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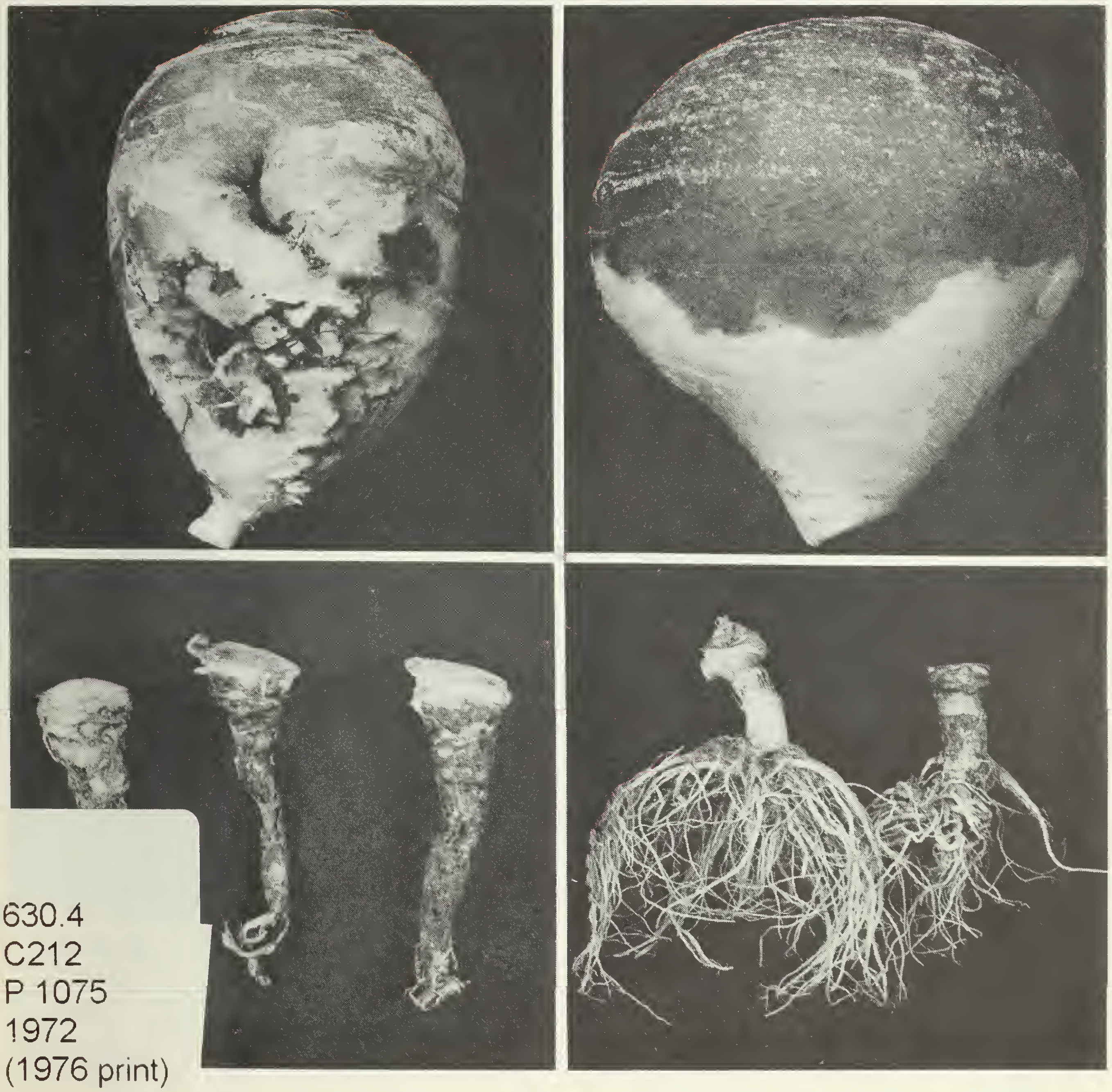

