Study and design of a pneumatic spray boom with slot nozzle

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Abstract

The aim of our study is to design, produce and adapt a multi-outlet ramp to a man-made pneumatic sprayer, this type of sprayer having only one outlet. The tests were carried out at The results of the experiment showed that the liquid flow is not totally uniform on the set of nozzles, the convergence of the surface treated in function Of the height of the ramp and the best covering obtained at a height of 60 cm, our tests showed that the optimum use of the sprayer is possible only with a flow rate of 200 ml / min at a height of Metre. And for best finesse in gouachetes was observed on the maximum speed of the fan rotation. We have also found that the number of droplets per square meter is strongly influenced by the liquid flow of sprayed product and the height of the ramp. The droplet diameter is strongly influenced by the liquid flow and the height of the ramp. The NMD is strongly influenced by the small drops and the VMD is strongly influenced by the large drops. The quantity of liquid sprayed per hectare is close to that of other sprayer between 400 and 600 liters.

Keywords : **Pneumatic spraying, Spray nozzle, Phytosanitary treatment, atomizer.**

1. Introduction

Agricultural spraying is the transport of pesticides and liquid fertilizers in the form of a slurry inside the tank in cm3 via the nozzles to form fine droplets in order to project them on the targets.[3]

The objective of the spraying is to make several types of treatment, with a suitable material (special nozzles, covers ...) to protect the crop plant or the délicate parts of it, Directe treatment, For the generalized treatment carried out on the whole of either the vegetation or the surface of a cultivated or uncultivated land, and for the latter type of treatment it is the localized method carried out on only part of the crop or Plant like clusters of resins for example. [1]

Howe ver, the treatment requiers, in addition to crop protection produits, adéquate material and a well-defined ajustement according to the type of crop and the working conditions.

Also for a good treatment efficiency it is necessary to choose the moment of application on the target or on the pests and the pests, among other things, the division and division mode of droplets on the targets as important and which depend on the machine and Tool. [6]

The aim of our study is to design, produce and adapt a ramp with several outlets for a pneumatic sprayer carried by a man, this type of sprayer has only one outlet

In case of poch results, this adaptation will increase the working capacity of such a device

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is to be able to use it on larger surfaces (more than one hectare) and inside the plasticulture greenhouses, or Well on intercropping and shelving between orchard trees.Because of the low cost it will be put at the disposal of small farmers, because the use of motorized equipment (tractors, mounted sprayer) is not possible because costly and not profitable, and also the access to the terain with the tractors is not possible after the fall rainy therefore a very favorable moment for the development of certain fungal diseases.

In general the manufacture of small materials can also participate in the creation of micro-enterprises without a large share of initial funds

Therefore after the design and manufacture of the pneumatic ramp with slot nozzles it would be mandatory to verify some hypothesis and problem that concerns the quality of work of the machine, therefore is that the nozzles give good droplets,

- What is the flow of liquid required for the good droplet?
- What is the correct fan speed that gives us a better spray?What is the proper height of the ramp to properly cover the target? Or which gives us à good recovery of the sprayed product.

2. Materials and methods

2.1. Characteristic of the backpack sprayer

The main element is the tank which contains the product with a capacity of 12,5 liters, the tank is very light and transparent plastic, and the same with the fuel tank which is beside it with a capacity of 2 liters.

The second most important element is the petrol engine (unleaded) has 2 strokes 42,7 cm^3 of speed 2700 rpm and a power of 0,5 hp. The maximum engine speed is 4000 rpm, and the minimum speed is 1500 rpm. The engine provided with an acceleration lever in order to vary the speed of the engine and its speed of rotation. For the regime recommended by the manufacturer, the accelerator must be set to level 2/3, above this regime is the risk of forcing the engine.

The machine equipped with a centrifugal bladed fan in the rear, which gives a high flow rate and low static pressure, we are interested more at the air speed which must approach 25 to 30 m / s for a fine spraying, This speed corresponds to the nominal speed of the 2/3 engine.

2.2 Ramp construction materials

To minimize the weight of portable sprayer, it must be made of plastic or aluminum.

The PVC tubes for the manufacture of the ramp of a length of 3 meters and diameter of 33 mm. The choice of this type of rigid PVC so that the ramp is resistant to the different loads of the other elements which it carries. The degree of elasticity is 2410 N / mm^2.

