RECENT TREND OF RESEARCH AND DEVELOPMENT OF PEST CONTROL MACHINE IN JAPAN

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INTRODUCTION

Steady crop production, increase of the yield, and improvement of the quality, largely depend on the improvement of cultivation techniques and so on, as well as that of agricultural chemicals application techniques.

These application techniques improve as agricultural chemicals, pest control machines and application methods improvement and development, since the above three are closely related with each other.

Requirements for the pest control machine cause high efficiency, labor saving and work load reduction, as well as sufficient effects by most effective application with minimum quantity of agricultural chemical applied target.

The development of techniques to avoid exposure to agricultural chemicals for safety of the workers during application and that of techniques to minimize drift of agricultural chemicals for the environmental preservation are also important.

This paper shows recent trend or situation of research and development of pest control machine in Japan.

1. Power sprayer

Reciprocating pumps for the power sprayer are used as a main part of pest control machines such as portable type power sprayer, traveling type sprayer or air blast sprayer, all of which spray liquid chemicals. Each basic structures of pump are similar, but the weight has due to adoption of aluminum die-cast and ceramic has come to use for the plunger, suction valves, discharge valve or pressure regulator and so on, allowing high pressure, high speed revolution and improving the durability of the pump. This allows use of smaller size diameter spray hoses while keeping the pressure of the nozzle even when using a long hose and making handling a hose much easier.

Also there are pumps which are designed to simplify maintenance. For example, those are designed to avoid uneven abrasion of the V-packing with the self aligning mechanism, those are equipped with the non lubrication mechanism to the V-packing, or those have spring loaded

semiautomatic fastening mechanism mounted for the fixing portion of the V-packing.

For hose reels used in the portable power sprayer, automatic hose reels or self-arrangement hose reels has been developed, thereby reducing the number of workers and the work load on the workers, or enhancing the efficiency of the operations.

The levee nozzle has a valve attached which closes automatically at the time of pressure drop. The valve operates to prevent the agricultural chemicals dropping times when the pressure regulator lever is shifted to the side of the pressurization or when the liquid chemical tank is emptied and the pressure at the nozzle pipe become lower than normal pressure.

Generally, power sprayer are used with hose reel, spraying hose and nozzles. Some models of the commercialized power sprayer have radio controller to reel the hose, start and stop the engine, or adjusted the throttle, thereby has attained substantial load saving.

2. Pest control machines for paddy fields

(1) Knapsack type power applicator

The knapsack type power applicator is a small and high-efficient pest control machine, especially, if it is used a boom type blow head with swath 20-40 m wide, it allows the area of 10a to be finished working in a few minutes. This is also used to apply powder, granular, or liquid formulation by changing or adjusting part of the machine. In addition, it is used to apply granular fertilizer as well as agricultural chemicals, resulting in wide spread on the market.

For knapsack type power applicators, enhancement of performance, research and development have been performed recently for more light weight and easier handling, in order to reduce work load on operators.

Just as the name shows, the knapsack type power applicator is carried on man's back while working, so it is difficult to know residual chemicals quantity in the tank, causing lack or over application. To prevent this, some applicators have the liquid-crystal indicator on the blow pipe at hand and silicon photo transistors to detect the residual chemical quantity in the tank, allowing you to know residual quantity during application.

Also, there are some applicators of the same type that are designed to prevent static electricity using the blow head and earth chain made of material with high conductivity, and that are designed to improve vibration resistance and air per meability by reforming the back plate.

Materials of conventional knapsack type power applicators were light alloys such as aluminum alloy or magnesium alloy, which are inferior in corrosion resistance, very often causing the inside corrosion even with sufficient surface treatment because of too much permeability of chemicals. To prevent this, plastic material has been used in recent years, thereby the corrosion resistance has been improved and the weight become more light.

Plastic materials have been used for chemical tank, fuel tank, and blow pipe. Recently, plastic parts are increasing except the parts such as blower and engine. Moreover, considering the heat resistance , stiffness or other features, polyester, Teflon, acotal, polycarbonate and nylon, etc. have been

widely used.