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ROOT MAGGOTS

IN RUTABAGAS, CABBAGES AND RELATED PLANTS IN THE ATLANTIC PROVINCES

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The small white maggots that attack the roots of rutabagas (swede turnips), cabbage, cauliflower, broccoli, and Brussels sprouts are the most serious pests of these crops in the Atlantic Provinces. Although several species of the maggots are found in or near the roots, the cabbage maggot[1] is the only one that causes serious injury. Millipedes (dark-colored, wire-like organisms about 1 inch (2.5 cm) long, and often confused with wireworms) feed on decaying vegetable matter and do not damage the roots unless root maggots are already there. The small black beetles[2] often seen near or in the roots are beneficial insects that kill root maggots.

Typical damage to the roots of rutabagas and cabbage by the cabbage maggot is shown in the illustration on the front cover. When the maggots attack small rutabaga and radish plants, the roots become distorted. Later in the season the maggots tunnel mainly near the surface of the roots below ground level and cause scarring and roughness. Early cabbage and cauliflower are often killed by the maggots. Severe attacks later in the season or when the plants are about half grown usually result in stunted plants and poor yields. The first sign of attack is the severe wilting of the leaves, particularly during dry weather, and as many as 100 of the small white maggots may be found around the roots and in the stem of a single plant.

LIFE HISTORY

Cabbage maggots (Fig. 1) hatch from small white eggs. The eggs are laid in the soil near the plants by flies that closely resemble the house fly in appearance, although the body is slimmer and slightly smaller. The small maggots, or larvae,

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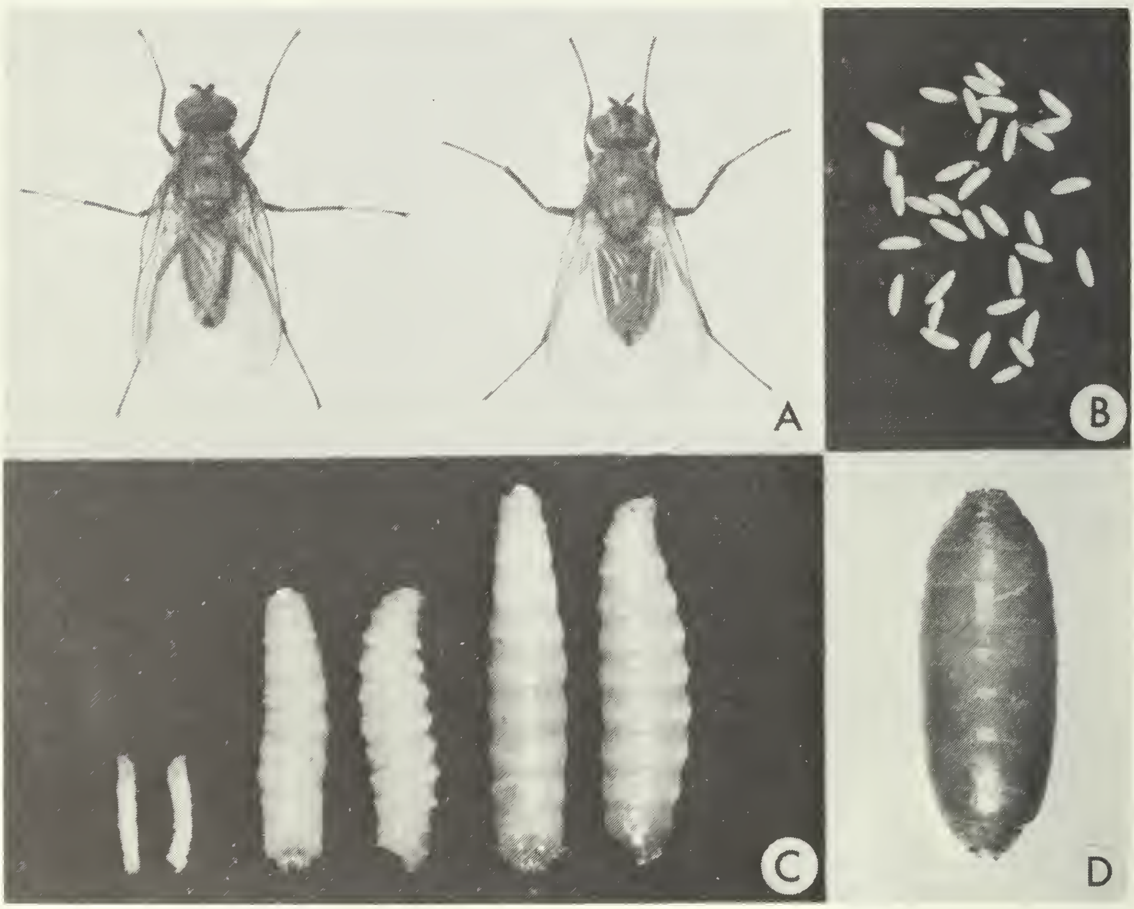
[1] *Hylemya brassicae* (Bouché).
[2] Mainly *Aleochara bilineata* Gyll.