For the manufacture of the nozzles, PVC pipes are made of non-rigid plasticized PVC to facilitate its flaring at the outlet. The diameter of this tube is 22 mm.

For the liquid circuit from the tank to the nozzles, 5 mm diameter, with a tap to control the flow of liquid with three positions: flow 1: minimum, flow 2: medium and flow 3: max**.**

2.3 Measuring equipment

The measuring equipment used in individualized by stages of experimentation is very necessary for the final characterization of the machine and spray technicians and operators.

- Tachometer : it is used to measure the rotational speed of the motor in revolution / min .Its conssite operation depression of the cone of the apparatus on the rotor of the fan,
- Anemometer : To measure the speed or the pressure of the wind, the speed of the air Va.

The air flow Qa crossing the section S of the nozzle (the venturi) of the atomiser is given by the following relation:

Q_a : Air flow rate in m^3/s

V_a : Section of the nozzle outlet in m²

S : Speed of air in m / s

- Microscope: the objective moves under the action of a micrometric vernier, it gives us the size of the droplets, it also allows the count of the droplets in a cm².
- Other equipment :

- A timekeeper for working time.
- A special paper (plain paper) used to measure the size and number of droplets.
- Water for spraying testing.
- A black dye (Chinese ink).
- Containers for the recovery of the liquid.
- Of the graduated cylinder, for the measurement of the volume of the liquid (scale of 500 ml / 250 ml of volume).
- (2 to 3 meters long).
- A micrometer reticle for measuring the actual size of droplets.

2.4Experimental method

2.4.1 Method of measuring air flow

In the experiment and for the variation of the air flow rate, we used the variation of the engine speed.

After the sprayer motor has been switched on, the speed of the air flow of the fan is measured by an anemometer placed at a distance of 20 cm from the air outlet or the refluxing flange for a few seconds.

The air velocity in m / s and knowing the cross-section is read on the counter of the anemometer, the air flow is drawn from the relation V = Q / S.

2.4.2 Demining the number of nozzles in the ramp length

The determination of the number of nozzles in the ramp is a function of the air flow delivered by the fan, this air flow must be sufficient to supply all the nozzles along the length of the ramp.

From the following relationship the air velocity at the outlet of the nozzles is determined as a function of the outlet and the air flow rate.

If the air flow rate of the main outlet of the fan is divided by the number of nozzles, the air flow at the nozzles is obtained:

Air flow rate of the nozzles = 0, 1056/5 = 0,02 m^3/s

The air velocity is checked as follows:

Therefore at the nominal speed of the engine there is an air flow at the main outlet equal to 0.1056 m^3 / s, it corresponds to an air velocity of 24 m / s, the air velocity obtained at the nozzles Is 18.18 m /s. It can be said that the dimensions and the number of nozzles are well chosen according to the length of the ramp and the air flow delivered by the fan.

2.4.3 Detonation the angle of the diffuser (nozzle) inside the ramp

The objective of this step is to ensure the same air flow for the 5 nozzles along the length of the ramp, it is a step which has required a lot of experimentation and tatonnage for its realization.

After the nozzle number of the ramps has been determined, and the different dimensional characteristics such as the internal diameter, external, a nozzle is obtained which assures several advantages such as: a great fineness of droplets, the surface covered or treated, and a penetration of Liquid in the vegetation, multiuse of this nozzle, its maintenance is very easy, interchangeability and they are not sensitive to the problems of precipitation of the liquid.

2.4.4 Method and measurement of liquid flow

The engine is operated at a nominal speed of 2/3 of the accelaration, then the valve is opened at position 1, the sprayed vomum is collected for two minutes in a receiver at a distance of 30 cm from the nozzle and this is repeated Measured for the three valve positions.

This process is repeated for different liquid flow rates in a growing prout

From the following relation, the liquid flow rate:

Q_t : Flow in liter per second (l / s)

V : Volume in liter (l)

t : Time in second (s)

The measurements were repeated for the three positions of the tap, in the same working condition

3. Results

3.1 Analysis of the air flow rate in relation to the speed of rotation of the motor

This analysis concerns the measurement of the air flow and establishes a relation between this flow and the engine regime. The results obtained in the experiment are indicated in fig 1 .

Fig.1 : Variation of air flow as a function of engine speed.