Therefore, plastic is considered to be used more widely in terms of its features in the future.

(2)Riding type vehicle with applicator in paddy fields

As spray for paddy, the application method which adopts a power sprayer with a levee nozzle, has acquired a widely spread conventionally. However, this method provides only the swath width of less than 20 m, which is insufficient for large plots, and has caused difficulty in ensuring the number of workers to hold spray hose.

Aerial application by manned helicopters or knapsack type power applicators is high efficiency, but they have caused a pollution problem in the regional environment due to drift as mixed areas of houses and farms expands.

In this background, techniques of the vehicle for the paddy fields has been developed recently.

A riding type vehicle in paddy field mainly used is a traveling device of the riding type rice transplanter, which can reduce production costs, attain more labor saving and can enhance the availability of the machines. Also, techniques to allow multiple works have been studied and developed.

While the method of band fertilizing for simultaneous work with rice planting intended for labor saving has been become popular, a rice planter with pest control machine and band fertilizer has been developed recently. The rear mounted pest control machine can apply granule herbicide in proportion to planting speed.

Granule discharged from the tank, is adjusted by metering device and it is drooped on the impeller which is rotating at high speed. Finally it is spread and applied.

Since fluid type herbicide has been developed and spread , dropping applicators set up on the riding type rice transplanter have been developed as well.

For multipurpose use or improvement availability of rice transplanter, researches have been performed on seeding and application of granule chemicals or granule fertilizer by the knapsack type power applicator mounted on the riding type rice transplanter whose transplanting device is remove.

Also, low volume sprayer which the pump is driven by ground speed PTO of the rice transplanter, has been developed and its availability is recognized.

In all the above cases, the rice transplanters are utilized. Based on the accumulated research on vehicle for crop tending work in paddy field, BRAIN has been making a joint research and development with manufacturers on the vehicles.

The purpose of this development is to develop multipurpose vehicle and working machine which carry out transplanting or crop tending work (agricultural chemical application and fertilization etc.), with high accuracy and efficiency.

In March, 1995, a vehicle itself, rice transplanter and low volume boom sprayer have been developed, and also they are scheduled to be put on the market around this fall of 1995. Also, we are carrying on study make a practical use of a granule applicator for herbicide, fertilizer and so on in next spring.

The vehicle has been developed based on a riding type rice transplanter, and has the following

features:

1) It has a standardized quick hitch, allowing a simple attaching or removing of various working machines.

2) It has two PTO shaft (one is ground speed PTO shaft and the other one is live PTO shaft), allowing various works.

3) Tread of front and rear wheel are same (120 cm), in order to reduce damage of paddy.

4) It is equipped with wheels suited for rice transplanting or crop tending work, allowing a good traffic ability and less damage of paddy.

5) Its minimum ground clearance is about 10 cm higher than that of ordinary rice planter, allowing less damage of paddy.

Low volume boom sprayer has the following features:

1) Application rate of this sprayer (swath width of 7.5 m) is 25L/10a (dilution is 300 times). Traffic ability and stability of the vehicle have been improved because the tank become smaller and the body become more light than ordinary sprayer.

2) It drives the spraying pump by ground speed PTO shafts, allowing more constant and accurate application in proportion to application speed.

3) It has the air-assist system therefor deposit efficiency on paddy has improved and drift has been reduced.

Rice transplanting by the vehicle is almost the same accuracy and efficiency as the ordinary riding type rice transplanter. Application speed is about 0.6-0.8m/sec and its work performance is about 1 ha/h.

There is small damage while working but one example of test results show that decrease rate of yield is estimated at 1-2% after 4-5 times works.

(3) Unmanned helicopters

Chemical application by manned helicopters tend to be harder, as the area where it is impossible to perform has been expanding due to more mixed area of farm and habitation in recent years. In this background, unmanned helicopters have been developed, designed to supplementary apply for paddy fields where application by manned helicopters is difficult and to be utilized for the upland fields or orchards where manned helicopters are hard to use due to small acreage and complicated cropping.

