15

Maintenance of equipment

The need for well maintained equipment is now emphasised by the legal requirement at least in several European countries for an official inspection of sprayers at regular intervals. A European Standard for inspection of sprayers (CEN/TC 144) is being developed. Hitherto, farmers often considered maintenance when a part failed, but regular preventative maintenance is now recognised as essential to meet the increasingly demanding legislation to avoid leakages and contamination of the environment with pesticides. The cost of pesticides also necessitates that they are applied efficiently.

A problem still exists in many parts of the world where spare parts are less readily available and service manuals may not be in the local language or in sufficient detail to provide users with a clear step-by-step guide to what maintenance is required. Manufacturers of motorised equipment still often distribute a separate manual for the engine, instead of integrating the relevant information into a comprehensive manual, describing how to use and repair the sprayer or applicator. Manufacturers and their local agents also need to ensure appropriate spare parts are readily available.

Users of pesticides need to have some training in both the biological and chemical aspects of controlling pests, together with training in the correct and safe use, calibration, maintenance and storage of equipment. In some countries, such as the United Kingdom, all users of pesticides have to pass a practical test. In the United Kingdom this is organised under the auspices of the National Proficiency Test Council; in addition to a foundation course, there are courses provided at agricultural colleges to prepare participants who need to pass the relevant NPTC modules (Table 15.1) for the equipment they will be using, and this training is supported by manuals produced by the British Crop Protection Council.

In other parts of the world, training is not so readily available, and in some countries greater stress is placed on testing the machinery. Some of the agrochemical companies provide training as part of their product stewardship programmes. This is supported by the Global Crop Protection Federation

Table 15.1 Faults with two-stroke engines and their remedies (from Clayphon and Matthews, 1973; Thornhill, 1984)

Fault	Remedies
Engine does not start	
Fault in fuel system	
Fuel cock not opened or blocked	Ensure fuel is present in tank. Open cock. If no flow, remove clock, clean and replace
Air vent in fuel tank filter is blocked	Clean vent
Thimble filter in carburettor is blocked	Remove filter, clean and replace
Main jet in carburettor is blocked	Remove, clean and replace
Water in carburettor float bowl	Remove and clean. Check also that fuel in tank is not contaminated with water
Float needle sticking and stopping petrol supply	Remove needle, check for burrs or rough surface. Clean off rough surface, if not possible, replace with a new one
Too much fuel in engine	Close fuel cock, remove spark plug, open throttle, pull recoil starter rope to turn engine over a few times, clean, replace
Fault in ignition system	
High-tension lead to spark plug loose or disconnected or insulation broken or burned	Fasten lead securely to plug, if badly damaged, replace
Dirty spark plug, carbon or oil deposits on electrodes	Remove plug and clean; set gap as recommended by manufacturer. If porcelain insulation is damaged, replace with new plug
Contact breaker points dirty or pitted	Clean and adjust to correct clearance when points are open. If honing fails to remove pitting, replace with a new set
Exhaust blocked	Remove exhaust and clean or replace with a new part
Engine runs erratically or stops	
Dirt or floating debris in fuel system	Clean all fuel lines, filters and carburettor bowl and check there is no air in fuel line
Main jet blocked	Remove, clean and replace. Do not use nail, pin or wire to clear obstruction
High-tension ignition lead loose or 'shorting' on metal parts of the engine	Check that lead is firmly affixed to spark plug. Where lead has been chafing on bare metal, either cover bare wire with insulation tape or replace with a new lead
Fuel running low in tank. Engine vibration or irregular movement of operator leaves output pipe uncovered, resulting in fuel starvation	Refill tank with correctly mixed fuel

Table 15.1 (*Cont.*)