move down by the stems of the plants and begin feeding on the tender, secondary roots. As they develop, they move up into the main root and continue to feed and to grow until they are about $^1/_4$ inch (0.6 cm) long. When fully grown, they usually move into the soil and form brownish protective cases, or puparia. However, if the surrounding soil is very dry, the maggots sometimes form puparia inside the roots. Inside the puparia, the maggots change first to pupae and later to flies. These flies produce a new generation of maggots later in the season. Maggots that form puparia late in the summer or fall usually do not produce a new generation of flies but overwinter as puparia and the flies emerge the following spring. These flies move to new fields of rutabagas, cabbage, and related plants, and begin to lay eggs 3 to 6 days after they have emerged. The flies live 2 to 5 weeks.

The time that the flies emerge from overwintered puparia varies with the type of soil in the fields where the puparia spent the winter. In sandy soil areas, flies emerge from the 1st or 2nd week of June to mid-July, whereas in clay loam areas emergence is mainly between mid-July and late August. In all areas, the flies emerge during a period of 6 or 7 weeks, the largest number coming out during the 3rd week.

Fig. 1. Stages of the cabbage maggot: *A*, flies, male (left) and female (right); *B*, eggs; *C*, three stages of larvae (maggots); *D*, puparium. The flies and eggs are five times natural size; the larvae and puparium are about six times natural size.



During midsummer, when soil and air temperatures are highest, the eggs hatch in about 3 days. The larvae feed for 3 to 4 weeks and then pupate. After pupation, flies may emerge in 12 to 15 days. The beginning of a new generation of flies may occur about 5 to 6 weeks after the first flies emerge from the puparia of the previous generation. During cooler weather in the spring and fall, development of the various stages takes longer.

The number of generations of root maggots during a season in the Atlantic Provinces depends mainly on the average temperature of the soil in the area. In sandy soil areas there are about two and one-half generations, with peaks in July and again in September. However, in clay loam areas, where the average soil temperature is lower than in sandy areas, development is retarded and first-generation maggots produced by flies emerging late in the season do not mature and form puparia until the fall. Many of these pupae go into diapause because of the lower soil temperatures, and flies do not emerge from the puparia until the next spring. Hence, in the heavy soil areas, only one complete generation is produced during a year.

Many farmers may note some details of the life history that are different from those described in this publication. For example, in all soil areas a few flies emerge during late May and early June. These come from puparia that overwinter near the surface of the soil or in storage bins, and they emerge earlier because of higher temperatures. They represent a very small percentage of the total maggot population and do not produce enough larvae to cause serious injury in large fields, although they may cause severe damage to a few plants in a garden. Although this insect usually overwinters as a pupa in the soil, another variation from the normal life history is that larvae may occasionally be found tunneling in roots in storage during January and February. The maggots are in an early stage of growth at harvest and develop slowly at low storage temperatures. They eventually mature and then usually crawl down into the soil in the bottom of the storage bin and form puparia, but they may sometimes pupate inside the roots if the surface is dry.