Fig. 1 shows the variation of the air flow rate as a function of the engine speed. According to this graph, it can be seen that the air flow rate of 0.02 m / s corresponds to an engine rotation speed of about 2000 rpm.

3.2 Analysis of the uniformity of the flows over all the nozzles

The uniformity of flows is a very important factor, which largely determines the quality of the treatments carried out using the sprayers. Our analysis focused on the measurement of the different flow rates over the nozzle assembly, the results obtained in the tests are given in fig.1.

From this Fig. 2 it can be deduced that the nozzles situated in the middle of the ramp have the highest flow rates while those of the ends have the lowest flow rates,

this is explained by the feeding system of the busses , The nozzles of the center are the first to be fed, and the manufacture of the nozzles.

Flow variability is practically recorded in almost all feeding pipes such as irrigation systems (pivot) and ramps of sprayers.

If the difference in flow rates is less than 10%, we can say that our supply is normal. Otherwise, the system is faulty which leads us to change the nozzle or to check the piping state in the general case of sprayers.

3.3 Analysis of the influence of the height of the ramp on the distribution of the jets

This analysis has focused on the influence of the height of the ramps on the distribution of the jets, the height of the rapes largely determines the quality of the spraying, and it influences the size of the droplets and especially on the drift. However, influenced by speculation and culture, the set of results shown in Fig.3.

Fig. 3 shows the influence of the height of the ramp on the surface of the impact of the liquid

From this figure it can be deduced that the height of the ramp is very important because of the mode of division of the liquid, this is explained by the modification of the trajectory and the size of the droplets under the secondary division effect.

Fig.3 : Influence of the height of the ramp on the diameter of the liquid jet.

Fig.2 : Presentation the three flows of liquid in the 5 nozzles of the ramps.

The trajectory of the droplets is variable with the height of the ramp, in fact, the graph shows a significant increase in the diameter of the jet, and the maximum valuesare between the heights 70 and 80 cm, finally marking a precipitation of the diameter of the jet for Heights greater than 80 cm. This progression is explained by the fact that the trajectory of the drop becomes very sensitive to the drift.

It is possible that the velocity of droplet drop influences the coverage of the jet, this will be verified by the results of the experiment

It is also logical that the average dose may decrease when the height of the ramp increases.

So it is worth mentioning, especially at our test conditions, that the best distribution is obtained at an average height of 75 cm.

3.4 visual analysis of droplet collecting paper

The effectiveness of a treatment depends first and foremost on a good spray coverage (number of impacts per cm²). The higher the density on the targeted target, the greater the toxic effect on the parasite and the greater the death rate Rapid, irrespective of the mode of action of the product [6].

We seek a homogeneous distribution dependent on the distribution of droplet diameters:

- Large drops, drops running down the vegetation and do not allow to reach precisely the expected value in density and total coverage.
- Too thin, their kinetic energy is insufficient, one risks a drift of the product, and even its partial evaporation.

3.4.1 Results in flow 1 and highyr 50 cm

From the results obtained from the visual maps of flow 1 height 1 with 50 cm, it can be seen that the number of droplets and the diameter of the latter per cm² is very high, which automatically gives us a coefficient of homogeneity Important, the density of the droplets will be large, which will lead us to conclude this type of adjustment is advised against in most of the treatment in agriculture.

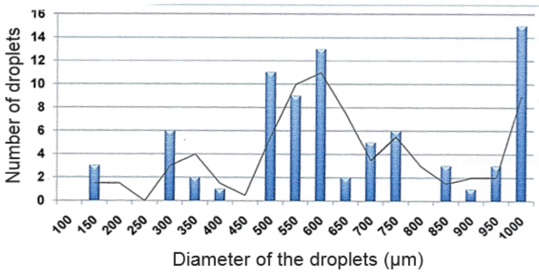

Fig.4 *:* Number of droplets per size class as a function of droplet diameter flow rate 1/50 cm.

Fig. 4 shows the variation in the number of droplets per size class as a function of the droplet diameter, this figure clearly shows that the droplets having a size between 500 and 1000 µm are the most numerous, but in most of the Agriculture these droplet sizes are not used.

3.4.2 Results in flow 1 and highyr 75 cm

The results obtained from the visual maps of flow 1 and height 75 cm (Fig. 5) show that the number of droplets and the diameter of these droplets per cm² is lower than the first, Gives us automatically a lower coefficient of homogeny, droplet density will be lower, which will lead us to conclude this type of adjustment is advised relatively for contact pesticides.

