The Application of Insecticides by Aeroplane.

Paper read by Mr Dudley Wright (Associate Member) before the Institution, in the Lecture Room of the Junior Institution of Engineers, 39, Victoria Street, London, S W 1, on 6th April, 1927 Mr H B Molesworth in the Chair

BEFORE presenting to you a description of the activities in applying insecticides by aeroplane, I wish to acknowledge the assistance of the U S Department of Agriculture, to whom I am indebted for the early history of this branch of flying, and to also acknowledge quotations from a report on the subject by Prof A D Imms, M A —

Early Experiments

I believe it correct to state that the possibility of applying insecticides by means of aeroplanes, was first brought to public attention by the work conducted in August, 1921, by the State Experimental Station of Ohio

This particular test, consisted of distributing lead arsenate from an aeroplane over a grove of catalpa trees, in an effort to poison the larvæ of the catalpa sphinx (ceratomia catalpæ Bdv) which were defoliating the grove

Leaf Worm Control

Following the success of this experiment, an opportunity to further the tests was afforded by the outbreak of the cotton leaf worm (Ala-bama argillacea Hubn) which appeared over several of the Southern States of North America at the time, in rather unusual numbers

The extent of this infestation varied from field to field, but the average appeared to be about 50 worms per plant Practically every plant had numerous eggs, but as they were laid at different times, it was usually found necessary to treat each field at a different period

Careful records were of course, kept on the worm infestation of each field and the individual fields were poisoned as became necessary for the control of the worms

Early Dust Hoppers

Early operations with dusting aeroplanes were carried out with machines fitted with a hand operated feeder crank The apparatus consisted of the dust chamber—constructed of sheet metal, the outlet or discharge tube, and the feeding mechanism A hinged lid was provided for filling from the top, and the capacity of the hopper was about 12,500 c i

The poison used in the majority of the tests was the ordinary calcium arsenate sold on the market for Boll-weevil control As the standard specification for this chemical requires a volume between 80 and 100 c i, to the pound, and the dust used in these experiments tested to the latter figure, the hopper capacity was approximately 125 pounds

The eddies caused by the protruding outlet tube, tended to draw the dust upwards around the fuselage, instead of forcing it downwards To ensure a downward pressure therefore, a slot was cut in the forward part of the tube, and a funnel attached which acted as an air inlet The outlet tube was also cut away somewhat at the rear The dust therefore, was forced in a downward direction

The dust feeding mechanism consisted of a cut-off valve in the bottom of the hopper, and a four bladed rotating paddle wheel

The valve was constructed to slide in and out under the paddle wheel, and was operated by means of a hand lever and connecting link

The paddle wheel was revolved by the operator through a pair of sprocket gears and a chain leading from the crank gear near the top of the hopper

The paddle wheel revolved when the valve was opened, and the dust was carried from the hopper and dropped into the air, through the outlet tube

Although this is one of the earlier types of hoppers, it most resembles the one in general favour at the present time Its chief drawback however is the irregularity of the dust flow by the hand crank control

Rate of Dust Delivery

The most satisfactory cranking rate at average flying speed, was found to be 30 revs per minute At this rate the hopper was emptied in approximately two miles

It was therefore necessary to take at each trip a strip of about 60 feet of cotton if the poundage of dust utilized per acre was not to exceed that distributed by the ground machines

These figures were obtained by straightaway flights with the feeder operating continuously from the start, until the hopper was empty

When this hand crank hopper was placed in service for actually dusting cotton fields, a serious difficulty developed, due to variation in the rate of flying speed of the plane, as it crossed back and forth over the fields

In turning to enter the field the plane would be flying at an altitude of probably 100 feet or more It would be manœuvred into position and then would glide downward with a throttled motor into the edge of the field It was often stil descending for perhaps the first 100 feet after crossing the edge of the cotton, especially if any obstructions intervened along that margin of the field The feeder would be opened and the crank started almost as soon as the plane passed the edge of the cotton

The dust would be blown out behind the plane for some distance, but often for about 150 feet after the plane entered the field, it was still gliding downward

The result was that the dust being put out at the normal rate, spread over a rather wide strip at the edge of the field Then the motor was gradually speeded up as the pilot neared the elevation desired, and when he reached this point he " gave her the gun " to maintain a safe flying speed at the low level across the field

