HERBICIDE APPLICATION — A NEW APPROACH

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Introduction

With diminishing labour supplies, chemical weed control is becoming increasingly important in the South African Sugar Industry. During the past two years Illovo Sugar Estates have made a concerted effort to face and answer this problem of labour shortage by embarking on a comprehensive chemical weed control programme.

It was necessary to decide (a) what chemicals to use and, (b) how to apply them? The former was easily established by employing a policy of non-sophistication and making use of the tried and true growth-regulator type herbicides (2, 4-D and 2, 4, 5-T) which, in the main, commercially control the weed complex present in company fields. The most efficient method of application was more difficult to establish.

On the company's coastal sections where topography precludes the use of large mechanical rigs, the choice of manual application by a trained gang of specialist labourers was unavoidable. On areas where mechanical operations are possible a short boom attached to a cultivator and spraying row only, three rows at a time, is employed. Such a system, on land where only relatively small acreages can be treated mechanically, is quite satisfactory. However, on the company's inland sections where approximately 60 per cent of the area is negotiable with a wheel-tractor and where no suitable labour is available for specialist manual operations, the introduction of the short-boom rig has exposed its inadequacies.

Such factors are the slowness of the operation and the relative inefficiency of using a tractor to treat only three rows at a time. Furthermore, if conventional nozzles and jets are used, the use of fairly large volumes of water (25-35 gallons per acre) results in time wastage and expense due to repeated filling operations. Such excessive water usage may be avoided if minute jets are used but this advantage is outweighed by the high frequency of nozzle blockages irrespective of using the cleanest farm water.

The resultant project was to develop a mechanism which could be activated by a small economical wheel-tractor yet carry a fairly large water supply and augment that supply by applying the very minimum amount per unit area of land consistent with efficient weed control. Furthermore, the applicator should present no problems of nozzle blockage and be large enough to treat a wide swath with each pass.

Description

A machine vaguely fitting these requirements has been developed as an orchard sprayer and is widely used throughout South Africa and overseas. Such machines are commonly known as low-volume mist-blowers and as their name implies, they convey the chemical to the plant by means of an airstream, reducing water as the transport medium whilst replacing it with air. The machine consists of a 150 gallon tank mounted behind a P.T.O. operated fan and centrifugal pump. The latter is used to agitate, by recirculation, the contents of the tank while simultaneously delivering the liquid to the airduct venturii. The pump is also used to refill the tank at the approximate rate of 30 gallons per minute.

The fan which is balanced and mounted between two bearings creates an airblast of considerable speed (in excess of 150 miles per hour) which is ducted to the head whence it is distributed through the jets. Inside each jet is mounted a venturi and the air rushing past the same sucks the pump-assisted liquid out at an adjustable rate. The liquid is "atomised" and forms a mist when it passes into the barrier of outside air (see Fig. 1). The venturii are approximately $\frac{1}{4}''$ in diameter thus blockage is impossible.

Water mainly fulfils the function of a solvent in the mist blowing system with the result that the proportion of water to chemical is less compared with the high pressure conventional systems. An important difference between the two systems is found in the size of droplet in which the chemical is dissolved. Some manufacturers claim that the droplets formed by the mist blower are the key to its success, resulting in a saving of up to 40 per cent of chemicals and 90 per cent of water used. The droplets from a conventional jet system can vary greatly in size but the majority occur in the range of 150 to 300μ while the average droplet from a mist blower is approximately 50μ in diameter. Mathematically, it may be interpreted that one droplet of 300μ diameter can be subdivided into 216 droplets of 50μ diameter. Without delving into the intracacies of mathematics and zones of chemical effectiveness surrounding each droplet, it may be accepted that a large number of small spheres (droplets) with the same total volume as a lesser number of larger spheres, have a greater surface area and hence could produce a superior cover and distribution pattern. In addition, when the airstream and liquid pass out of the jet they break through the relatively static air surrounding the head carrying a portion thereof along, which produces a turbulence thus ensuring that all parts of the plant population are thoroughly covered with chemical.

