GROWING AND HANDLING DRY BULB ONION IN THE CARIBBEAN

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FOREWORD

The Common or Dry Bulb Onion (*Allium cepa* L.) is one of the few bulb crops used for food. It is popular as a vegetable, but is used more often as a seasoning. Onion is second only to tomato in world vegetable production and demand is generally inelastic.

In the Caribbean, over 8,000 tonnes of onions are imported annually at a cost of approximately EC$11 million mainly from Netherlands, USA and Spain. Foreign exchange savings through import substitution is a priority for Caribbean governments, and onion shows potential for this purpose.

Onion is currently being produced in Antigua, Barbados, Grenada, Jamaica, Montserrat, St Kitts, Nevis and St Vincent. Research is aimed at increasing self-sufficiency in onions in these countries. While intra-regional exports could also be considered at certain periods of the year particularly when the world market price for onions is high, it is doubtful whether extra-regional exports would be feasible.

The major constraints to achieving self-sufficiency have been seasonality of production, limited availability of water for irrigation in some countries, poor shelf-life of most short-day varieties and a host of pests and diseases which make onion a "high risk" crop for growers in the Caribbean.

The scale on which onion is grown varies from one country to another eg. in Montserrat, production is characterised by small plots 0.05-0.1 ha (0.1-0.2 ac) in area, while in Barbados the crop is grown on a larger scale i.e 1-5 ha (2.5-12 ac) mainly by sugar cane farmers and specialist vegetable producers, but a few small farmers have started production during recent years. The production system varies from totally manual in St Vincent to partly mechanised in St Kitts to nearly fully mechanised (except for the harvesting operation) in Barbados.

Although the climatic conditions within the Caribbean region are relatively uniform, onions are sensitive to small environmental changes, even at a particular site from year to year, and varietal performance may vary slightly from country to country. It is therefore important to note that when new varieties are being introduced, they should be tested in small plots alongside proven varieties over at least two seasons before acreages are increased.

This bulletin seeks to bring together information gathered from a number of sources, including farmer experience over the past two decades to provide both large and small scale onion growers in the Caribbean with comprehensive production and post-harvest recommendations which are relevant to the prevailing environmental and economic conditions. The bulletin is divided into three sections:

Section I overs detailed recommendations for the production of the onion crop.

Section II describes the major aspects of post-harvest management of onion bulbs.

Section III gives general information on the maintenance of equipment and on pest and disease control methods.

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11. Post-harvest management

The objective of any grower should be to provide the consumer with the best possible produce. Where onions are concerned, the following characteristics should be aimed for:

- Bulbs well covered with dry scales (no fleshy scales exposed)
- Dry, thin necks
- No root growth
- No sprouting
- No disease
- No splitting of bulbs

Although the post-harvest technology of onions is well documented for temperate conditions, and a number of sophisticated handling systems is available, most of these are either unsuited to the needs of Caribbean growers and marketers or are too costly. Therefore only simple handling systems which should be affordable and are compatible with the present conditions prevailing in the region will be described here.

Drying and curing

Proper drying and curing of onion bulbs is necessary to minimize disease development after harvest. In the tropics drying and curing take place simultaneously. Optimum conditions are 27°C (80°F) and 60% relative humidity. An air flow of 7 m³ (250 ft³)/min/ton has been recommended by researchers working in this area. The aim of the process is to remove about 4-5% moisture to produce bulbs with tightly closed necks and dry outer scales which 'rustle' when handled. Further shrinkage due to water loss is minimized during marketing and storage.

Field drying or 'windrowing' as it is called, is the cheapest method of drying available and should be used whenever possible, particularly if the crop is destined for the local market where standards are not expected to be as stringent as on the export market. After harvest, bulbs with tops attached, should be laid in one layer on the beds in the field to dry, if weather conditions are suitable. In the Caribbean however, these conditions are not always easy to predict, since even in the 'dry season' a number of rainy days may be experienced. When arranging the bulbs on the beds it is best to cover the bulbs in one row with the leaves of another, so as to avoid 'sunburn' of bulbs. If in fact heavy rains do occur during the windrowing period, it is advisable to turn the bulbs so as to assist in drying. This is more feasible if production is on a relatively small scale.