This rapid increase in speed, with no change of the rate at which the dust was delivered, resulted in a very wide strip being treated at the edge of the field The margins being pulled in rapidly to a much narrower strip across the centre of the field, where the plane was travelling at full speed Then when the plane reached the far edge of the field it zoomed upward quickly and blew backward into the field the dust which was delivered as the feeder was being shut off

This practically reversed the conditions experienced while entering the field The zooming not only decreased the ground speed of the plane, but blew the dust downward and backward from a distance beyond the field

An outline of the dust cloud produced by this trip, presented somewhat the shape of an hour glass—wide at both ends, and narrowing rapidly to the middle

To avoid leaving untreated cotton with a dust cloud so shaped it was necessary to take only narrow strips

This resulted in much overlapping of poison near the ends of the rows if the strips were spaced close enough to give a thorough application at the middle

This may be compensated by varying the rate of cranking, as the speed of the plane changes

This, as I have stated, was attempted by hand, but proved impracticable because it depended on the personal equation and the judgment of the human

When moving at the rate of from 75 to 90 miles per hour, as is the case in this dusting work, ground is being covered so rapidly, that the slightest error in calculation on the part of the operator of the crank is tremendously magnified The need for a feeder which would perform this function automatically, resulted in the construction of the—

Air-Suction Hopper

In this device the dust is carried from the hopper by means of air suction created by the stream of air flowing down through the hopper

Since the air is collected by a funnel pointing forward over the trailing edge of the upper centre wing, its velocity is determined by the plane's speed, and the amount of suction created is thus in turn proportional to the speed of the plane

The general shape of the hopper is much the same as in the first design, and its size and location (between the pilot's and observer's cockpit) practically identical In this case, however, the paddle wheel is eliminated and a feeder inserted which consisted of a funnel extending slightly above the upper wing and connected to a 4 inch diameter sheet metal tube which extend down through the inside of the hopper, and to within 5 inches of the bottom

This tube acts as a guide for a sleeve valve (bell-mouthed at its lower end), which is free to slide up and down When at its lowest position, this sleeve seated on the upper end of the outlet tube, and thus prevents the dust from feeding out, while the rate of dust flow can be controlled by varying the height to which this valve is raised A cut off valve is provided, which is controlled through a link, attached to a lever hinged to the bottom of the fuselage, with a sliding rod and handle attached to the other end, to bring it within reach of the operator

The operation of the feeder is as follows The high velocity current of air blowing down through the tube has a tendency to create a vacuum around its lower end, producing a suction effect which would draw the dust out of the hopper into the air stream whenever the valve was lifted and will thus carry this dust out through the discharge tube In other words, it provides an air current running down through the hopper and an adjustable opening in the bottom of the hopper so that the varying quantities of dust can be drawn out with the air

To prevent packing of dust at the outlet, branch air tubes are fitted to the main duct, about midway up These discharge an air current around and above the outlet

When the dust discharge is shut off, the air duct is simultaneously closed by a butterfly valve Due to the resistance set up by the protruding air funnel and the occasional clogging of the small brach air tubes, this type of hopper has been superseded by an air-driven paddle type

Paddle Type Hopper

At this stage, designers learnt to pay more attention to the contour of the hopper, and we eventually evolved a very successful hopper, in the following form

At the top, a hinged lid for filling At the bottom the outlet (an aperture about 4 inches wide, extending to the full width of the hopper) This valve is operated by levers from the pilot's seat Above the outlet is a two-bladed paddle wheel, the shaft of which extends through the centre section of the wing and connects by means of gears to an air screw which has its bearing in the leading edge of the wing All unnecessary air resistance is eliminated throughout

Atmospheric Conditions

At the outset of dusting experiments, two problems were paramount First Can the planes be operated over a field in such a manner that the field will be thoroughly subjected to the cloud of dust? Secondly Can the dust be forced down from the plane into the plants and be made to adhere to them in a quantity sufficient to control insects?