The fundamental design of unmanned helicopters is as follows:

1) Maximum weight of equipment should be 100 kg or less.

2) The loading capacity of agricultural chemicals should be 10 kg, and payload for the machine shall be 20 kg or more.

3) The flying speed, application height, and effective swath width shall be allow for approximately 10-20 km/h, 2-5 m, and 5 m respectively.

4) It shall be operated mainly manually for radio control, and it should be easy operation.

5) The accuracy of the radio control shall be expected in accessible distance of 100 m at least.

As a result that the test was performed on its effect on paddy rice, its practical use has been considered, and " guidelines for utilization techniques of unmanned helicopters " was established in April, 1990.

As unmanned helicopters have been spread recently, much effort have made to increase applicable agricultural chemicals and train a lot of excellent operators.

In addition, its practical use on the following has been considered: pest control of wheat, soybean, lotus root, fruit trees and direct seeding.

3. Applicator for upland field: boom sprayer

Most of the traveling systems of the boom sprayer are conventionally of tractor-mount type, but recently self-propelled type boom sprayer with high volume liquid tank has been marketed, and also those with simple cabin or cabin have air conditioner, has been put on the market in order to improve working conditions or exposure of agricultural chemicals for workers.

Generally, the boom is mounted as the part of the machine, but some self-propelled type, boom sprayers have the front mounted boom, allowing work while watching the splaying condition, with easier adjustment of application height.

The swath width of many boom sprayer is usually more or less than 10 m, but recently those with swath width of 25 m has been marketed as the weight has been reduced due to adoption of the boom made of aluminum. Many of the booms with such wide swath width allows the swath width to be adjusted by the telescopic boom, thereby improving the work efficiency or preventing overlap application.

Also, in large scale vegetable production areas, one side application type boom sprayers with swath width of about 15 m have increased with increase of big size tractors in recent years. There are fixed and reversible one side application type boom sprayers. Some of the former sprayers have the liquid chemical tank offset considering stability of the machine.

These one side application type boom sprayers allow the number of paths in the upland field to be half decreased, thereby improving utilization and work efficiency of upland field.

During application, the application height varies depending on height of crops and unevenness inclination of upland field. Also under some conditions of upland fields, the application speed varies with slippage of wheels, etc., causing non uniformity of application due to inconstant application rate. To prevent this, the devices which use photo elutric sensors or ultrasonic sensors to detect the distance from boom to crop and adjust the boom to keep constant application height automatically have been developed, or the study in which the application rate can be controlled automatically in proportion to application speed have been made.

4. Pest control machines for greenhouse

Recently, production of vegetables, flowers, or fruits has been getting more dependent on greenhouse cultivation, especially that of tomato, cucumber, strawberry, and melon grown in greenhouses

is more than that in open fields. These greenhouses have some faults to damage by disease and insects pest due to its closed condition and high temperature and humidity. Therefore, chemical application is generally more necessary to keep steady yield or quality than that for open fields. For pest control in greenhouses, the application method which application rate of diluted liquid chemicals is high, has been widely used conventionally. However, this method causes a trouble in handling hoses, high work load and exposure to agricultural chemicals on workers under the condition of high temperature or humidity.

To solve these problems, various unmanned application methods which workers need not stay longer in a green house, have been utilized. Especially, automatic sprayers with ridge sensing systems have been widely used in recent years. Also much attention is paid to the study about method of electrostatic application utilized for the cold foggier.

(1)Automatic sprayer with ridge sensing system

The automatic sprayer with ridge sensing system is constructed of traveling devices which mounts a hose reel nozzles. The traveling devices driven by motors whose power source is battery, and that can travel by the front wheels with a one -way clutch mounted on the axle.