Having seen these machines operating in orchards for pest control and in one area on wheatlands for weed control, in their conventional form, the writer considered that the principle was worthy of a trial at Illovo. However, it was obvious that the conventional cluster of jets spraying a cloud of

chemical and water upwards into the air, while completely adequate for tree spraying, would not be efficient for spraying weeds in a row crop such as sugarcane under more windy conditions. A more definite and directed spray pattern would be required while still employing the principle of airblast through venturii. It was decided that the best means of achieving the above was to design a boom system, but that the latter should carry air to large jets containing venturii directed downwards at approximately 40 degrees from the horizontal. The liquid is fed into the venturii via reinforced plastic hoses strung along the boom. (See Fig. 2.) The jets and venturii are also arranged in a set pattern of direction so as to achieve a curtain of spray over the full width of the swath (See Figs. 1 and 2).

The boom had to be ducted with progressively decreasing diameters in order to obtain equal volumes of air passing out of each jet irrespective of the latter's distance from the air source. This need for ducting the boom has subsequently been found to be not highly critical, although if disregarded it would cause uneven delivery of air and varied droplet sizes from the different venturii.

The machine fitted with the boom has been operating on an experimental basis at Illovo for approximately one month. During this period results of post-emergence spraying using a 2, 4-D low volatile ester have been outstanding. These results were obtained by using a 6.7 lbs. acid equivalent 1S0-octyl ester at rates of 2 to 3 pints per acre in 13 gallons of water as a full cover operation. The water output of the machine can be varied by finger-tip adjustment to deliver quantities varying from nil to approximately 100 gallons per acre.

The machine is trailed by a 35 horsepower wheel-tractor operating in second gear, low ratio, at 1800 revolutions per minute which produces a forward speed of 1.90 to 2.00 miles per hour. In theory, at this speed and under ideal conditions, the implement can treat approximately 6 to 7 acres per hour. In practice, however, it has been found that 30 to 35 acres are treated in an 8 hour day under Illovo conditions. The discrepancy between theory and practice is due to time wastage on rough narrow headlands, sloping and undulating infield conditions, and refilling. The latter is of least importance as the machine, when delivering water at 13 gallons per acre, can treat over 10 acres before refilling becomes necessary.

Unfortunately the opportunity to test the machine as a pre-emergence sprayer has not arisen. However, it is reasonable to assume that pre-emergence results would be satisfactory especially if water output and chemical concentration were increased by 50 per cent. The spray pattern delivered by the mist blower, as modified, is similar to that of aircraft spray systems and the latter are widely used in South Africa for pre-emergence work.

There is no information available with regard to the efficacy of the airblast system when using herbicides other than the growth regulator type. With most commercial herbicides, however, once the inherent weed killing properties of the chemical are established, their efficiency is largely dependent on an adequate and uniform spray pattern regardless of their mode of action. Such a spray pattern has been established with this machine.

Discussion

As with most prototype machines, certain disadvantages have been noted and are listed below. It should be stated that some of the physical disadvantages were realised at the start of the project but these were temporarily accepted as the main objective of the exercise was to test the principle of air-cum-water spraying for herbicide application.

TABLE I

Pertinent specifications applicable to the air-cum-water herbicide applicator

	Dimensions	Remarks
Width of Boom.	28 ft. 7½ ins.	Swath width approx. 32 ft. due to overlap of jets.
Height of jets.	3 ft. 5 inches	This is an approx. figure depending on uniformity of land surface.
Diameter of boom.	1st segment is 11 in. 2nd segment is 9 in. 3rd segment is 7 in.	Reduced diameters at greater distances from air source in order to maintain constant air pressures.
Diameter of jets.	2¼ inches.	
Spacing of jets.	Approximately 4 ft.	See text re reduced spacing between jets.
Type of fan.		It is a forward curve multiblade single inlet centrifugal fan.
Capacity of fan.	320,000 cubic ft. per hour.	This volume produced at a max. rated speed of the impeller of 3,400 r.p.m.