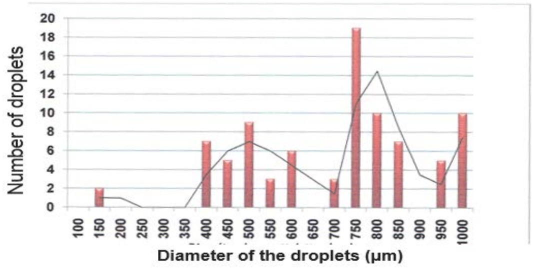

Fig.5 : Number of droplets per size class as a function of droplet diameter flow rate 1/75 cm.

Fig. 5 shows the number of droplets per size class as a function of the diameter of the droplets, and noting that although droplets having a size between 400 µm and 750 µm are the most numerous, this case nevertheless approximates the settings recommended in Treatments of pesticides on different crops and pests.

3.4.3 Results in flow 1 and highyr 100cm

The number of droplets and the diameter of the droplets per cm², is the most ideal, the coefficient of intake of the droplets, Homogeneity is equal to 2.5, the droplets are very homogeneous, this case is frequently encountered in the treatment with slit or spray nozzles, which leads to the conclusion that this type of adjustment is to be prescribed in most treatments Used in agriculture,

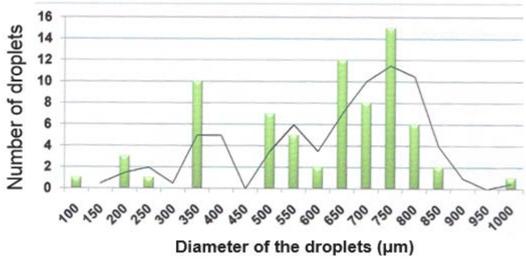

Fig.6 : Number of droplets per size class as a function of droplet diameter flow rate 1/100 cm.

Fig. 6 shows the variation of the number of droplets per size class as a function of the diameter of the droplets. This figure clearly shows that the droplets which have a size between 350 and 750 µm, this case is most found in the majority of processes Phytosanitary.

3.5 Analysis of the volume of the sludge per hectare

This analysis was carried out in order to verify the quantity of the liquid sprayed per hectare. The results obtained are as follows:

The time to travel a distance of 200 m is 308 seconds and therefore 5 minutes and 12 seconds, so the speed of travel during treatment V = 0.86 m / s = 3.12 km / h.

For 600 m traveled consumed 23 liters of liquid which thus for one hectare a consumption of 770 liters.

In the field of agricultural spraying with crop protection products, from 50 to 500 l / ha are sprayed with current values of the order of 200 to 300 l / ha. For our sprayer we pulverize to an amount that approaches other sprayers.

Therefore the results obtained with the aid of our sprayer are in the noremes, it is nevertheless necessary to fill the tank 62 times per hectare.

The objective of our work is design is to treat small plots that do not exceed one hectare, and inside the tunnel greenhouses, which reduces the number of filling of our tank.

4. Conclusion

The objective of our work is the design, production and adaptation of a multi-outlet ramp with a pneumatic sprayer carried on a man's back.

This type of sprayer has initially only one outlet.

Our work is a contribution to the preoccupations of pneumatic spraying.

The interest of such an apparatus are as follows:

- Treatment done on small to medium surfaces without incurring any major disturbance, the length of the ramp being 3 meters.
- The same appliance equipped with a longer ramp could handle larger surfaces.
- compared to the single output sprayer, the projected one saves time.
- Not being carried by a tractor, it can be treated even when the soil is soaked.

The following conclusions can be drawn from the examination of all the results of this study:

- Presence of uniformity of liquid flow rate on the assembly of the nozzles.
- Presence of a cover of the diameter of the jet depending on the height of the ramp.
- The number of droplets per square centimeter is strongly influenced by the liquid flow and the height of the ramp.
- The diameter of the droplets is strongly influenced by the liquid flow and the height of the ramp.
- NMD is strongly influenced by small drops.
- VMD is strongly influenced by large drops.
- the quantity of liquid sprayed per hectare is the same as that recorded with the other sprayer tuprds, on the order of 400 to 600 liters per hectare.

As a perspective of our taravil it would be advantageous to modify the wearing of the ramp by a single operator thus facilitating the adjustment of the spray height.

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