Fault	Remedies
Engine lacks power	
Choke is closed	Open choke
Fuel starvation	Partially blocked pipes or filter should be removed and cleared
Air cleaner blocked with debris	Remove, clean by washing in petrol and squirt a little light oil on the cleaner element. Conform with manufacturer's recommendations
Dirty carburettor	Remove from engine, dismantle carefully, clean and examine all parts. Any worn parts such as float needle valve, etc. must be replaced with new parts
Loose or leaking joint at carburettor flange to cylinder	Check gasket. Replace if worn or damaged and tighten nuts or studs
If whistling noise is heard from cylinder when engine is running, there is a possibility of the cylinder head gasket being worn or damaged	Check carefully by feel when engine is running. If gases are escaping, remove head, fit new gasket, tighten nuts evenly. On a new machine, it may be necessary to tighten the nuts evenly without fitting a new gasket. If heavy carbon deposits are seen on piston crown or when cylinder head is removed, these should be scraped away carefully. The ring of hard carbon should not be disturbed in the cylinder.
Dirty exhaust	Remove exhaust, clean carbon deposits from exhaust if possible, or replace with new part
Engine backfires	
Ignition may be badly retarded	Should be attempted only by trained or qualified personnel. Magneto should be checked and reset to manufacturer's specification
Carbon whisker bridging gap in spark plug	Remove plug, clean, adjust gap to correct clearance and replace
Overheating of engine	
Incorrect mixture of petrol and oil in fuel tank	Drain off tank. Refill with fuel in the correct ratio (see handbook or markings on tank)
Incorrect size of main jet	Remove and refit one that complies with manufacturer's specification
Ignition retarded too far	To be checked and reset by a competent person
Exhaust and silencer choked with carbon	Remove, dismantle, clean and reassemble

(GCPF), formerly the Groupement International des Associations Nationales de Fabricants de Produits Agrochimiques (GIFAP). In countries where farmers have insufficient mechanical knowledge to maintain application equipment, practical field training courses are essential for both individuals and those supervising spray teams. Such training must be supported by the availability of suitable instruction manuals which need to be well-illustrated and written in simple and clear terms to facilitate translation into the verna-

cular. International organisations such as WHO and FAO have published specifications of different types of equipment to ensure that minimum standards can be attained. They have also prepared some booklets that are aimed at promoting better use of equipment.

Problems with the spray system

Nozzle or restrictor blockage

Improvements in particulate formulations have been made so that any nozzle blockage is most likely to be due to extremely small particles in the water used as diluent, especially if it has been taken from a stream or borehole on a farm. There is also the possibility of particles flaking from the inside of the pipework of a sprayer if it has not been washed properly after use or some corrosion has taken place. Such blockages can be minimised by adequate filtration. When a closed system of loading is used, there should be a large filter between the mixing unit and the sprayer tank. The mesh size and area of the filter need to be selected to cope with the volume of liquid being used and in relation to the nozzles used. The filter mesh at the nozzle must be smaller than the orifice diameter; for most agricultural work a 50-mesh filter is adequate. When spraying has been completed, there may be several litres of spray remaining in the machine; the actual quantity will depend on the type and size of the sprayer (Taylor and Cooper, 1998). Ideally, the operator should only mix sufficient pesticide so that the spray liquid is used up just by treating a field; sufficient clean water is then used to wash the sprayer tank and pipework, and the washings are sprayed out within the last part of the treated field. An EC Directive 414 Annex III requires that an appropriate decontamination routine is defined to obtain approval for an agrochemical. This is important if traces of chemical from inside the tank were to contaminate the next pesticide used and cause phytotoxicity on the crop.

When washing out a sprayer, several washings of a small volume of water are better than filling the tank once with clean water. Cleaning the sprayer can be improved using a 0.2 per cent suspension of activated charcoal, but this is expensive. Some manufacturers now market products specifically for cleaning sprayers. Household ammonia diluted at 10 ml per 5 litres of water is also a useful cleaning agent, provided there are no brass components in the equipment. On motorised equipment, the volume of water must be sufficient to operate the agitation system. The final rinse must be with plain water.

Each nozzle should be dismantled and the individual components – filter, tip and cap – cleaned and replaced. All other filters on the sprayer should be removed, cleaned and replaced. In general, it is never possible to clean a sprayer completely, as some of the chemical can become impregnated in hoses. If possible, separate equipment should be used to apply herbicides such as 2,4-D, which could affect other crops when different pesticides are subsequently applied. Alternatively, equipment must be decontaminated with

charcoal or other recommended procedure and the hoses replaced. The suitability of the sprayer can be checked by treating a few plants susceptible to the herbicide used in the equipment, for example tomato plants are susceptible to 2,4-D herbicide.