(a) The machine, being trailed, is clumsy to handle under rough uneven conditions. Furthermore, due to the width of the boom and the fact that it is fixed when in position, difficulty is experienced in turning on small headlands especially if obstacles in the form of trees, hedges, banks or standing cane occur.

(b) The disadvantage of width also exists when the machine has to be transported to a new field. The arms of the boom must be removed and re-positioned on the new site. An associated disadvantage is the frailness of the boom which can be easily damaged with constant removal.

(c) As the jets of the mist-blower are relatively high above ground level (see Table I), spray drift due to wind does present a problem. Droplet distribution tests were carried out in wind speeds of 20 to 25 miles per hour and the results were uneven and not acceptable. However, in wind speeds of up to 8 miles per hour spray drift is negligible for commercial operations.

At the start of the project the eight jets present on the conventional machine were the only stock available and these were fitted to the boom with no specific ratio of boom (swath) width to number of jets. Fortunately, the illustrations indicate that the droplet distribution is satisfactory, although, in the light of subsequent experience, the same could be improved by increasing the number of jets on the boom to fourteen. Such an increase would halve the span from one jet to the next with resultant improvement in droplet distribution and reduction in wind disturbance. These improvements can be achieved without necessitating an increase in volume output per acre as the liquid delivered per jet can be reduced proportionately. The only disadvantage to this is that a larger fan may be necessary in view of the greater drain on the air supply when using more jets.

A further factor which reduces the importance of wind effects as a disadvantage to this machine is that its daily work potential is such that the operator can choose weather conditions under which to operate i.e. work only during those times of the day when no wind occurs.

It will be noted that the disadvantages listed are mainly of a physical nature which can be reduced or eliminated by thoughtful modification. Such modifications will consist of mounting the implement, including water tanks, on to the tractor, constructing a hinged boom which can be fixed in "travelling" position for road-haulage or turning on limited headlands and using heavier gauge material for the central section of the boom on to which the two outer sections will be hinged. The increase in the number of jets on the boom will complete the modification. It is hoped to develop the redesigned version of the machine in the near future.

Criticism may be forthcoming at the lack of cost figures in this paper. Attention is drawn to the fact that the machine is a prototype which has been operating under experimental conditions to date and hence operating costs, if available, would not be valid. It is envisaged that the machine will be slightly less expensive to operate than a conventional rig although the initial capital outlay will be higher. To partially offset the capital costs it may be stated that, once established, the machine should be long lasting without the need for excessive maintenance and spares.

In drawing conclusions it should be borne in mind that to the best knowledge of the writer this is the first attempt in South Africa and possibly elsewhere, to modify the mist-blowing system for the specific purpose of developing a herbicide applicator. Consequently, from the disadvantages described it will be obvious that the machine is not perfect and is very much a pioneer in its field. However, the primary objective of the project has been achieved in that the advantages viz. no nozzle blockage, greater efficiency of water usage and high work potential, of the air-cum-water sprayer for herbicide application have been demonstrated.

It remains to streamline the mechanism as described above to suit the rugged conditions under which it will work at Illovo. For areas of flat country where field layouts have already been prepared and planned with a view to mechanisation, the implement could be of special usefulness and could probably treat almost double the area of land per day as compared with present performance at Illovo.

Acknowledgements

This paper would be incomplete without the writer's acknowledgement of the very real assistance obtained from various organisations and individuals. It is with gratitude that the writer acknowledges the assistance obtained from Lloyds Industrial & Farm Agencies (Pty) Ltd., of Johannesburg and more especially their Mr. P. Bruce from whom the basic mechanism on which to experiment and make modifications, was borrowed. Acknowledgement must also be accorded to Mr. G. Alder of Associated Air Conditioning and Refrigeration Corporation (Pty) Ltd., of Durban, who, in a private capacity, spent many hours assisting the writer and who designed the boom and ducting system.