In the wet season a 37% loss from rotting and physiological weight loss may occur after windrowing in the field for 14 days. Under these conditions or if praedial larceny is a problem, it is advisable to dry bulbs in a protected, covered area.
The drying method used will depend on the scale on which the crop is being grown. If the crop is very small, it may be placed in portable wooden trays (Figure 18) which can be stacked up to 10 high in a safe area near the farmhouse, exposed to sunshine when possible and protected from rain. Alternatively, the trays may be per manently placed in a simple wire sided shed with enough overhang to protect the bulbs from rain. An additional design for a permanent drying shed is shown in Figure 19. It is important to position these sheds so that there is maximum air movement through the bulbs.

Another possible design for a drying/storage shed for small-scale production is shown in Figure 20. Here the roof is made of clear plastic which results in elevated temperatures being produced in the shed. After drying has been completed, coconut leaves or shade netting should be placed over the roof for storage of bulbs.

Two additional designs for drying and storage are shown in Figures 23 and 24. The first is a zinc roofed structure with permanent mesh wire shelving. In this case air movement is improved by using a small blower fan, and a suction fan to remove the moist air above the onions.

The second design could be used for slightly larger scale production e.g. more than 0.4 ha (1 ac) as it allows for easier handling of the crop. Instead of permanent shelving, plastic ventilated field crates which hold approximately 14 kg (30 lb) of bulbs are used. The stacks of field crates with the bulbs are placed in the raised shed with a clear plastic roof to aid the solar drying process. After drying has been completed, a retractable shade is extended to protect the stored bulbs from the sun. Wire siding protects the bulbs from praedial larceny.

In the interest of reducing cost, make use of the sun and wind wherever possible to help dry the crop. In some cases field drying may be combined with solar drying under cover to produce a better quality crop.
**Figure 18** Drying/Curing trays for onions (FAO Manual)

**Figure 19** Permanent shed for outdoor drying of onions (Ministry of Agriculture, Jamaica)
Figure 20  Small-scale passive-solar onion dryer (Virginia Polytechnic)

Figure 21  Concrete (or zinc) shed for semi-commercial drying and storage of onions (Ministry of Agriculture, Jamaica)

An example of a solar dryer fitted with a fan is shown in Figure 23. This type of dryer has been used successfully in Barbados.

Dryers driven by electricity or diesel fuel have also been used in Barbados, but of course these methods are costly. In the case of the diesel powered dryers, oil leaks may occur and can cause contamination of the crop.
Bulbs may be dried with or without tops, but where natural air movement is being used, it would be advisable to remove the tops before drying. This is more easily done after windrowing for at least two days when the tops have wilted.

A comparison of storage of solar-dried and windrowed bulbs indicated that large bulbs in particular which were solar-dried stored better than those which had been windrowed.

**Topping and tailing**

After a windrowing period of about 10 days, bulbs should be topped and tailed. If necks are thin and the drying process is complete, this should be easily achieved using a sharp knife. Bulbs with dry, well sealed necks should result. Even though this is the target, some bulbs will inevitably have thicker necks which may not be completely sealed. To allow these to dry out, it is recommended that the topped and tailed bulbs should be allowed to remain in the sun for a few hours to allow the cut surfaces to dry. At this point, any rotted or damaged bulbs should be discarded.

![Figure 22](image-url) Large-scale passive solar onion dryer (Virginia Polytechnic)

![Figure 23](image-url) Side view of solar drying facility (Barbados Agricultural Development and Marketing Corp.)
Packing and transport

The method of packing will depend on the destination of the crop. If the crop is to be marketed immediately, then mesh bags holding 23 kg (50 lb) are generally used. However, some researchers have observed that small bulbs store better in smaller lots e.g. 5 kg (11 lb) than in larger 10-20 kg (20-40 lb) lots. Do not use bags with solid bands since this tends to encourage rotting of bulbs in this area. Stacking of bags should be avoided if possible at this point. Tagging of bags to identify growers is recommended so that problems with quality may be reported and if possible corrected.

Only firm, healthy bulbs should be bagged. Although some thick necked bulbs are generally acceptable on the local market, these should be marketed only for immediate consumption. The weights of bags should be adjusted in the field before being placed on the transport vehicle. Since the reduction of handling is of primary concern in the post-harvest management of onions, it is recommended that wherever possible, the wholesaler should collect the onions directly from the field.

If the wholesaler has the facility of a forklift truck at the warehouse, then the bags should be packed on to pallets which are already on the tray of the vehicle. Care should be taken by workers loading the onions not to drop the bags or to pack them more than six bags high. The bags may then be easily off-loaded at the warehouse or delivered directly to retailers with minimum damage. The actual packing process should be done carefully, and workers should realise that throwing bags on to trucks will cause bruising of bulbs which will inevitably lead to spoilage.