The behaviour of the dust in the air was the subject of the first studies conducted In ordinary poisoning of cotton, what has been termed the "dust cloud method" has been developed

The dusting machine passing between or over the cotton rows, blows out the calcium arsenate in a fog which penetrates between all portions of the cotton plant,

https://doi.org/10.1017/S2976693100000892 Published online by Cambridge University Press

and consequently covers every exposed particle of plant tissue Successful dusting of this kind can be done only when the air is calm, and its success is greatly enhanced by the presence of moisture on the cotton leaves

For these reasons ordinary cotton dusting has become almost entirely a nocturnal operation , beginning usually during the period from 6 to 8 o'clock in the evening and continuing in the morning until the dew dries from the leaves, and the breeze springs up

At this point I will say that through data collected by aeroplane dusting experiments, more efficient ground machines have been evolved

Considerations of safety indicate, that flying for dusting should be confined to about seven or eight hours—say four hours in the early morning, and three in the afternoon Any attempt at low flying during the middle of the day is dangerous on account of rough air , and the air temperature is such that the engines overheat very badly in a short time From the results of analyses, together with the observations made on worm control it seems quite obvious that an astonishing amount of the poison adhered to the plants under a very wide path, under atmospheric conditions such, that it would be considered impossible to make the dust stick to the plants with the best of present ground dusting machines

Ground Equipment and Wind Information

In previous work of this kind the gound equipment has usually consisted of —

A tent for the storage of poison and equipment

Acetylene lights for illuminating the field when early morning poisoning is planned

A tower erected for the support of wind instruments, to provide definite information on the conditions of air movement near the ground This tower should be so arranged that the anemometer and wind vane are mounted about 15 feet from the ground

Definite information on wind conditions usually proves very important in deciding the manner in which a field should be safely flown

Although an eight miles-an-hour breeze would render impossible any effort to dust cotton with ordinary ground dusting machines, the dust application proves exceedingly uniform and successful under such air conditions

Altitude

Throughout the experimental periods of aeroplane dusting, flights were made at varying elevations, ranging from 5 feet to 50 feet above the plants, and it was almost always possible to distribute the poison from 25 feet or lower, regardless of air conditions

It is sometimes possible to distribute the dust down among the plants from even as high as 50 feet or more Apparently the explanation of this fact lies in the air currents set up by the plane and its propeller

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Slipstream Effect on Dust

A plane in flight is surrounded by a body of air moving backward at a considerable speed, and this air flow follows a spiral course, tending to one side and decidedly downward

Dust dropped from the plane into this air current, immediately becomes subjected to its influence, the air current being so exceedingly powerful that it completely counteracts, for some distance behind the plane all light breezes or other slight air movements existing on the ground Consequently, for some distance to the rear of the plane itself, the dust is still under the control of this air movement set up by the plane

All of these effects are exceedingly important in the dusting operation In fact, the downward tendency of the air current is probably one of the greatest contributing factors toward success in forcing the poison dust among the plants, regardless of existing air currents

The dust being delivered under the plane , instead of going directly to the ground, is blown backward from the point of delivery, and in some instances it is found that the dust is shot 100 feet or more to the rear of the point where it was dropped from the plane

Instead of opening the hopper at the edge of the field, it is opened a short distance after the plane has passed into the field, and this air current shoots the dust back to the margin of the cotton This is also of importance in connection with manœuvring, for dusting difficult situations , as I will explain later

Fog

The element of fog has a rather peculiar effect on the operations On one occasion during esperiments, the ground was blanketed by a layer of thick fog, about 20 to 30 feet in depth The haze was so heavy that vision did not extend far enough down the field to see the planes when they left the ground Thirty feet above the ground the pilots found that they were out of this fog with perfectly good air and vision for flying, but from the ground it was difficult to see the planes operate Flying as low in the fog as was possible without impeding the vision, the planes crossed back and forth over the cotton fields

Instead of a white dust cloud being swept out behind the plane, almost none was visible, although the feed valve was wide open, and putting out dust at the usual rate

The planes seemed to churn out a channel in the fog just slightly larger than the propeller diameter The dust delivered was entirely confined by the wall of fog nearly surrounding this channel, and did not spread out at all , merely coming down in a strip which did not cover more than three rows of cotton

In the next flights, made just as soon as the hoppers could be reloaded, the planes were operated a few feet above the top of the fog, and the behaviour of the dust changed entirely It was blown downward until it encountered the fog, but instead of immediately penetrating through it, it spread out on the top of the fog in a layer from 50 to 60 feet wide

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It seemed to remain at this point without motion, and the observers standing about in the cotton field under this fog, were puzzled to know what would become of the dust It could be observed on the fog for a few moments and then it seemed gradually to disappear