A variation in the expected peaks of attacks by maggots may be caused by weather. During periods of high temperatures and dry weather, the numbers of root maggots are greatly reduced. This may happen even when the largest number of flies is emerging and you would expect maggot infestations to be high. For example, if the weather is very dry in July, the peak infestation in a sandy area may occur in late June and early July rather than in mid-July as expected. The reasons for this are that many eggs and young larvae die in the dry soil and that the predators and parasites, which are most active at high temperatures, destroy many root maggot flies, eggs, and larvae.

CULTURAL CONTROL

In sandy soil areas, severe injury may be avoided by planting susceptible crops such as rutabagas, cabbage, and cauliflower in early July, if there are no early plantings of these crops nearby. Flies that develop from the first-generation maggots in early crucifer crops tend to move into adjoining late plantings where the plants are younger and more succulent. If the crops are 100 yards (90 m) or more apart, the flies usually remain in the early plantings where they settled early in the season. Conversely, severe damage may also be avoided if all growers in a light soil area plant early and harvest all the plants from the fields in July or early August. This method keeps the numbers of maggots in the area low, since no crops are present late in the season to harbor infestations.

In clay loam areas in the Atlantic Provinces, severe maggot injury may be avoided by planting early and harvesting in late July or early August. Also, severe damage to the crops may usually be avoided by delaying planting until about mid-July. The maggots are not likely to become abundant then because many eggs and young larvae die (dessicate) in the dry soil in midsummer; the late-seeded plants are small and do not have sufficient foliage to shelter the eggs from the direct rays of the sun; and predators and parasites destroy large numbers of eggs and larvae so that few second-generation maggots develop to infest the crops later in the season. However, with the development of strains resistant to certain insecticides, the time of emergence of flies from overwintering puparia (and therefore the time of attack by the root maggots) has changed somewhat and the cultural control methods are effective only if all farmers in an area follow the same cultural practices.

CONTROL WITH INSECTICIDES

Root maggots can be controlled with several insecticides, but these materials are also very poisonous to the beneficial predators and parasites that normally destroy many of the pest insects. There are at least five different beneficial insects that help to keep down the natural populations of the root maggots; some destroy root maggot eggs, larvae, and pupae in the soil, while others destroy the root maggot flies. Therefore, you should apply the poisonous insecticides so that they are concentrated against the maggots and have as little contact as possible with the predators and parasites.

The most efficient way to kill the root maggots is to concentrate the insecticide in a band below the surface of the soil in a shallow seeding ridge. Some of the new insecticides are phytotoxic (harmful to the young plants) and the poison should therefore be applied so that it is not in contact with the seed. Sprays and broadcast applications of insecticides should be avoided because they are more concentrated against the predators and parasites than against the root maggots.

Methods of Application

Soil Treatments at Seeding Time

For small acreages of rutabagas, cabbage, cauliflower, broccoli, and Brussels sprouts, apply insecticide in a 4- to 5-inch (10- to 13-cm) band by the following procedures:

For ridged seeding

Make a shallow ridge with a horse hoe or hiller, and level off the top with a roller drawn along behind. Adjust the setting of the hiller shears and the weight of the roller so that the flattened surface of the ridge of compact soil is about 2 inches (5 cm) above ground level.

Apply the band of insecticide on the flattened ridge with a band applicator.[3]

Place soil over the insecticide with the hiller so that there will be 1 to $1^1/_2$ inches (2 to 3 cm) of soil above the insecticide *after* the rows are rolled for seeding.

Sow the seed in the normal way but be sure it is slightly above the center of the band of insecticide.