Care must be taken to avoid the washings contaminating any drinking or other water supply. Analysis of water in a section of a river in Europe indicated that pesticide was detected when sprayers were washed out rather than from spray drift (Fig. 15.1) (Beernaerts *et al.*, 1999). Some countries have issued guidelines or a code of practice concerning the cleaning of equipment, and this should be consulted. Protective clothing should not be removed until after the equipment has been cleaned and returned to the store.

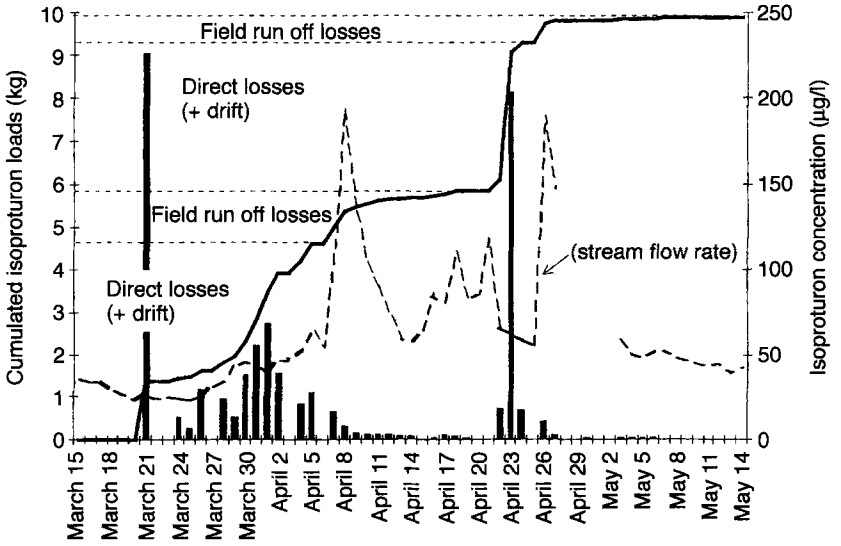

Fig. 15.1 Peak contaminants of a river related to direct losses when spraying – mostly due to washings of sprayer.

If special formulations have been used, a particular solvent may be needed to clean the equipment. Information on the suitability of solvents for cleaning should be obtained from the supplier of the pesticide or equipment, to check that there is no risk of detrimental effects on plastics and other materials used in the construction of the machinery.

If a nozzle blockage does occur while spraying, the nozzle tip and filter should be removed and replaced by clean parts. The blocked nozzle is more easily cleaned back in the workshop, so sufficient spares should be taken to the field. When spare nozzles are not available, sufficient water or solvent should be taken to the site of operations for cleaning a blockage. If washing does not remove the obstruction, giving the nozzle a sharp tap with the inner surface downwards may be sufficient to dislodge it. Alternatively, air pressure from a

car or bicycle pump can be used to blow it from the nozzle orifice. Nozzles should **never** be placed in the user's mouth to blow through the orifice as their surface is inevitably contaminated with pesticide. A hard object such a pin, nail or stiff wire should **never** be used, as the orifice can be so easily damaged. When ceramic nozzle tips are used, extra care is needed as the slightest damage to the nozzle orifice can affect the distribution of the spray liquid. If several blockages occur, the whole system should be checked to determine the source of the material causing the blockage. Corrosion, especially inside the metallic parts of the sprayer, may result in small particles which can accumulate on the filters. With some of the particulate formulations, deterioration during storage can result in poor suspensibility, so particles settle out and can be the cause of a blockage.

The flow-control valve or restrictor may become blocked on sprayers which do not have hydraulic nozzles. As mentioned above, the occurrence of blockages can be reduced by proper filtration, but if a blockage does occur, it is usually quicker to replace the restrictor rather than attempt to clean it in the field.

Inefficient pumps

Piston pumps are fitted with 'O' ring seals or cup washers of synthetic material or sometimes leather, although this is less likely now. As ths seal can be damaged by particles suspended in the spray liquid, it should be checked regularly to keep the pump operating well. Where leather seals are used, they require regular treatment with a vegetable oil to prevent them drying out and shrinking. Some synthetic materials used in pump seals or as diaphragms may be affected by solvents and swell, making the pump harder to operate, but the majority of pesticidal liquids are diluted in water. Poor pump performance may also be due to faulty valves. Ball valves and their seating can be pitted or coated with sediment, debris from the water supply or pesticide. Apart from cleaning and replacing damaged parts, it may be necessary to change the formulation used or to improve the filtration of the water before use.