For application, it adopts an automatic reciprocating application method in which it travels along the ridge intervals, and when getting to end of the ridge, the switch of the sprayer touches the pre-installed stake and starts traveling back ward while reeling the hose automatically proportionally to the traveling speed, until it returns back to the starting point. The liquid chemical is applied by power sprayer and liquid chemical tank where is located on the outside of greenhouse.

Four kinds of methods on guided traveling systems have been developed. One is the method which L-shaped steel is put between the ridges guides the machine to travel to according to the guide mounted on the wheel at the right side of forward, one is the machine travels along the side of a ridge by the guide wheel, one is using electromagnetic guide cables, and other is that to detect the ridge to guide the machine to travel by the photoelectric sensors mounted at front, rear, right and left sides of the machine.

As good points, it is capable to apply without human by using power sprayer at hand, and also use any applicable agricultural chemicals inside a greenhouse.

Moreover it is able to use not only for greenhouse cultivation but also for open field cultivation.

(2) Electrostatic application with cold foggier

In electrostatic application method, agricultural chemicals are applied to be attached to crops by using the electric power generated when fine particles of agricultural chemicals given high voltage static electricity and crops given the opposite electric charge.

This method has the same features as follows. Reduction agricultural chemicals can be possible because of its high effect on application of agricultural chemicals. The deposit on even back side of leaves can be higher than the conventional method. It is good for environment because of its less scatteration agricultural chemicals.

On the other hand, it has some problems as following. It needs high voltage equipment. Careful attention should be paid to insulation. After agricultural chemicals are used to apply because it is possible to only low and ultra-low volume application.

The equipment considered to use for a practical use of it, consists of a liquid chemical tank, blow head (two-fluid nozzle), a voltage generator, an electrode, and a compressor to send air to the nozzle.

For the electrode charged on applied particles, annular electrode by inductive electrification method is adopted.

5. Sprayer for fruit trees

In fruit culture, chemical application is necessary for pest control. More than ten applications per year are performed, though it depends on the kinds of trees. Chemical application was mechanized for fruit culture on relatively earlier time and in cultivation of deciduous trees like apples, the reduction of labor has been accomplished due to adopt of air blast sprayers.

On the other hand, the decline in both quantity and quality of labor force is caused by increase people of advanced age for farm work. To solve this problem, the reduction of labor and a safety and comfortable working condition should be used.

Form this point of view, study for full-automating sprayers(unman)for fruit trees has progressed, and in fact some of them have already been commercialized.

(1)Radio control sprayer

The radio control sprayer is constructed of an automatic hose reel, blower and blow head on a traveling unit. Liquid chemicals are sent to sprayer by power sprayer from liquid chemical tank where are located outside of the field as in the automatic traveling type sprayers.

It is employed one side application type which is able to apply agricultural chemicals to one side row in forward travel, and after the direction of the blow head is shifted at the end of the tree row, it sprays agricultural chemicals to other side row in backward travel while the hose is reeled.

The traveling unit employs a crawler which allows forward and backward traveling, stoppage, open/close of spray cock, and turning the blow head, by radio control. A switch is mounted at the front bumper of the machine, and if the bumper touches a stake pre-installed at the end of the tree row, the traveling of the machine and its application can stopped.

This is mainly used for chemical application of dwarf apple, and also it has been attempted for citrus trees.

(2) Citrus sprayer

Because of that citrus is generally grown on slant areas and it is densely planted in Japan, it is difficult to use machines.

At present, the spraying by using a power sprayer with a long hose is widely performed, but since it is a very hard work, a development of a sprayer is needed to reduce the labor and rise the efficiency.

In some cases, sprinklers or air blast sprayers are utilized . However one row of trees should be cut away to make enough space for using air blast sprayer. As result, it is caused a problem of decrease in yield per area, and another problem of safety due to easily fall of the sprayer on the slant area. The citrus sprayers have come to use practically as following.