About the same instant however, everyone in the cotton field noted that the air was filled with fine, almost invisible particles of dust, falling to the plants After about two minutes, the plants which had been perfectly green before, presented the whitened appearance of a very heavy dusting

Method of Treatment

The usual manner of treating a field, consists of flying back and forth on paths which permit the dust clouds to overlap slightly The plane proceeds along one edge of the field and gradually works over to the other

Whether the plane flies *with* the rows, or at right angles to them, seems to make no important difference in the behaviour of the dust cloud Usually, the plane manœuvers at an altitude of from 50 to 100 feet or more until the right point is reached for entering the field It then dives, and if possible reaches the desired altitude of from 8 to 25 feet above the plants just before coming over the edge of the field The plane is then levelled out and shoots across the field at this elevation

At first the manner of leaving the field at the end of each trip was based somewhat on the surrounding conditions, but it was soon found, that the efficiency of the treatment could be considerably increased by turning upward sharply, just as the plane reached the edge of the field

This is because the dust is carried back for some distance by the slipstream, and if the plane is zoomed as the feeder is closed, the last dust delivered is blown back into the edge of the cotton field, giving a heavy treatment for the row ends

Confined Areas

In treating a field extending along timber, it is often possible to operate without difficulty by simply flying parallel to the timber line

In some instances, where a field is adjoined on two or more sides by timber, right-angle corners are presented After a little experiment, it has been found possible to treat these in either of two ways

If the timber is not too high, the plane should fly directly at the timber line and zoom upward sharply so that the tail points downward, and the dust is thus blown down into the corner of the field Where this is not possible, the plane is flown parallel to one side of the timber directly towards the right-angle corner, and banked sharply into a climb so that the tail of the plane is again turned into this corner It is thus found possible to treat any such situation encountered, even though the plane could not actually be flown over the whole field

Similar manœuvres are necessary in cases of trees scattered over the cotton fields On careful examination navigable lanes can often be found between the trees, in which to fly

Flight Direction

In operating the plane the pilot is forced to keep a keen look-out forward, and has very little chance to judge whether all portions of the field are being thoroughly treated Special arrangements must therefore be made for directing the flight from the ground, and when actual field poisoning is in progress, a man carrying a large white flag may be posted at each end of the path to be followed Photographic maps may be made of the area under treatment, and each section or field numbered on the map This will facilitate the distribution of areas to different pilots

The care and efficiency of the pilot will always be a very important factor in determining the thoroughness of the treatment

Extent of Dust Cloud

It is found that by properly controlling the dust delivery it is possible to give effective treatment to strips varying from 25 to approximately 50 feet in width Of course in the smaller fields, especially in those immediately adjoining obstructions, where definite direction of the dust is particularly desirable, the narrow strips are utilised, while in the larger fields, where it is desirable to take as much area at a time as possible, the feed may be increased to take care of wider strips These wide strips are possible only under favourable air conditions, and are especially suitable when the plants are moist

As the breeze increases later in the day and the plants become dry, the poison can be better controlled and the applications made more thorough and accurate, by taking narrow strips at a reduced rate of dust delivery

Adhesion of Poison to Plants

One of the most remarkable results of aeroplane dusting is the large amount of poison which adheres to the plants over a very wide path, and even under atmospheric conditions which would be considered impossible for adherence to occur with the use of the best of existing ground dusting machines This fact is interesting since it indicates the possibility of all types of dusting taking place during the daytime It has been suggested that it is probable that a considerable portion of the observed effect is due to the positive electrical charging of particles of the dust, and their coming in contact with the plants which carry a negative charge

Quantity of Poison Required

In using the standard calcium arsenate for leaf worm control, it has been found that from two to four pounds of the poison per acre is sufficient for the maximum effect The results of such dosages, so far as leaf worm control is concerned, is quite equal to those obtained from the use of ordinary dusting machines applying the poison at the rate of six or seven pounds per acre

In every instance during experiments the effect of the applications was watched with respect to mortality, not only of the worms in the field at the time, but also of those that hatched later from the eggs then present As with any form of dusting apparatus, it is difficult to control infestation when the plants have been rather thoroughly skeletonised before treatment, as it provides very little leaf surface on which the poison can adhere On the other hand, the control which results from aeroplane dusting on such fields is fully equal to that which follows the use of the most efficient hand guns or wheel traction machines, ordinarily used for Boll weevil dusting