If the crop is to be collected from the grower within a day or two of harvest, then the bags should be packed carefully on to a farm vehicle and transported to a farm shed for temporary storage.

Figure 24  Farmer transporting onions for temporary storage
Storage

Planned production to avoid extended storage

Although the more recently selected onion varieties produce firm bulbs which have a relatively long shelf life, storage losses are inevitable, and storage involves additional costs. As long as irrigation is available, the aim should therefore be to extend the length of the growing season so that the crop is more uniformly distributed over the year, and there is less need to store onions for any extended period. There may be a need to offer some price incentive to growers with irrigation to produce during the dry season.

Temporary “on-farm” storage

If bulbs are to be stored for about one week on the farm, they may be stored in a farm shed. This shed should have a high roof and wire sides, allowing good ventilation, and protection from rain. It should be fitted with pallets, and the bags should be packed around the edges of the pallets (at a maximum height of six bags) with a free area in the centre of the pallet to allow air circulation.

Figure 25  Stacking arrangement of onion bags for temporary storage

If on the other hand, the crop is to be stored for more than one week “on-farm” before being marketed, ventilated field crates rather than bags are recommended. Bulbs should be placed directly in these crates in the field so as to minimize handling. The crates are easily stacked without damage to the bulbs while being transported to the shed or during the storage period. At the time of sale, the bulbs should be inspected, and any damaged or otherwise unmarketable bulbs removed before bagging takes place. Again, the bags should be packed on pallets as described above while awaiting collection.
Warehousing

Warehouses used for onion storage during marketing should exhibit features similar to the on-farm sheds. They should have good ventilation and air movement if possible, as well as a provision for removal of the moist air from above the onion stack. Two main types of extractor fan are available. One uses electricity as its source of energy, while the other uses wind. Bagged onions should not be stored for more than a month, and should always be arranged on wooden pallets as described above.

Storage conditions

Recommended long term commercial storage conditions for onions are 0°C (32°F) and 65-70% humidity. These cold storage conditions are reported to maintain dormancy and keep bulbs relatively free from decay; but cold storage is expensive, and the handling of the bulbs after removal from cold storage under tropical conditions can sometimes present problems due to moisture condensation which may pre-dispose bulbs to decay. Gradual warming of the bulbs under conditions of good air movement will assist here.

If cold storage is not used, then relatively high temperatures of 25-30°C (77-86°F) must be considered for short term storage, since intermediate temperatures of 5-20°C (41-68°F) will cause sprouting. Under these high temperature conditions however, desiccation and disease losses increase. Humidity does not appear to affect sprouting, but high humidity will increase rooting and decay. Some researchers have found that it is better to use storage conditions which reduce disease rather than desiccation under ambient conditions in the tropics.

Storage problems

Disease rather than sprouting is the major cause of onion storage losses in the Caribbean and black mould caused by Aspergillus niger is the most commonly occurring storage disease. This fungus is well known to exist under high temperature conditions. Two types of symptom have been observed in Barbados - a dry powdery black blemish mainly on the outermost dry scale or sometimes along the veins of the first fleshy leaf, and a wet symptom on the first fleshy leaf. A degree of the dry Aspergillus is acceptable on the local market, but would not be acceptable on the export market. Bulbs showing the wet symptom are totally unacceptable.

Research in Australia has shown that Aspergillus infection starts in the field as early as six weeks before the crop is harvested. It is advisable therefore to control the disease in the field if the crop is to be stored. Barbadian farmers have used Benlate® during the last month before harvest with some success, but research is continuing in an attempt to identify alternative control measures.

Soft rot caused by Erwinia spp. may also account for a high percentage of storage losses. This occurs most frequently in humid weather and can cause considerable losses particularly in thick necked bulbs which are not well cured. Bacteria may enter the neck tissues as bulbs approach maturity and invade one or more of the fleshy scales causing them to become water-soaked and pale yellowish to light brown. The bulbs eventually become soft and a foul smelling liquid is emitted at the neck if bulbs are squeezed.
Retailing
The use of small mesh bags is advisable, but if plastic bags cannot be avoided, then use a size that can hold a maximum of 1.4 kg (3 lb). These bags should be perforated with holes 6 mm (0.25 in) diameter. The bags should have 10-15 holes for every 450g (1 lb) of onion bulbs.