For ground-level seeding

First sow the seed about $^1/_4$ inch (0.6 cm) deep and then apply the band of insecticide over the row.

Using a hiller and roller, cover the insecticide with about $^3/_4$ inch (1.9 cm) of soil. Do not remove any soil while weeding or thinning the crop.

For treating large acreages, the two-row machine shown in Fig. 2 applies fertilizer, makes the ridges of soil for seeding and covers the fertilizer, applies precisely the required amount of insecticide at any desired level in the soil, and sows the seed at a predetermined depth. It also lessens the hazard to the operator, who may be handling very toxic chemicals. This machine will treat the soil and sow 2 to 3 acres (0.8 to 1.2 ha) of land in an hour. It may be set up to be drawn behind a tractor, or it may be mounted on a three-point hitch. Blueprints for the machine may be obtained free of charge from the Research Station, Canada Department of Agriculture, Charlottetown, P.E.I., or the machines may be purchased commercially.

Transplants

Treatments should be applied within 2 days after transplants of stem brassicas such as cabbage and other vegetables are set out in the field, and the insecticide should be covered lightly with soil to lessen the danger of destroying predators and parasites. For small acreages, it is most economical to apply granular formulations of the insecticides around individual plants with a spot applicator. Drenches of emulsifiable concentrate or wettable-powder formulations in water at 2 ounces (60 cm^3) per plant may also be used. For larger acreages, a drench application that provides a continuous flow of material is preferable because of the speed of application, although more insecticide is required and the treatment is therefore

[3] A convenient hand applicator may be made from an ordinary 2-gallon (9-litre) plastic garden watering can by making holes in the spout large enough for the granules of insecticide to flow out at the required rate.

