delivery rates for the p.t.-o. driven machines tested were not affected by the factors referred to, so they can be calibrated anywhere. If, however, the implement is used for more than one job at a time, as may be the case when ridging and fertilizer application are done together, then tractor wheel slip must be considered, and the machine must be calibrated in the field.

Fertilizer tests

A short test on all three fertilizers used, showed

that most of the moisture taken up was absorbed during the first hour of exposure. Details are given in Table III.

TABLE III

Gain in weight of fertilizer samples exposed to the air for one and two hours

Fertilizer type	Sample weight (6 samples)	Average % weight gain after 1 hour	Average % weight gain after 2 hours
4:1:6 (31)	200 g	5.22	5.17
S/ammonia	200 g	5.17	5.25
1:0:1 (47)	200 g	4.90	5.13

It was decided, in view of the findings, that any bagged fertilizer to be used in tests should be opened an hour before being applied, so that the material for each machine would be as consistent as possible.

Tests were conducted to determine the effect of a range of humidities on the efficiency of operation of the metering mechanism. The humidities experienced varied from 41% to 100% and in some cases, bags were left open for five hours, in humidities ranging from 61% to 75%. In no case was any detrimental effect observed in the operation of the delivery mechanism. Moisture did, however, affect output when:

- (a) a granular or powdery fertilizer was used in a machine which had been working over a long period in the field, under conditions of high humidity. The powder then tends to form a scale inside the chutes which have become damp from dew or rain, and this results in a reduction in the size of the outlet;
- (b) fertilizer applied in wet weather and rain is permitted to enter the hopper or bag of fertilizer;
- (c) fertilizer is put into a wet or damp hopper;
- (d) fertilizer is allowed to lie in the machine after use, especially if the hopper contains only small pockets of fertilizer, as small quantities will absorb moisture very rapidly;
- (e) two fertilizers are mixed and the contents allowed to stand for days in a thin layer on a concrete floor;
- (f) there are obstructions in chutes such as sharp bends and joints.

The troubles caused by the difficult and sticky fertilizers used in the tests were in no way attributable to high atmospheric humidities. The fertilizers were naturally moist when delivered in sealed bags. The only way to deal with these fertilizers is to ensure that the hopper and chutes are clean when filling the machine and to provide some form of agitator in the hopper.

Conclusion

In non-positive, displacement feed, fertilizer distributors, variation from the calibrated speed will have a marked effect on output. If the operating speed of a distributor is increased beyond the speed at which it was calibrated, then its output will also increase but at less than the calculated proportional amount. Similarly, if operating speed is reduced, the output rate will also be reduced, but at less than the proportional rate. The rate of application per acre will, as a result, increase. It is axiomatic therefore that with this type of distributor, a uniform speed of operation must be maintained if accurate spreading is to be achieved. Positive displacement feed distributors are not affected by speed variations.

Tests revealed that the fertilizer content of a hopper had no detectable effects on machine output, providing some fertilizer was present, and a suitable agitator fitted, particularly when sticky fertilizers are being used. When no agitator is employed, fertilizer may in some cases fail to leave the machine due to immediate cavitation or tunnelling of the hopper contents.

Vibration produced variations in delivery in machines with gravity feed and slow moving mechanisms. Vibration can occur when the machine is run over uneven land surface; when the mechanism and linkages are worn; if the drive mechanism is bent; or if the tractor engine runs unevenly. If a distributor is susceptible to the effect of vibration, it must be calibrated under the actual

conditions in which it is to operate. This will reduce variations in output due to vibration, but it quite obviously cannot take into account major changes in field conditions.

Slope affects the operation of distributors that do not have one or more centrally placed outlets, or which have two opposing outlets when both have to operate at full capacity. If, therefore, a fertilizer distributor is to be operated on a hillside, cognisance must be taken of the following:

- (a) the distributor must be calibrated on the slope;
- (b) calibration should be checked at least once each day;
- (c) chutes should be freed from any build-up of fertilizer, induced by powdering and caking on the chute walls, which leads to reduction in chute diameter.

Field tests show that output from all the distributors tested were affected when the machines were driven over a sharp bump. This indicates that a poorly prepared or uneven field surface could adversely affect output by a distributor. Distributors mounted on a tractor three point linkage were found to be affected more than those that are trailed. Furthermore, correct tractor and implement tyre pressures are important to reduce "bounce".

It was found in tests that feed mechanisms with "multi-cell" metering mechanisms, produce a more uniform pattern of fertilizer distribution along the row than those fitted with few or single "cells". The fewer fertilizer meterings there are over a given distance, the poorer is the control secured over output. This is a feature which must be considered when selecting a distributor, particularly if it is to work on uneven terrain.

Surging takes place in machines with slow moving feed mechanisms, where the speed of the mechanism controls the feed rate. It follows therefore that the smaller the amount of fertilizer to be applied per acre, the greater the distance will be between surges. Such machines should therefore be avoided where low rates of application are to be used.

Calibration in the field is of the utmost importance if accurate application rates are to be obtained. Stationary setting is hopelessly inaccurate, especially with landwheel driven machines. P.t.-o. driven distributors should also be calibrated in the field if they are to be used in conjunction with other equipment, as is the case when ridging and fertilizer application are carried out together.

A uniform flow of material through the distributor can be maintained if: the hopper is clean and dry before filling; the bags of fertilizer to be used are not left standing open for very long periods before use; fertilizer passage through the chutes is not obstructed by sharp bends or joints; the hopper is thoroughly cleaned after each day's work; machines are correctly maintained; and when using sticky fertilizers, an efficient agitator is fitted within the hopper of the machine,

Discussion

Mr. Bartlett: This is the most comprehensive report I have read on the calibration efficiency and operation of a variety of fertilizer distributors.

It assists the grower by pointing out, for instance, that a change in engine revolutions will affect rate of application.

The report has been sent to the designers of the machine and has had a very favourable reception generally.

Dr. Hill: I would like to hear the current Experiment Station thinking on banding versus broadcasting of fertilizer under both bare and trashed conditions.

Mr. Moberly: As far as nitrogen is concerned there appears to be very little difference in the ultimate effect.

Phosphate was recently tested on a soil most able to fix phosphate. It was found when testing band-

ing of the top, banding below the surface and broadcasting over the top of trash that the broadcasting method was equally good in the first ratoon and that its residual effect was slightly superior.

It seems therefore that we are safe in broadcasting all our fertilizer.

Mr. Stewart: As higher grade fertilizers are now being used, I think machines should be more sophisticated so that more critical amounts can be applied.

Users might also have to accept fertilizer blends that are suitable for machine application.

I would appreciate Mr. Statham commenting on the Spandicar method of application.

Mr. Statham: The Spandicar is not mentioned in the paper but we found it produced very accurate results when tested on the toolbar. The hopper capacity was good but the longitudinal distribution was erratic.