Exporting
Since the export market usually has more stringent standards than the local market, particular care must be paid to all aspects of production, post-harvest handling and transport to ensure that a good quality product reaches the market. It is recommended that only fully matured bulbs are harvested under dry conditions, and that drying is done in a protected environment. Bagging should be done just prior to shipment.

Grading
A CARICOM standard for onions is being prepared, but in addition to these guidelines, the specific requirements of the buyer (e.g. bulb size, bulb colour etc) must be strictly adhered to. Only thin necked bulbs which are well sealed and which are well covered with dry scale leaves should be exported. Careful handling of bulbs is essential to ensure that this dry scale leaf cover is maintained since this is important in extending the shelf life of the bulbs.

Labelling
Bags must be labelled with the name of the packer, the nature and origin of the produce, the class, size and weight of the produce.

Shipping
Although shipment by air is preferable, if shipment by sea must be used, the bags must be stored in a well ventilated area, and must be protected from damage by sea water or by rain.
SECTION III

MAINTENANCE OF PLANTING AND SPRAYING EQUIPMENT

Proper storage and maintenance of all equipment used in producing the onion crop are essential if the equipment is to function efficiently.

12. Maintenance of equipment

Storage of planter
- After seeding is completed, remove seed from seedboxes, remove seed belts, chokes and spring bases and release all tensioners from drive belts.
- Clean seedboxes, making sure that all seed dressing is removed as this may cause corrosion.
- Lubricate all bearings, clean the coulters and wheels, grease all bright parts and store seed drill in a dry place. If it is impossible to store the complete drill under cover, the seed boxes at least must be protected from the weather.

Spraying equipment
The single most costly item in onion production is pest control. It is therefore essential that attention be given to the equipment used and to the actual application of chemicals since recommendations are worthless if chemicals are not properly applied. Improper application can even cause damage to crops (particularly in the case of herbicides). A complete servicing of sprayers should be carried out before planting of the crop.

a) Tractor mounted boom sprayers
- The pump should be dismantled and any worn rubber diaphragms, valves, rollers or seals replaced.
- The condition of all hoses should be checked. If they show signs of wear or dry rotting they should be replaced since weakened hoses can leak and may burst unexpectedly.
- Strainers should be checked to make sure they are clean and in good order.
- Boom shut-off valves and boom selector valves should be checked to make sure they are working properly.
- The pressure gauge should be checked. The by-pass line to the spray tank should be checked to make sure it is clear.
- Ensure that proper agitation of chemical is possible. This is especially important in the case of wettable powders where intense agitation is required to keep the chemical in suspension. The return flow from the
pressure regulator will not normally provide enough agitation in this case, especially when the pump output drops off. To ensure adequate agitation a small submersible pump (such as the type used as bilge pumps for boats) may be fitted inside the spray tank.

- Boom should be checked to make sure that it is straight.
- Make sure that nozzles being used are the correct type.

b) Knapsack sprayers

Servicing of knapsack sprayers should be carried out periodically. Similar checks to those described for boom sprayers should be made.

Care and storage of sprayers

At the end of each day's spraying, the sprayer should be washed thoroughly with clean water. No spray mix should be left standing in the tank, hoses or nozzles, as this may cause blockages especially with wettable powders. Each nozzle should be dismantled and the filter, tip and cap cleaned and replaced. The sprayer should then be checked by pumping clean water through it.

The cleaning of nozzle tips with wire is strongly discouraged since nozzle tips are easily damaged and this will result in uneven application rates. If necessary a soft brush or a piece of grass or straw should be used. Never use your mouth to blow a tip clean. Nozzle tips should be removed and stored in light oil after each season. Store the sprayer in a dry place, secure from children and farm animals.

Cleaning of sprayers after use with 2,4-D herbicides

It is recommended that separate equipment be used for the application of 2,4-D and other hormone type herbicides but if this is not possible, special care should be taken to thoroughly clean the sprayer before use on sensitive crops. The following procedure should be followed:

- Rinse tank, lines, screens, pumps and nozzles with warm water.
- Remove pressure chamber and line strainer, and drain.
- Fill tank with about 90 L (25 gal) of warm water and add either of the following:
  - 0.9 L (1 qt) household ammonia or
  - 0.5 kg (1 lb) washing soda or lye.
- Spray out a small quantity of the solution and leave the remainder in the tank overnight.
- Drain the tank and rinse the equipment several times with warm, soapy water before finally rinsing with clean water.