Grade of Poison

Some trouble has been found by using different grades of the poison For example, calcium arsenate ranges in volume from 40 to 250 cu ins to the pound This is due to difference in the size of particles The heavier material does not behave very well in the air and drops directly to the ground The best results are obtained by using a material with about 90 cu ins to the pound

Alternative Insecticides

An alternative insecticide to calcium arsenate for leaf worm control is a mixture of ½ part of lime to one of Paris Green, and five parts of white flour The adhesive qualities provided by the flour seem to hold the material together fairly well in the air, which is a great advantage The quantity of this mixture used per acre in aeroplane dusting is only 1½ lbs, but with ground machines, Paris green is used to the extent of from 2 to 5 lbs per acre

Flying Obstructions

In some cotton plantations the ground is not thoroughly cleared Tree stumps are often left to rot instead of being pulled, and these stumps provide hibernation quarters for the insects

In using ground dusting machines it is a serious problem to take care of any considerable acreage of this sort, because the larger machines cannot be operated under such conditions These stumps of course, present not the slightest obstacle for the aeroplane, except to provide an element of danger if forced landings should be necessary, and with the planes it is possible to produce a much more thorough application than has ever been accomplished in ground work

In small fields, loss of time certainly occurs through turning at the end of each strip In some cases, however, strips from one to six, or eight miles long, are treated in a straight away flight

Danger of Poison Drift?

Many have feared danger from poisoning cotton fields adjoining corn or pasture land, the produce from which is to be fed to stock However, poisoning under such conditions has been done innumerable times for a number of years with ground machines, which permit fully as much drift of poison as the planes

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Forest Pest Control

The application of the aeroplane for forest pest control is now an accomplished fact in German forestry practice, and the subject has been recently reviewed by Wolff and Krausse (1925) Kreig (1925) refers to a severe outbreak of the pine moth (panolis flammea) in Germany in 1924, which was followed early in 1925 by an infestation of the nun moth (Lymantria monacha)

As this threatened to be of serious proportions, opportunity was taken to dust the infested area of forest with calcium arsenate discharged from aeroplanes

Flying at a height of 12 to 60 feet above the tops of the trees, the planes dusted strips varying from 80 to 120 yards wide A forest of about 600 acres, composed of mixed trees, required 38 such strips, and in the case of spruce, the poison expenditure amounted to about 26 lbs per acre

Since the nun moth larva is comparatively resistant to insecticide, the expenditure of calcium arsenate can be reduced for other insect pests

Subsequent examination showed that all the nun moth larvæ were killed in five to six days, and it is stated that no injurious effects were observed on birds or game

Locust Control

In North and South Africa, and other countries, where locust invasions are prevalent, the aeroplane is destined to form the most formidable weapon for controlling these plagues No other means can compare with it in such cases where prompt and energetic action is demanded at short notice and extensive areas of country are concerned

Large scale experiments by means of aeroplanes were carried out in 1925 by the Russian Commissariat of Agriculture, in conjunction with their Air Force, in the extensive reed beds of the River Kuma in the Northern Caucasus The experiments were directed against the European migratory locust (locusta migratoria L) and the trials were very satisfactory , about 2,700 acres being dusted

Mosquito Control

The mosquito (Anophelis larvæ) is another insect that has found a formidable enemy in the aeroplane Over flooded rice fields and swamps, much has been done to control the larvæ of malaria carrying mosquitos Much work of this nature has been carried out by the R A F in South Africa

Although in cotton dusting work under favourable conditions, several hundred acres an hour can be treated by a single plane, the swamp areas present much more difficult conditions One factor which appeared to favour the distribution of dust in such a manner, was that the direction of the air currents is usually downward over woods and bodies of water, whereas over open ground it is upward

Paris green appears to be the most favourable larvicide available for such insects It has proved to be as effective as oil, and is very much less expensive

The amount of dust desired has been determined by placing glass plates and dishes at varying intervals along the course, and studying the extent of the dust

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deposited thereon As so small an amount of this poison is necessary for killing this type of pest, a diluent in the form of finely ground silica earth is used, which helps to break up the poison in the air