Leaks

'O'rings, washers and other types of seal are liable to wear or be damaged when hose connections, trigger valves and other components are unscrewed. Similarly, seals around the tank lid and in the pump assembly can be damaged whenever the connection is broken. The damaged part should always be replaced to avoid occurrence of leaks. Some connections such as nozzle caps may not have a washer and rely on direct contact of smooth surfaces to seal. Any dirt on the nozzle or cap, or damage to the threads, may prevent a proper seal.

Proper functioning of some spray equipment, such as compression and

certain motorised knapsack mistblowers, depends on an airtight seal of the container or spray tank (Fig. 15.2). For example, it is impossible to spray liquid upwards with some mistblowers when the nozzle is above the level of the spray tank because there is insufficient pressure to force liquid to the nozzle. Small air leaks from the lid or other fittings to the tank, for example a pressure gauge on the container, can be detected by smearing a soap solution over the joint. Soap bubbles should be readily detected where air is escaping.

Fig. 15.2 Checking seal on lid of spray tank of motorized knapsack mistblower.

Problems with motorised equipment

Two-stroke engines

Users of motorised knapsack mistblowers frequently complain that the engine is difficult to start. Various causes for the failure to start and other problems are listed in Table 15.1, together with remedies. Many of the starting problems could be avoided if the carburettor and engine were drained of fuel after use to avoid gumming up the machine with oil when the petrol has evaporated. This can be done simply by turning off the fuel tap and allowing the engine to continue running until starved of fuel. Preferably, the fuel tank itself should also be drained to avoid the ratio of oil to petrol increasing, especially in hot climates. Starting problems are definitely reduced by ensuring the correct type of oil is used (see p. 225) and that the fuel is properly mixed.

The fuel line from the tank to the carburettor is often made of plastic, which becomes hardened by the action of the petrol and is sometimes loosened by the engine vibration. This plastic tube should be regularly inspected and replaced, if necessary, to avoid fuel leaking onto a hot engine and causing a fire. The sprayer's straps should be designed to allow the machine to be removed very easily in case a fire starts. On some machines, the fuel tank is now situated below the engine so that fuel cannot leak down on the engine.

The spark plug should be inspected regularly and cleaned if necessary, so it should be readily accessible (Fig. 15.3). The spark plug gap may need adjusting to obtain a good spark before replacing. The plug should be replaced with a new spark plug after 250 h as a routine. The air filter should also be examined at the end of each day's spraying and cleaned according to the routine recommended by the manufacturer.

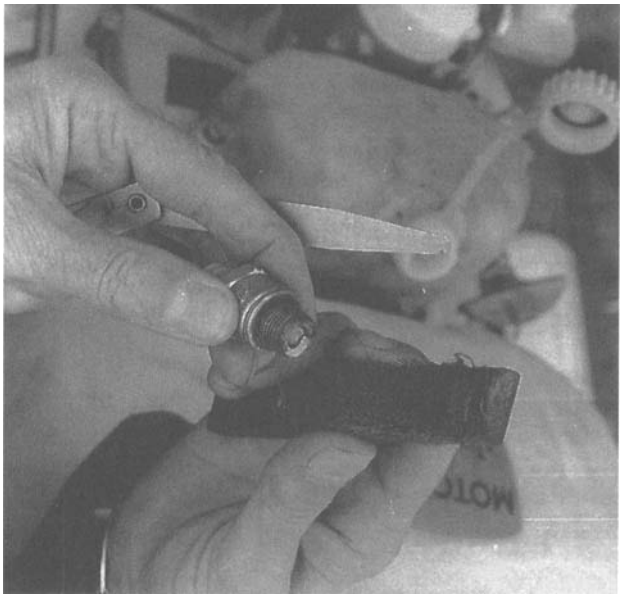

Fig. 15.3 Cleaning spark plug and checking gap.

Fault finding

Some of the faults commonly found when using hydraulic sprayers are indicated in Tables 15.2, 15.3 and 15.4, together with possible remedies. Similarly, faults with the small hand-carried spinning disc sprayers are given in Table 15.5.