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Irrigation systems

Overhead (sprinkler) systems
The maintenance on overhead sprinkler systems is usually relatively low, but attention should be paid to leak prevention and nozzle management to reduce water use and save energy. Rubber gaskets in lines should be replaced when necessary, and nozzles should be cleaned with a 15-20% hydrochloric acid solution if there is a calcium buildup, or replaced if worn.

Drip irrigation systems
The maintenance of drip irrigation systems includes periodic flushing of the laterals to prevent clogging of the emitters. The laterals should be filled with a hydrochloric acid solution (pH 4) and allowed to stand for 1-1.5 hr before flushing with clean water. If pond water is being used, periodic flushing i.e. at three month intervals with a bleach solution (0.5-1.0 ppm chlorine) is recommended. Filters should be cleaned when there is a pressure differential of 3.5 kg (8 lb) before and after the filter. Disc filters are removed and the material physically extracted, while sand filters are back-washed.

13. Efficient application of pesticides
The application of pesticides is critical to the successful management of the onion crop. The efficiency of this operation and therefore the control of pests by foliar sprays in most cases depends to a large extent on the completeness of coverage of the leaves by the spray droplets. The choice of nozzle type, agitation method, pressure of application and placement of nozzles, in addition to spray volume per area are all very important considerations.

Some boom sprayers fail to cover completely the outer rows of onions over five beds. To ensure thorough coverage, it may be necessary to extend the boom by welding on lengths of hollow section or pipe to the ends of the boom and then fitting an additional nozzle each side. At the same time 0.6 cm (0.25 in) pipe sockets may be welded to the ends of the boom which will allow it to be cleaned by flushing with water after spraying.

It is not advisable to use the same sprayer that has been used for herbicides for the application of insecticides and fungicides.

Insecticide and fungicide application
When applying insecticides and fungicides remember to fit hollow cone nozzles. These nozzles give a much finer spray mist and hence a better spray cover on the crop. Care must be taken to ensure that the spray patterns from individual nozzles overlap to give satisfactory overall distribution. Also, since many fungicides are formulated as wettable powders, consistent mixing and adequate agitation of spray solution is important.

Spraying of insecticides should be carried out as late as possible in the afternoon or in the early evening. Insects are usually more active at these times. In addition, wind speeds are generally lower and less drift will occur.
Preferably fungicides should be sprayed very early in the morning as this reduces spray drift and often coincides with periods when fungal and bacterial infections may be more sensitive.

**Herbicide application**

When applying herbicides (e.g. Dacthal®, Herbadox®), higher volumes and lower pressures are used than when applying insecticides and fungicides. Flat fan e.g. Allman No. 3 or flood jets e.g. Spraying Systems TK No. 7.5 are two types of nozzle which could be used. Application rate should be 467-560 L/ha (50-60 gal per ac) and pressure should be 1-1.4 kg per cm² (15-20 p.s.i).

Pre-emergence herbicides (e.g. Dacthal®) are usually applied before the crop emerges on moist soil which is free of weeds and large clods. These chemicals will be effective only on weed seeds and not on emerged weeds.

If weeds are present, paraquat (Gramoxone®) may be added to the tank mix. Note that if heavy rains occur or if heavy irrigation is applied after application of Dacthal®, poor germination of the crop may occur. For this reason, application of Dacthal® is sometimes delayed until just after the crop has emerged.

Agitation is extremely important in the case of herbicides since settling of the chemical at the bottom of the tank can cause damage to those beds of the crop which are sprayed with this concentrated solution. Care must be taken not to apply an overdose at the ends of the beds. This may happen if the boom is not switched off, and tractor speed is reduced when turning.

Always ensure that correct sized mesh strainers are fitted to nozzles e.g. coarse with Allman No.3 or TK 7.5 and fine with Allman No. 0 etc.

**14. General insect control**

Insect pests may in some cases cause a total loss of crop or in others minor damage and no economic loss. It is therefore important to monitor crops on a regular basis to decide when and if pest control is necessary. The following guidelines will assist in making this decision and in using chemicals safely and efficiently.

- Know the insects and how much damage is being done. The location of the pest, the type and extent of damage and pest numbers are all important factors which determine whether insecticide should be used. It is not always necessary or advisable to apply a treatment even though pests may be present, as factors such as the stage of the pest present, whether further damage is likely will influence this decision.

- Use pesticides only when needed.

- Use the pesticide which is effective on the particular pest or growth stage of pest i.e. some insecticides control adult insects, other larvae or eggs. Some insecticides are broad spectrum and kill many types of insects while others are specific to one or two groups.