Type of Aeroplane Used

During the experimental stages of cotton dusting by aeroplane in the U S, the Curtis JN6H machine, popularly termed the Jennie was used Fitted with the Hispano 150 h p engine, its maximum speed is about 90 miles per hour, while the safe ground speed is about 50 m p h The dust hopper capacity of this type of machine did not exceed 250 lbs

D H 4b's were also used, which enabled a dust load of 500 to 700 lbs to be carried

The popular types for this branch of flying in the U S to-day, are the Huff, Daland, and the WACO

The Huff, Daland Model 5 is a machine especially suitable for the small field type of work on account of its diminutive size, manœuvring capacity, and ease of control It has a dust load capacity of 300 lbs , carries fuel and oil for a four hours flight, and is capable of dusting 300-400 acres per hour

The Huff, Daland Model 31 was built to meet the requirements of dusting large open areas It has a dust load capacity of 1,000 lbs , carries fuel and oil for four hours, and can dust 600-1,000 acres per hour

Extent of Operations

It is assumed that 80 per cent of the average cotton fields in the United States can be dusted with the small machine, and at an average of 360 acres per hour, a day's flight of four hours will be capable of treating 1,440 acres This company alone dusted nearly 100,000 acres of cotton in 1926 The figure for 1923 being only 6,000 acres, proves beyond doubt the rapid progress in this branch of flying, and its superiority over ground operations

Allow me to sum up the advantages over ground operations, and cost

(1) It saves 50 to 60 per cent of the calcium arsenate required to produce the same results by any other method of dusting

(2) Unlike ground dusting it is not necessary that it should be carried out at night, and the usual dry winds are not a hindrance

(3) One aeroplane will carry out the work of 50-75 cart dusting machines, as the best cart machine, under favourable conditions, dusts about 30 acres a day compared with 200-1,000 acres *per hour* by a single aeroplane

(4) The possibilities of the aeroplane are limited only by its capacity for carrying fuel, oil, and dusting material

(5) In no case is the cost of the plane and its upkeep in repairs more than the original cost plus upkeep of the dusting machine that it replaced

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Possibilities in the British Empire

In England of course, there are comparatively few large areas devoted to single crop cultivation, and the possible application of the aeroplane, is necessarily limited Nevertheless, in 1924, fifty acres of fruit trees on a farm near Sevenoaks, were dusted against caterpillar infestation, and similar operations were carried out on potato crops more recently

Although the cotton plantations of the British Empire are not troubled with the same species of insects predominant in the United States, I can see no reason why similar operations cannot be carried out in place of the ground machines used in the extermination of the pests in our plantations

DISCUSSION

The CHAIRMAN I should like to ask the lecturer if the use of aeroplanes for dusting crops would be useful in hilly country In Ceylon, for instance, there are great plantations of tea, cocoa and rubber, but unfortunately they are nearly all in the hilly country, and I should think the pests there are quite as numerous as in the United States

It seems to me that very useful information might be obtained from the motion of the dust cloud, which would give some visible sign of what the actual currents are in open air Perhaps we might get information in that way which could not be obtained from wind tunnel experiments

I was very interested in the lecturer's remarks about the fogs that are sometimes experienced It reminds me of what happens in Bengal sometimes in the cold weather mornings There will be a dense fog about ten or twelve feet in depth, quite low on the ground, and the trees and houses can be seen standing out above it

I wish that in my younger days we had known a little more about the methods of destroying mosquitos There used to be five of us out at a place in Bengal, which is now a large railway junction, but there were never more than two on duty at one time—the others were always down with fever When I got out there I weighed a little over 11 stone In about two years I gained about 5 inches in height but my weight went down from 11 stone to about 9 stone

Mr RAYNHAM I should like to know if any experiments are being made with hoppers outside the slipstream? It would be interesting to know if the hoppers require the propeller slipstream to break up the dust, or whether it would break up equally well by letting it out at the wing tips If that were so it would make the dusting path very much wider

The lecturer said the cost of the ground dusting machines would be as much as the cost of the aeroplane I do not know whether he meant that the cost of 75 dusting machines would be the same as the cost of one aeroplane, but it would be rather interesting to know the cost of the ground dusting machines