(1) Citrus sprayer with twirling nozzle pipes for small type vehicle

As stated above, it is difficult to use a sprayer in citrus orchards, but it can be possible to use a machine by changing the shape of the machine and dwarfing of it. So a low height vehicle which has a traveling part with the crawler was developed to avert falling on the slant area and narrow the contacting portion with the trunks.

At the same time airless sprayer which travels spraying agricultural chemicals with twirling multiple nozzle pipes was developed practically in 1992.

This machine is capable to spray agricultural chemicals with twirling nozzle pipes in order to improve the application effect without blower. Also it has the another advantages as follows.

The required power can be reduced little due to no use of a blower.

It is possible to dwarf the body of the machine.

It makes noise lower.

It causes less drift of agricultural chemicals.

As the comparison between an air blast sprayer and a citrus sprayer though an air blast sprayer is little but better than a citrus sprayer in the ability of application, a citrus sprayer is no less than manned application ability.

Recently the study about radio control for vehicles is carried out

(2) Pipe guiding type sprayer

There is a lot of trouble to install air blast sprayers due to its way of cultivation in Japan. Especially labor saving is also one of them. To solve these problems, small pipe guiding type unmanned sprayers have been developed.

This sprayer has a liquid chemical tank with capacity of 300 L and it works along about 3-4 cm wide guiding pipes which are placed on the earth without driver. The traveling part employs 3 wheels. The front wheels are constructed of dual wheel and auxiliary guiding wheel which sandwich the guiding pipe while traveling. For guiding pipes, the polyethylene is usually used on effectively in installation or functions. However, another materials can be available with the same diameters. And in the case of the moving or an orchard where no pipes can be used as a walking type machine with man. For transmission, a hydrostatic transmission system is adopted to select the working speed depending on the conditions of the fields.

The spraying system employs airless spray method with twirling nozzle pipes. Each 5-nozzle pipes on both side of the machine. Though it is available for about 2.5 m high, the number of nozzles can be increased and the angle of them can be adjusted, depending on the height of trees. And infra-red ray type sensor detects trunks, and opens/closes the vales of the sprayer on the right and left side automatically.

Moreover, it allows working in the safety and pleasant environment because start or stoppage of the machine or open/close operation of the spray valves can be performed wireless by radio control from far distance.

In addition, the traveling clutch is released and the machine is stopped automatically in any case as following. When the amount of agricultural chemicals is reduced less than the specified. When the machine deviates from the guiding pipe. When the machine contacts any objects.

This has similar advantage with citrus sprayer. Its efficiency is more than twice manual spraying. Moreover, it is possible to reduce the application rate due to its uniform application.

This is planed to be put on the market after this fall.

(3) Microcomputer controlled unmanned air blast sprayer

Since the spraying direction for fruit trees is upward there is problem of exposure to agricultural chemicals on the operator during application. This requires that the operator must wear protective clothing, thereby causing hard work during the hot seasons. It is possible to work with a cabin mounted on the air blast sprayer to avoid exposure to agricultural chemicals on the operator, but if space between tree branches and the top of the cabin is too small it can't be use.

For application in orchards, substantial labor saving has been allowed by using the air blast sprayers, and further if the unmanned sprayer is developed, exposure of operators to agricultural chemicals will be avoided and the working condition will be improved

Then, BRAIN developed a unmanned sprayer in 1933. which have already been put on the market by some manufacturers.

There are various types of unmanned operation system, and the machine developed employs a microcomputer controlled method in which the traveling operation can be performed depending on the deviation of the forward travel while right and left sensors sense the magnetic field incurred by supplying electric current to the cables which are installed along the work course in the orchard.

The cable can be installed along the work course on the earth or from the surface to up to 30 cm deeper for common fruit trees such as apples, and can be installed in the air, 150-200 cm high from the earth for trellis fruit trees such as pears or grapes. Two loops whose range are about 1000 m each can be installed.

The transmission frequency sending signals to the cables is 1.5 kHz, and Ni-Cd battery is used as the power source, and once the battery charged, it allows a continuous 8 hours of operation.