- Seek advice on the proper method of control if uncertainty exists.
- Use only the recommended insecticide at the specified rate. These are detailed in Section I. A rate 750-930 L/ha (80-100 US gal/ac) of diluted chemical is recommended for spraying insecticides. If several pesticides are recommended, always choose the one that is least toxic to mammals and if possible the least persistent.

- Select a formulation that is effective against the insect to be controlled and suited to safe application with the equipment available.

- If there is a choice between using a spray or a dust, select the spray since this tends to drift less than the dust. The average dust particle is much smaller than that of most sprays.

- Select granules if they are as effective and as economical for your purpose as a spray or dust. However granules are more persistent.

- Observe the recommended safety period between the last spray and harvest.

- Where possible, purchase insecticides in containers which are of such a size that the containers will be used completely in the spraying operation. This avoids the hazards of handling and storing partially filled containers. - Read the label.

- Ensure that the protective clothing which is mentioned on the label is available and that the recommendations are fully understood by those applying the insecticide.

- Check equipment for leaks.

- Have plenty of water and soap and a towel available in the event of accidental contamination.

- Take only enough insecticide from the store-room for the day. Do not store pesticides in soft drink bottles. Never leave pesticides in spraying equipment.

- Know the first aid procedures before you attempt to use the insecticide. You may not have enough time to search for these procedures if an accident occurs.

- Have a blood test done before using insecticides. If the cholinesterase count is low, do not handle insecticides.

15. General disease control

- Ensure that your seed is treated with the recommended fungicide seed dressing, e.g. Thiram®, Captan®, Benlate®, etc.

- Use resistant or tolerant varieties of seed wherever possible and feasible.

- Before planting, ensure that your field is well drained, protected from prevailing wind, and adequately weeded.

- Practise crop rotation - do not replant onions in the same field from which an onion crop has recently been harvested.
Walk the field on a daily basis and observe carefully any plants that appear to be unthrifty. If you see disease symptoms, have the problem diagnosed.

Do not over-irrigate, and use drip irrigation if possible. If using overhead irrigation, try to irrigate during daylight hours. Overhead irrigation applied at night may lead to attacks by disease organisms.

Control insect pests since damage to plants by insects predisposes them to entry by disease organisms.

Avoid mechanical damage to onion plants as this may predispose them to secondary infection by pathogens.

Spray fungicides preferably very early in the morning as this reduces spray drift and often coincides with periods when fungal and bacterial infections may be more sensitive.

Give your crop optimal agronomic attention.

Disinfect implements that were used in diseased areas of a field before using them in healthy fields.

Destroy crop residues after harvest by deep ploughing.

Windrow onions for the recommended period of days before bagging.

Collecting samples for pest identification

In order to speed up the process of pest/disease identification, farmers may need to take samples of damaged plant tissue to either a plant pathology or entomology laboratory for identification.

Collect plant tissue with as many stages of disease/pest symptoms as possible including healthy tissues.

Often leaf symptoms may be due to root damage or damage to other parts of the plant. Check all parts of the plant and collect samples from all areas that appear unthrifty.

Transport samples in polyethylene bags.

Submit samples to the laboratory as quickly as possible. If delay is unavoidable, store samples in polyethylene bags in a refrigerator.

Chemical disease control methods

Diseases of onions may often be controlled by the application of various fungicides or bactericides. There are three main methods of application:

- **Seed treatment.** Onion seeds are dusted with such seed treatments as Captan®, Thiram® or Fernasan®. This is to protect the growing seedling from attack by soil and seed borne fungi. Examples of such fungi are those causing Fusarium Basal Rot and Purple Blotch of onions.
• **Soil application.** Chemicals formulated as granules or dusts, e.g. Captan®, PCNB or Terrazole®, may be incorporated into the soil to control soil borne diseases such as Fusarium Basal Rot. The disease may also be controlled by directed “in-furrow” drenches or sprays with chemicals such as Benlate® and Captan®.

• **Foliar sprays.** Onion plants may be sprayed at regular intervals to protect the foliage from infection by fungi or bacteria that may otherwise affect the plant. Intervals are usually weekly or two-weekly periods, depending on the weather. The disease control programme given in Section 1 details recommended chemicals, rates and times of application. A rate of 933 L/ha (100 US gal/ac) of diluted chemical is recommended for the spraying of fungicides/bactericides. It is also recommended that spraying be carried out to the point of run-off from the leaves. The large spray volume recommended is required because complete coverage of foliage is necessary for good control where spraying is of a protective nature, and the chemical is not systemic and therefore is not absorbed by the plant.