Table 15.2 Faults with slide pumps (single- or double-acting continuous operation)

Fault	Remedies
No spray at nozzle	Check nozzle and clean if necessary Check that container is full Check pump, especially non-return valves Check for leaks on hose and connections
No suction	Check pump, especially pump seal Check valves and seatings Check strainer in container
Leaks from pump	Check gland and packing, replace if worn or damaged

Table 15.3 Faults with knapsack, lever-operated (piston or diaphragm) pumps

Fault	Remedies
No spray	If resistance is felt on downward movement of lever with cut-off valve open, check nozzle for blockage, and clean if necessary. Check and clean filter or strainer in handle of cut-off valve. If no resistance is felt, check tank contents and fill if necessary. Ensure that operating lever is tight, together with all the connections to the pump. Check that when the lever is operated, the shaft or connecting mechanism and the piston or diaphragm all move together. Pump valves and valve seat should be checked. If worn or damaged these should be replaced. Dirt and debris should be removed
No suction	Ensure that liquid is present in the container. Check that the suction and discharge valves are not sticking. Make certain that the liquid ports that permit flow from tank to pump are not blocked. If a piston-type pump is employed, check that the piston seal is not excessively worn or damaged, as this will permit the liquid to pass between the piston and cylinder wall.
No pressure	Check liquid contents of container. Fill if necessary. After several strokes of the operating lever, look in the tank to see if air bubbles are rising to the surface. If so, this could indicate a leak in the pressure chamber. Where pressure chamber is screwed into the pump body, check that the seal is not damaged. Replace if necessary. Check both suction and discharge valves. Remove any accumulated dirt or debris from discs or balls and valve seats. If discs are worn or damaged or the rubber is perished, replace. If ball valves and

Table 15.3 (*Cont.*)

Fault	Remedies
	seats are pitted or balls are no longer spherical, replace with new ones. If resistance is felt when pumping and no reading is seen on pressure gauge, replace gauge. If pump is of diaphragm type, check that it is seating correctly, that it is not damaged or split and that the rubber is not porous. Where a pressure-relief valve is embodied in the pressure chamber, check that it is adjusted correctly and that the spring-loaded valve is seating properly. Ensure that the openings between the pump inlet and outlet ports and the liquid container are not blocked. Check that the air vent in the filler cap is not blocked, as this could be the means of a vacuum forming in the container
Pressure drops quickly	Check pressure chamber for leaks. Air bubbles seen rising to the liquid surface are a good indication. Check valves for discharge. The discharge rate may be higher than pump capacity
Liquid leaks onto operator	Where pump is mounted in base of sprayer, a ruptured diaphragm, or one incorrectly assembled, will permit liquid under pressure to leak. For a piston type pump, a worn piston seal or deep scratches in the cylinder wall will also permit the liquid to escape and wet the operator. Check the container for cracks or leaking joints. Metal tanks can be soldered or brazed. Check that the lid of the container is fitting tightly

Table 15.4 Faults with compression sprayers

Fault	Remedies
No spray	Ensure container has liquid. If pressure gauge shows a reading and there is no spray when cut-off valve is opened, close valve and check nozzle. If nozzle is blocked, follow procedure for clearing blocked nozzles. Check strainer in cut-off valve. Clean and replace. Check hose connections and tighten. If no reading is shown on the pressure gauge, ensure that the gasket between the pump body and the liquid container is not leaking. Replace if leaks are present. Remove pump from container and check by giving a few smart strokes on the pump handle to test the valve. On each pressure stroke, the valve should 'grunt' or make a noise of escaping air. If the valve disc or ball is malfunctioning it should be replaced. Where a dip-tube is part of assembly, check that this is not blocked with debris

Table 15.4 (*Cont.*)