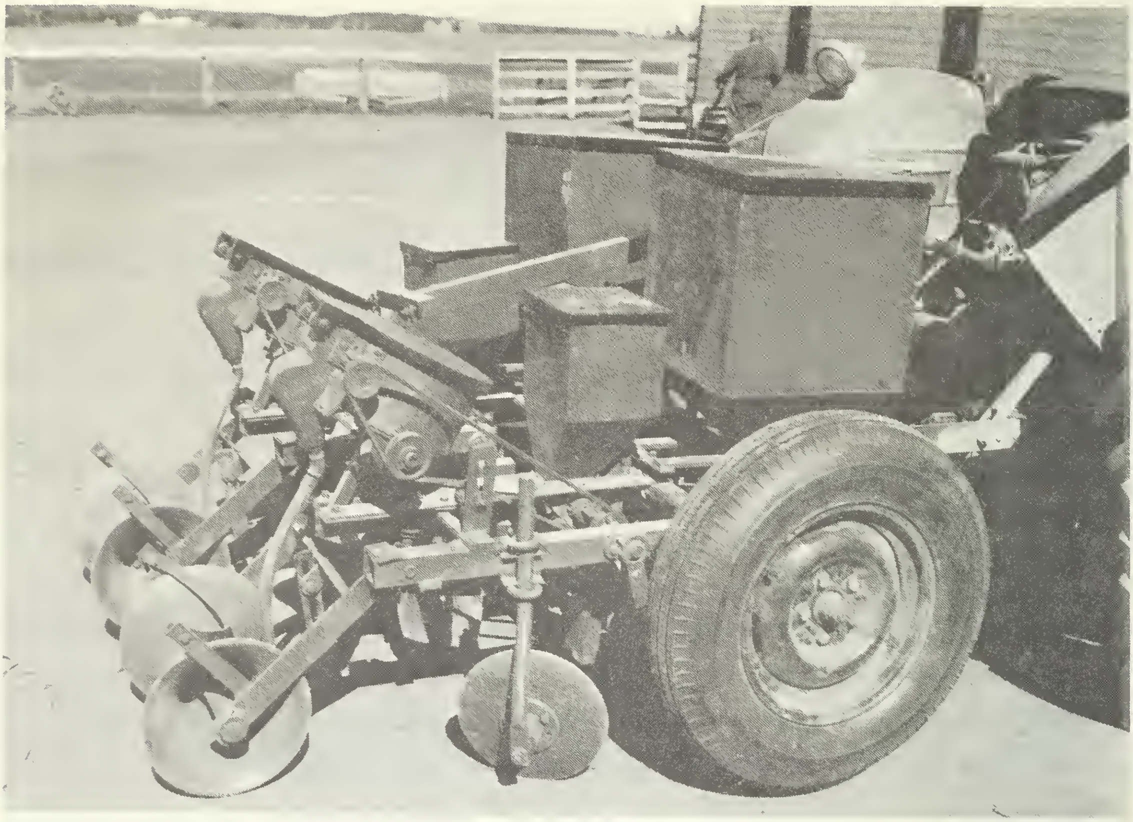


Fig. 2. Two-row machine for making subsurface applications of granular insecticide (center hopper), with fertilizer applicator at front and space-planting seeder mounted at the rear.

more costly. A shower nozzle or some similar device that delivers the insecticide mixture in a 2- to 3-inch (5- to 8-cm) band over the rows is suitable for applying drenches. The nozzles are simply connected to pieces of hose from a sprayer or any suitable tank. Do not use pressure.

Recommended Insecticides

For the current year's recommendations, obtain a copy of the Atlantic Provinces Vegetable Production Recommendations from your nearest agricultural representative or provincial department of agriculture.

Cautions

Follow closely the cautions listed on the insecticide label. When inhaled, absorbed through the skin, or swallowed, many of the newer materials are extremely toxic to humans and all warm-blooded animals.

Observe closely the time interval required between the last application and harvest; the established time varies with the crop, the insecticide used, the amount applied, and the number of applications.

CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in:	
LINEAR			
inch	x 25	millimetre	(mm)
foot	x 30	centimetre	(cm)
yard	x 0.9	metre	(m)
mile	x 1.6	kilometre	(km)
AREA			
square inch	x 6.5	square centimetre	(cm^2)
square foot	x 0.09	square metre	(m^2)
acre	x 0.40	hectare	(ha)
VOLUME			
cubic inch	x 16	cubic centimetre	(cm^3)
cubic foot	x 28	cubic decimetre	(dm^3)
cubic yard	x 0.8	cubic metre	(m^3)
fluid ounce	x 28	millilitre	(ml)
pint	x 0.57	litre	(ℓ)
quart	x 1.1	litre	(ℓ)
gallon	x 4.5	litre	(ℓ)
bushel	x 0.36	hectolitre	(hl)
WEIGHT			
ounce	x 28	gram	(g)
pound	x 0.45	kilogram	(kg)
short ton (2000 lb)	x 0.9	tonne	(t)
TEMPERATURE			
degrees Fahrenheit	(°F-32) x 0.56 or (°F-32) x 5/9	degrees Celsius	(°C)
PRESSURE			
pounds per square inch	x 6.9	kilopascal	(kPa)
POWER			
horsepower	x 746	watt	(W)
	x 0.75	kilowatt	(kW)
SPEED			
feet per second	x 0.30	metres per second	(m/s)
miles per hour	x 1.6	kilometres per hour	(km/h)
AGRICULTURE			
gallons per acre	x 11.23	litres per hectare	(ℓ/ha)
quarts per acre	x 2.8	litres per hectare	(ℓ/ha)
pints per acre	x 1.4	litres per hectare	(ℓ/ha)
fluid ounces per acre	x 70	millilitres per hectare	(ml/ha)
tons per acre	x 2.24	tonnes per hectare	(t/ha)
pounds per acre	x 1.12	kilograms per hectare	(kg/ha)
ounces per acre	x 70	grams per hectare	(g/ha)
plants per acre	x 2.47	plants per hectare	(plants/ha)