Stickers/spreaders are important ‘additives’ to fungicides for foliar applications. They improve the adherence of the fungicide to the leaf and provide greater coverage. Many modern pesticides are formulated with stickers and spreaders already incorporated. You should therefore read the label carefully before adding a sticker or spreader.

**16. General weed control**

The use of herbicides alone may not give satisfactory weed control. It must be supplemented by a number of other agronomic practices such as proper cultivation, mulching, optimal plant population density and crop rotation. An evenly spaced, vigorously growing crop will better compete with weeds than a sparse, poorly growing crop. Chemicals used in weed control differ in their mode of action. It is therefore important to know some basic terms used in chemical weed control in order to apply these herbicides effectively.

• **Selective herbicide.** A chemical used in such a way that it will control weeds in a growing crop without damaging the crop itself.

• **Non-selective herbicide:** A herbicide which controls plant growth generally without regard to plant species. Thus the herbicides used for weed control of non-crop land such as road-sides are of a non-selective type.

It must be realised however, that these terms are only relative, as very high rates of almost any herbicide will act non-selectively and will either damage or destroy all types of plants. Hence farmers should ensure that not only the recommended chemical is used, but also at the **correct rate.**

**Time of herbicide treatment of crops**

The susceptibility of both crops and weeds to herbicides depends to a large extent
on the time of application. Therefore it is important to apply herbicides at a time when crop plants are most resistant and when weeds are most susceptible. This time will vary according to the crop and the herbicide being used. There are a number of terms which describe the times at which herbicides may be applied:

- **Pre-emergence treatments.** Chemicals in pre-emergence treatments are applied after seeding but before weeds or crop emerge. The chemicals may act by destroying weed seedlings and/or by forming a toxic layer of chemical on or near the soil surface in which germinating weed seeds and young seedlings cannot survive. Thus the crop seedlings must either be tolerant to the chemical or the toxicity must have disappeared before the crop emerges. Pre-emergence treatments generally require larger volumes of water than post-emergence treatments and time of application may vary from seeding time to just before the crop emerges. A smooth, well prepared bed, free from clods is necessary for effective weed control and the surface must remain undisturbed so as to maintain a weed killing surface layer of soil. The soil surface should also be moist. Pre-emergence treatments are not effective against established perennial weeds. There are a number of types of pre-emergence treatments.

  **Contact pre-emergence treatments** are those which are applied after the weeds have emerged but before the crop is above ground. These chemicals are not selective and act by killing the green parts or plants with which they come into contact e.g. paraquat (Gramoxone®).

  **Systemic pre-emergence treatments** are those involving chemicals which are absorbed by foliage and translocated throughout the plant’s entire system, inhibiting or preventing its growth e.g. glyphosate (Roundup®).

  **Residual pre-emergence treatments** affect weed seeds as they germinate, or in a few cases, kill small weeds before the crop has emerged. This action continues for a period of time even after the crop has emerged, without injuring the crop. The application is however, made generally before the crop has come through or just as the crop is emerging e.g. DCPA (Dacthal®).

- **Post-emergence treatments.** Are those which are applied after the crop and weeds have emerged. Selective chemicals are used and the weeds are killed with little damage to the crop plants. The success of this type of treatment depends on the susceptibility of the weeds and the tolerance of the crop to the chemical e.g. pendimethalin (Herbadox®, Prowl®), fluazifop-butyl (Fusilade®) may be used safely on an onion crop. It is important to apply the treatment at the correct stage of crop and weed development. Since most weeds are more susceptible to chemicals when young, early treatments will require less herbicide and will result in less damage to crops from weed competition and from spray equipment.

Sometimes a herbicide may be applied post-emergence to the crop but **pre-emergence** to the weeds. For example, a crop such as tomatoes may be cultivated,
then a herbicide such as diphenamid (Dymid®) applied to the weed-free soil to control weeds which subsequently germinate. There are two types of post-emergence herbicides: contact types or systemic types. The action of these is similar to the pre-emergence contact and systemic types.