Fault	Remedies
Leaks from pump	After the container has been filled with spray liquid to the required level, if on the first or second downward strokes of the pump handle liquid is forced up past the shaft and out through the guide, this is a good indication that the valve requires attention. Furthermore, if strong resistance is felt on the downward stroke, again the valve is faulty and has permitted liquid to enter the pump barrel and, as liquid cannot be compressed, resistance is encountered
Pressure drops quickly	Check that the filter cap or lid gaskets are serviceable and that the cap is properly secured. Check also where a safety valve is fitted that it is not leaking and is in a working condition. Some compression sprayers have a constant-pressure valve fitted. Check that this is adjusted correctly and that there are no leaks from the point of entry to the tank. Ensure that all connections to the tank are tight and that all gaskets and washers are serviceable. Check tank for leaking seams by pressurising and immersing completely in water. Air bubbles rising to the surface will indicate the presence of a leak. Leaking tanks cannot be repaired in the field. All repaired compression sprayers must be pressure-tested to at least twice the working pressure before being used on spraying operations.
Other faults	If nozzle dribbles with cut-off valve closed, the 'O' ring seal or the valve seat is damaged. Dismantle and check. Replace with new parts if unserviceable. With some of the plastic-type pressure gauges, the indicator pointer sometimes becomes loose on its pivot. This can give a false pressure reading. By tapping the gauge against the hand it can be seen whether or not it is loose. If it is, remove the protective glass front, replace the needle on the pivot loosely and, with it pointing to zero, press it firmly on to its mounting. Replace the glass with a master gauge

Table 15.5 Faults with spinning disc sprayers

Fault	Remedies
No spray	Restrictor may be blocked. Clean with solvent or piece of very fine wire or grass stem. Check whether air vent is blocked
Leaks	Check that spray container is fitted correctly
Spinning disc not rotating or rotating intermittently or slowly	Check that enough batteries are fitted in containers. Check that all batteries are inserted the correct way. Check battery connections. Check switch (if any). Check connections to motor, clean connections with a dry cloth or sandpaper and fit new wires if necessary. Check that the '+' terminal of the batteries is connected to the '+' terminal marked on the motor. Replace batteries if necessary. Where large numbers of the sprayers are in use, it is advisable to provide a voltmeter and tachometer to check the revolutions per minute of the disc. Check whether disc is fitted correctly to motor shaft; it may be pushed on too far and touch the backing plate. If necessary, replace motor

Maintenance in the field

One or two tools should always be taken into the field while spraying, together with extra nozzles, washers and other spare parts. The non-mechanically minded user will find one pair of pliers, at least one screwdriver, or preferably two of different sizes, one small adjustable wrench, a knife and a length of string invaluable. Spare washers for the trigger valve, nozzle body or even the filler caps should be available, but if not, a length of oiled or greased string can be used as a substitute in some circumstances. Some washers may be cut from the inner tube of a car or cycle tyre and used temporarily until the proper spare washer can be fitted.

Quick repairs to leaking plastic containers which are not pressurised can be made by drawing the edges of a small hole with a black-hot nail, and smoothing it over with a wetted cloth. A 15 cm nail is suitable and can be heated in a fire, even out in a field, but it must not be made too hot, otherwise the plastic may melt and the hole enlarged beyond repair.

Those using engine-driven equipment, such as a knapsack mistblower, will also need to carry a spare spark plug and a plug spanner, while those using small battery-operated sprayers need a 'Philips' screwdriver, as well as a tachometer. Tools and spares can be conveniently carried in a small tool box. If the spray programme entails the use of several machines simultaneously, one or two complete machines could be taken to the field as spares so that work may continue when weather conditions are favourable, rather than delay spraying while repairs are attempted.

All stoppages and breakdowns that occur in the field should be reported to the workshop personnel, so that repairs and maintenance can be done without delay. Where several machines are used by a team of operators, it is a good policy to allocate a specific machine to each individual who then becomes responsible for its care and maintenance.

Storage of equipment

After each day's field work, and at the end of the season, complete checks should be made of the pump and, where necessary, the engine, before storing the sprayer in a dry place. All sprayers should be kept locked away from children, food and farm animals, and measures taken to prevent rats from chewing hoses and other parts. Many small hydraulic sprayers are preferably stored upside-down with the lids removed to allow complete drainage of the container. If engines are to be stored without use for a prolonged period, the spark plug should be removed and a small quantity of oil, preferably formulated with an anti-rust additive, poured into the crankcase. The engine should be turned over a couple of times to ensure the oil spreads. Similarly, at the end of each day it is advisable to add some oil to pumps on any type of sprayer. This is not necessary if the sprayer is used again the next day, but adverse weather conditions or some other factor may prolong the period of storage.