Finally, the writer wishes to acknowledge the practical assistance, criticism and encouragement received from colleagues at Illovo during the course of this work.

Summary

Due to labour shortages a concerted herbicide programme became necessary at Illovo. At its commencement this necessitated the choice of herbicides and how to apply them. The former was no problem but problems of application in the form of wasted tractor power, slowness of the operation and nozzle blockage became obvious when large areas were treated.

The need to develop an economical applicator capable of treating large areas per unit time with no hindrance due to nozzle blockage and excessive time wastage while refilling with water, became necessary. The air-cum-water spraying system used for orchard spraying appeared to have potential but needed modification. Such a modification in the form of a boom carrying air to large jets in which venturii are situated and from which the water and chemical is blown out as an air-cum-liquid mixture, has been developed. The system, although possessing certain disadvantages of clumsiness and frailty has achieved successful results in the field. The disadvantages have been noted and alterations in design to eliminate them are already under way.

References

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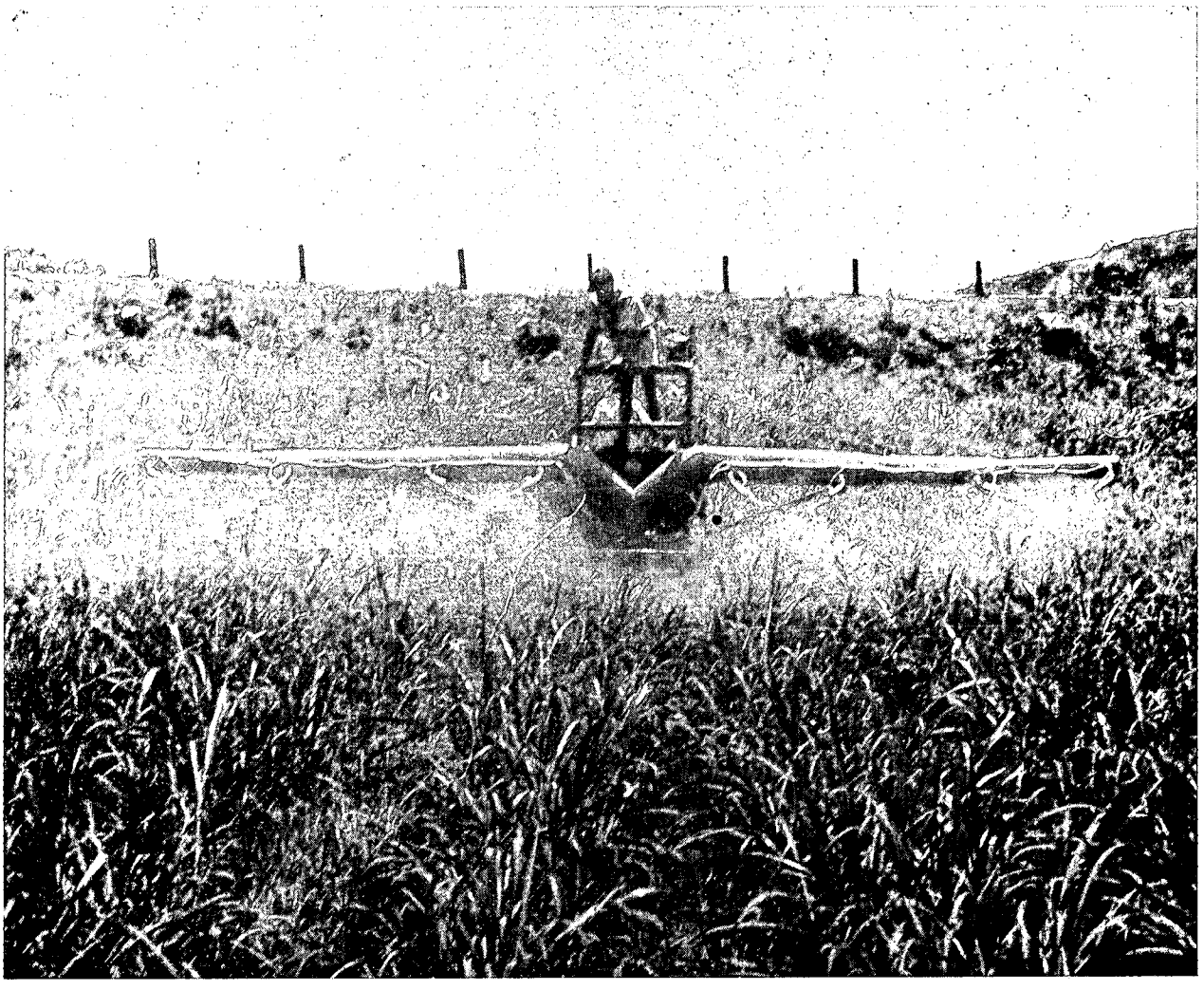