**Notes on the use of herbicides**
- Do not use any herbicide unless it is recommended for use on the particular crop either by the Ministry of Agriculture or similar agricultural institution or by the manufacturer on the product label. Details of recommended herbicides for onions are given in Section 1 of this manual.
- Best control is achieved if chemicals are applied when weeds are at the seedling stage.
- For best activity of soil-acting herbicides, soil must remain moist for two or three weeks after application to allow weed seeds to germinate so that they can be killed by the pre-emergent herbicide.
- Herbicides are most effective when conditions favour rapid weed germination and growth.
- When using wettable powders, make sure that the liquid in the tank is agitated constantly during spraying.
- To avoid spray drift and evaporation of volatile herbicides, applications are best made in the late afternoon hours when wind speeds and temperature are low.
- With residual herbicides, avoid disturbing soil surface after application of herbicides since a protective layer of herbicide is present in the top 0.6-1.2 cm (0.25-0.5 in) of soil.
- Sprayers should be calibrated so that correct application rates are used since rates which are too high can injure crops. A rate of 375 L/ha (40 gal/ac) of diluted chemical is recommended for application of herbicides.
- Thoroughly clean spray tank after use.

**Calibration of sprayers**
The output or spraying rate of equipment must be determined i.e. the sprayer must be calibrated. This should be done at least once every season.

**Method of calibration of boom sprayers**
- Fill the tank with clean water and select a suitable operating pressure, jets or nozzles, and tractor speed.
- Determine the spraying width of the boom. This is achieved by multiplying the number of nozzles or jets on the boom by the nozzle spacing.
- With the above boom width or spray cover, measure off the distance which the tractor has to travel to spray
Distance to be travelled to cover

\[
\frac{1/10 \text{ha}}{10} = \frac{1,000 \text{ m}^2}{10} \quad \text{OR} \quad \frac{1/10 \text{ac}}{10} = \frac{4356 \text{ ft}^2}{10}
\]

- Fill the tank to a definite marked level and spray the distance which would cover 1/10 ha or 1/10 ac using the same pressure and forward speed as you would use in the field.

- Measure the amount of water required to refill the tank. This amount of water multiplied by 10 gives the output or spraying rate per ha (or per ac).

**Compatibility of pesticides**

Since most spray applications consist of a number of chemicals, usually an insecticide, a fungicide and sometimes a foliar fertiliser, it is important to check whether these chemicals are compatible i.e. whether they can be safely mixed. Damage to the crop can result from spraying with mixtures of chemicals which are incompatible. Even if no damage results, the action of one chemical may be adversely affected by the presence of another. For further information consult the compatibility chart (Figure 10).

**Tank mixing of chemicals**

Having ensured that all chemicals to be used are compatible, mix the chemicals as follows to achieve uniformity of the spray mixture.

- Fill clean tank with water until it is one quarter full. This is best level for effective agitation.

- Mix wettable powders with a small quantity of water in a bucket and add to tank, rinse bucket and add rinse to tank.

- Agitate until wettable powders are well dispersed.

- Add flowable liquids (if no wettable powders are to be used) then flowable liquid can be added before first agitation.

- Add emulsifiable concentrates.

**Acidity, alkalinity and pesticides**

The acidity or alkalinity of a solution is measured by its pH on a scale of 0-14; 7 is neutral, below 7 is acid and above 7 is alkaline.

Research has shown that the effectiveness of most pesticides, in particular the organo-phosphates (e.g. Diazinon®) and the carbamate insecticides (e.g. Lannate®) are adversely affected by alkaline conditions due to a reaction known as alkaline hydrolysis. Since the hydrolysis may take place over a period, it is advisable to use spray solutions as soon as possible after mixing. This is particularly applicable to Barbados and Antigua where the pH of water may be >7.
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- **generally compatible**
- **WP** wettable powder forms
- **X** Incompatible
- **D** decomposes on standing - use immediately
- **O** Not usually mixed or compatibility unknown
- **C** generally satisfactory but unknown occasionally damage occurs.

**Figure 26** Spray compatibility chart (adapted from Alberta Vegetable Production Guide for Commercial Growers)
This chart applies only to the use of two material combinations. When three or more materials are mixed or when a wettable powder and a liquid formulation are mixed, incompatibility may develop. In all cases, follow directions on the label.

For more detailed information on the use of herbicides and the calibration of sprayers please refer to the following CARDI Factsheets:

- What you always wanted to know about weedkillers (but didn’t know whom to ask) by John Hammerton (Order No. CP-F/14.88).

- Knapsack Sprayer Calibration (and other calculations) by John L. Hammerton (Order No. CP-F/13.88).
REFERENCES


Anon
Onion production (CARDI, Antigua Unit).

Anon
Guidelines for onion production in Montserrat (CARDI, unpublished).

Anon

Anon