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The aeroplane strikes me as being more favourably placed for dusting forests than for cotton fields, because it would be almost impossible to make dusting machines capable of dusting forest trees If the forests were of sufficient value to call for protection against insects, I should think aeroplanes would be of the greatest value

Major HEMMING I should like to congratulate Mr Dudley Wright on his very excellent paper and the large amount of useful information it contains

It strikes me that this cotton dusting is very dangerous, and I should like to know what rates the Insurance Company quote from the operating point of view It makes me think that the two-engined air survey machine which we hope to operate shortly would be the right kind of machine to use, especially for forest country I rather expected Mr Raynham would have something to say about flying over forest at a height of 50 feet, I do not think we could get an insurance rate for carrying out such flying

With regard to mosquitos, I am very interested to hear that this method of dusting has been used against mosquitos, but I am not quite clear whether they are killed in the larva stage in the water, or after they have developed I thought the only satisfactory way to kill mosquitos was in the larva stage, as was done at Panama

With reference to landing grounds, is it generally found in cotton plantation areas that you get good landing places, because that seems to me most essential, especially as the aeroplane can only dust for about half an hour or so, and then has to land It would appear that if a large area is being tackled an enormous number of landing grounds would be required

MR DUDLEY WRIGHT'S REPLY TO THE DISCUSSION

I wish to first thank you very much for your congratulations and appreciation of my paper, and for your attention during its reading

In reply, Mr Chairman, to your question regarding the operation of dusting aeroplanes in hilly country I think that the dangers of possible forced landings over such areas, would be offset by the advantages of time saving and accessibility, that would be experienced over ground operations

Mr Raynham raised the question of the possible use of hoppers situated on parts of the aeroplane other than in the slipstream, with a view to obtain a more expansive dust cloud

I will say, however, that the slipstream effect has proved so important in the efficient application of the dust, that it is very improbable that relocation of the hopper would prove successful I regret to say that I do not possess figures of cost for existing ground dusting machines I should like to draw your attention however, to a comparison made by Mr Henry Ford between horse and mechanical means for agricultural operations, in reference to ploughing

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Cost of Fordson Tractor (at time of comparison), 880 dollars.		
Wearing life, 3,840 acres (4,800 hours at 4/5 acres per hour).		
3,840 acres at 880 dollars.	Depreciation per acre	$.221
Repairs for 3,840 acres, 100 dollars.	per acre	$.026
Kerosene Fuel at 19 cents. per gallon......2 gallons	per acre	$.380
Oil, $\frac{3}{4}$ gallons per 8 acres	per acre	$.075
Driver at 2 dollars per day of 8 acres	per acre	$.250
Cost of ploughing with Tractor	per acre	$.950
Eight horses cost 1,200 dollars.		
Working life, 4,000 acres (5,000 hours at 4/5 acre per hour).		
4,000 acres at 1,200 dollars	Depreciation per acre	$.300
Feed per horse during 100 working days, 40 cents	per acre	$.400
Feed per horse during 265 idle days, 10 cents	per acre	$.265
Two drivers (two-gang plough) at 2 dollars per day	per acre	$.500
Cost of ploughing with horses,	per acre	$1.460

In this instance the use of mechanical means saves 51 cents. or half-a-crown per acre, and the work is completed in one-fourth the time.

Although I realise that the cost of aeroplane operation is considerably greater than that of motor tractors, I must emphasise the paramount importance of time saving and its bearing on ultimate cost.

Major Hemming suggests the use of twin engine aeroplanes in dusting operations, to minimise the risk of forced landings. I do not consider that twin engine machines have sufficient manœuvrability for the short and frequent turns necessary for economical aeroplane dusting of crops. For forest pest control however, such machines should be of advantage, and are actually used at the present time in German forestry practice.

With regard to difficulty in securing a conveniently situated landing ground. In the United States such a problem was rarely encountered, and I think it unlikely that a suitable area could not be discovered within a reasonable radius of any similar operations. In reference to mosquitos ; these are poisoned in the larva stage.

The cost of cotton dusting by aeroplane in the United States amounts to approximately 30/- per acre, and the cotton infestation is such that at 5d. per pound of seed cotton, it is worth £6 16s 0d. per acre for the grower to have his crop so treated.

A hearty vote of thanks to the Lecturer and the Chairman brought the meeting to a close.

https://doi.org/10.1017/S2976693100000892 Published online by Cambridge University Press