FIGURE 1: The modified mist-blower in operation illustrating the curtain of spray over the full width of the swath

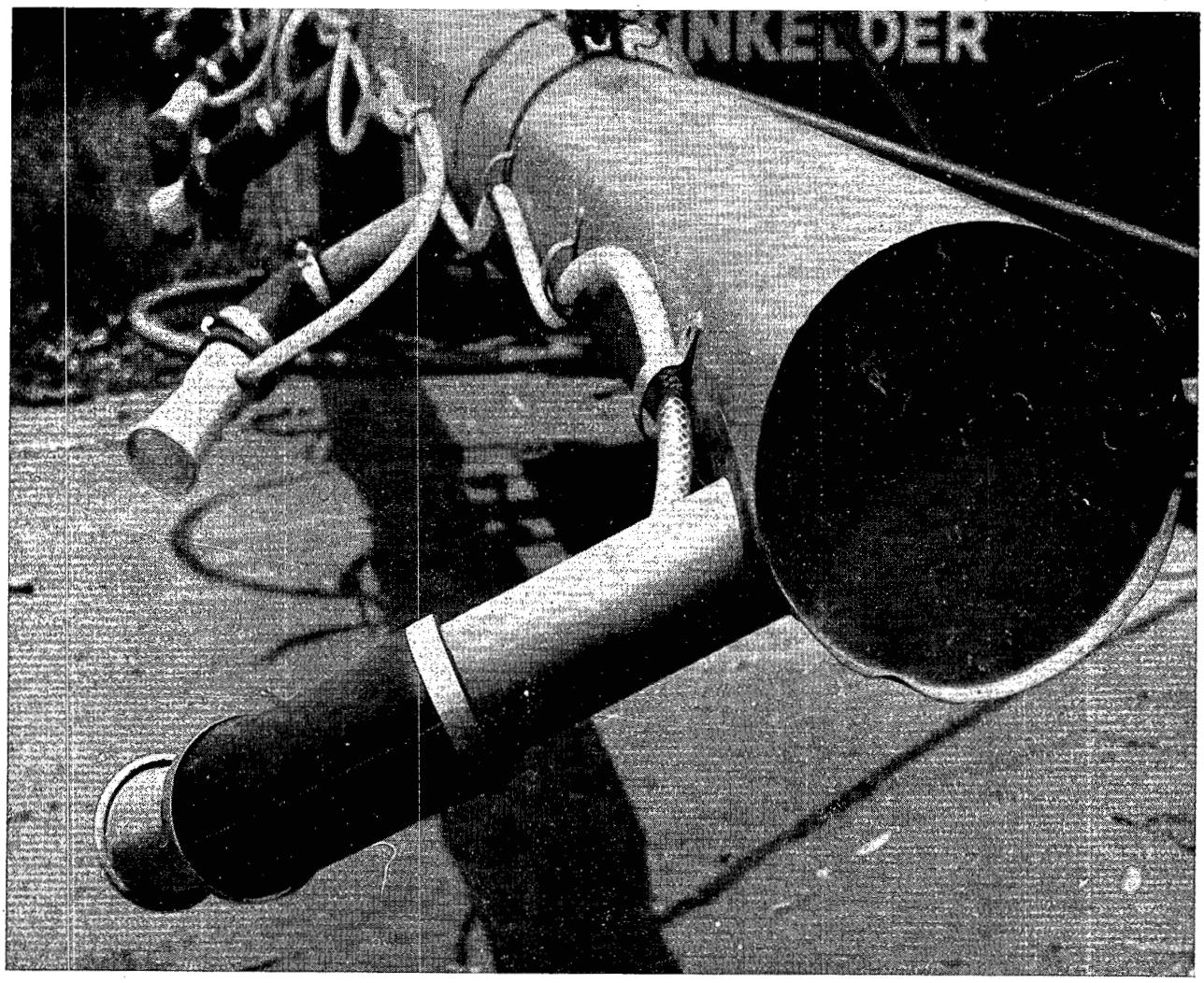

FIGURE 2: The vertical and horizontal angles of inclination of the jets are shown together with part of the boom and take-off pipes for air supply to the jets

Discussion

Dr. Dick (in the chair): There is a limit to decreasing the size of droplets. Below a certain size the droplet will not adhere to the plant at all and a bigger droplet will possibly cause slight damage to the plant and allow entrance for the chemical.

Mr. Wardle: I think it would have to be a rather large drop or a very flimsy plant before that type of damage would be caused.

Dr. Thompson: When iso-octyl ester was used as a post-emergent application at Illovo, what was the weed population?

Mr. Wardle: A selection of broad-leafed weeds and water grass. We commercially control the water grass by turning the leaf yellow and retarding its growth for a certain period of time, about three weeks. Damage occurs where the root and stem join when 2,4-D is used but regeneration takes place from that point after three weeks.

Mr. Gosnell: Cannot the water application be reduced below thirteen gallons and adequate cover still be maintained? In the photograph of the machine in this paper there appears to be quite a lot of overlap and possibly this could be decreased.

Mr. Wardle: We hope to reduce water application. I have used the conventional model of this machine on wheat in the Orange Free State and the rate of water application was only 3½ gallons per acre with satisfactory results.

Mr. Gilfillan: Our biggest expense when applying herbicide by machine is the time lost in filling the machine with water.

What are the manufacturing costs of this machine, are running costs high and does it absorb a lot of horsepower?