Start-up of sprayer is performed by the assisting radio control system (maximum accessible distance of radio wave: 150m) at the area far from the unmanned sprayer in order to avoid exposure to agricultural chemicals on the operator. In addition, the assisting radio control system can be done as follows. Start/stop of the machine, operate and stop the blower, and stop the spraying.

In unmanned operation the following functions are operated.

1) Overall application is performed among the tree rows during unmanned spraying, but the application is stopped at unnecessary part specially outward of tree rows while turning automatically.

2) Both traveling and spraying automatically as soon as the liquid chemicals is emptied in the

tank.

3) All the operation are stopped at the time of completion of work. When the drivels operation is released, it can be used as the manned air blast sprayer.

In full- atomization, it should be given the most priority to safety.

From this point of view, this machine is equipped with the following safety systems.

1) Automatic suspension system to stop the traveling and spraying when detecting obstacles.

2) Automatic suspension system to stop the operation of the machine when contracting obstacles.

3) Manual suspension system to stop the operation of the machine when in an emergency.

4) Automatic suspension system to stop the traveling and spraying when control of the auxiliary radio control is disabled.

5) Automatic suspension system to stop the operation when deviating from the microcomputer cable and breakage of wires occurs.

By using this sprayer, the following can attained

1)Possibility to avoid exposure to agricultural chemicals, noise and danger for operators.

2)Possibility to improve labor saving and efficiency in work because the operator can be performed another work like prescription of agricultural chemicals during unmanned application.

3)Possibility to improve labor saving and good timing application because under some conditions one operator can operate multiple sprayers.

Future View

It is said that the mechanization of paddy production has been completed, but as large-scaled management or compartment advances, the current system is insufficient, accordingly, more labor saving, more efficient, and more precise mechanization are coming necessary.

In terms of high productivity, low cost and labor saving, sufficient working methods and mechanized techniques should be improved, corresponding to the expansion of machine-dependent areas, huge compartment of paddy fields. organic utilization of machines. And increase in working period.

To cope with lack of workers or to reduce the working load, transition from walking agriculture to riding agriculture must be obviously advanced.

Not only labor saving and amenity but also high efficiency and high precision for riding agriculture, are considered to advance further.

The series work of administration in paddy field by vehicles is expected much, since they can contribute to the labor saving and high precision-acquisition and so on. Especially, low volume application techniques are important for the work in paddy field required portability of the machines.

In terms of the environmental preservation type agriculture promotion in recent years, low volume application techniques are more important. It is necessary to contribute to control the occurrence of carbon dioxide. In conventional application methods, since the machine would be large to put large quantity of liquid chemicals, the high rate power was necessary to operate machine. Thereby it

was caused that increasing the consumption of fossil fuel and increasing the occurrence of carbon dioxide.

Recently much social attention has been paid to non chemical cultivation or low volume chemical cultivation in Japan. Accordingly, there are less poisonous chemicals to avoid the agricultural chemicals residue and to prevent environment pollution. This new types of agricultural chemicals for that purpose are being developed.

It seems that development of resistant variety or biotic pesticide for pest control will be advanced the advancement in biotechnology. On the other hand, there will be no change in necessity of application by spraying pesticide (agricultural chemicals) in the future.

From now on improvement of safety for both consumers and workers must be done. And it is also necessary to reduce the amount of agricultural chemicals in agricultural management, therefor, it is important to perform on suitable period of application and restrain both over-application and drift of agricultural chemicals.

And it seems that it will be more necessary to develop an application machine and techniques be able to apply lowest amount of agricultural chemicals for highest efficiency.

In order to achieve the above purposes such as high accuracy, high efficiency of the pest control machine, labor saving, and safety, it is important to adopt sensing techniques like crop information sensors or controlling techniques and soon. It can be said that since the working conditions in case of agricultural production are not so same in industrial fields, it is difficult to use high technology practically. However, a technology, has advanced steadily, so full-automation and intellectualization of sprayers will be progressed further, and will be more utilized more in the area of agricultural production.