If drift is a problem could not an amine formulation be used instead of an ester. How much 2.4-D is used per acre to get the stated amount of control of water grass?

If you manufacture a machine with swinging booms in a horizontal plane I suggest you arrange for the booms to swing in a vertical plane in order to avoid damage from jarring when travelling by road.

Mr. Wardle: We intend to swing the booms forward, not backward, and clamp them into sockets.

We applied between two and three pints of 2,4-D to the acre, full cover.

We are not particularly worried by spray drift as it is negligible and in any event will be effective wherever it lands. When the vehicle is operated wind direction is allowed for. Spraying can be carried out from one side only if required.

Capital expenditure on this machine will be higher than for a conventional one but cost of operation will be lower because of time saving in filling up with water, use of less water, and coverage of a larger area per operational cycle.

Certain tractors have advantages over others when using this machine. The horsepower required is between 30 and 35.

Mr. King: Can this machine be used for a pre-emergent spray and on what sort of topography can it be used?

Mr. Wardle: Wo do not use it on hilly land and so far have not used it for pre-emergent treatment, although it should work. In the Orange Free State we used to spray pre-emergent, by aircraft, with an application as low as 3½ gallons per acre. I think results depend largely on soil moisture and soil structure.

Mr. Roodt: Has Mr. Wardle considered the use of a herbicide other than 2,4-D?

Mr. Wardle: When the chemical effectiveness of a herbicide has been proved the next important factor is suitable droplet size and distribution and as these have been established there appears to be no reason why most herbicides should not be effective with this machine.