

RESEARCH for FARMERS

SUMMER 1965

GREEN MUSCARDINE
WIREWORM KILLER

CROP RESIDUES IN SOIL
CAN BE TOXIC

ASTER YELLOWS—
A CEREAL DISEASE

RUST IN FLAX

ORGANIC NITROGEN IN SOILS

INSECT CONTROL IN RAPE

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CANADA DEPARTMENT OF AGRICULTURE

Ottawa, Ontario

MINISTER, HON HARRY HAYS

DEPUTY MINISTER, S. C. BARRY

VOL. 10 SUMMER 1965 No 3

"Research for Farmers" is published quarterly by the Canada Department of Agriculture. Its purpose is to help keep extension workers informed of developments in research and experimentation as carried on by the various units of the Department.

COVER PHOTO—A diamondback larva hanging from its own silken thread. This is presumed to be a defensive reaction to a disturbance (see page 14)

NOTES & COMMENTS

Ever hear of green muscardine fungus? Fox and Jacques (p. 3) tell us it is a wireworm killer. But results of their field experiments suggest that the fungus is so dependent on proper conditions of temperature and humidity as to make its artificial distribution impractical except where it is not naturally present. These authors further explain that although this pathogen, in nature, causes only low mortality, it probably contributes substantially to the total of natural control factors that may prevent more serious outbreaks.

* * *

Did you know that rape seems to be more frequently affected economically by insect pests than other oilseed or cereal grain crops in the Prairie Provinces? So Putnam (p. 14) reports as he lists the most serious insect pests of rape, according to findings at the CDA Research Station, Saskatoon, Sask. He confines his reporting to their discoveries about the diamondback moth. Studies on the immigration of this undesirable alien are continuing because it is not completely known for the Prairie Provinces.

* * *

Are crop residues in the soil toxic? Patrick (p. 4) says they can be—and illustrates the fact by field and lab studies at the CDA Research Station, Harrow, Ont. . . . Hoes and Tyson (p. 10) report on race 300—a flax rust that attacks Marine, Arny, Cree and Sheyenne varieties—and tell what the CDA Experimental Farm, Morden, Man., is doing about it. . . . Chiynowski (p. 7) writing from the Plant Research Institute, Ottawa, discloses experiments being conducted on cereals which have been found susceptible to aster yellows—until recently, considered a disease of vegetables and ornamentals. . . . Sowden (p. 12) reveals what the Soil Research Institute, Ottawa, is doing in an intensive study of the nature of soil nitrogen.

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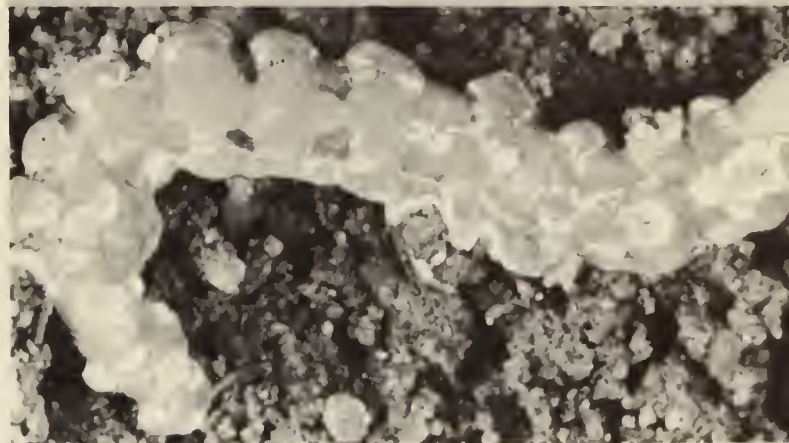
GREEN MUSCARDINE - wire worm killer

C. J. S. FOX and R. P. JACQUES

Wireworms often are important crop pests in Nova Scotia. Fortunately, natural forces help to control them. Sometimes many are killed by the green muscardine fungus. This fungus, *Metarhizium anisopliae*, was first isolated from a beetle in 1879 by the great Russian biologist, Metchnikoff. Subsequently, he infected beetle larvae experimentally and thus may be credited with establishing the idea of artificially causing disease of insect pests.

This disease was first recorded in Nova Scotia as early as 1908. In recent years it has been studied extensively at the CDA Research Station, Kentville.

In studies on the ecology and control of wireworms, large numbers of individuals were collected and examined by sifting soil through quarter-inch mesh screen. Records obtained in the spring showed that relatively few larvae (wireworms) and adults (click beetles) that had overwintered were killed by the disease. The highest mortality occurred immediately before, during, and after the pupal period which extends approximately from July 15 to August 25. Most of the dead wireworms had apparently been infected and had died just before entering the pupal stage. Mortality in the pupae never exceeded 2 per cent. Adults collected after July 15 had newly emerged from the pupal stage and at this time appeared to be more susceptible as over 8 per cent were killed. Therefore, it appears that the insect is most vulnerable to infection by the fungus shortly before, during, and after pupation when the outer



Top: A healthy wireworm.

Bottom: Wireworm killed by green muscardine fungus.

covering or cuticle of the insect body is undergoing change or is not fully hardened.

In our studies, we attempted to infect wireworms with the fungus under laboratory conditions but so far have met with little success. Wireworms reared in vermiculite or soil treated with the fungus were infected only slightly more frequently than those reared in non-treated vermiculite or soil. These tests are continuing to determine the factors that influence infection.

We have also conducted field experiments to determine the value of artificially spreading the green muscardine fungus in the soil. We cultured the fungus in bran, soil, or peat moss, broadcasting and working it into the soil with a rotary cultivator. Both a native and an European strain of the fungus were tested. However, sampling the wireworm populations for several years after application gave no indication that incidence of the disease had increased.

The negative results of the field experiments suggest that the fungus is so dependent on the proper conditions of temperature and humidity as to make its artificial distribution impractical except where it is not naturally present.

Although, in nature, this pathogen causes only low mortality it probably contributes substantially to the total of natural control factors that may prevent more serious outbreaks of wireworms. ●

Mr. Fox is an entomologist and Dr. Jacques an insect pathologist at the CDA Research Station, Kentville, N.S.

Z. A. PATRICK

In the course of most farming practices, considerable quantities of crop residues, resulting from unharvestable portions of plants, cover crops, farmyard manure and other sources, are left in and on the soil and are continually being added to the soil. These materials at various stages of decay, and the many decomposition products resulting therefrom, are ever-present components of the soil, and the environment of plant roots. A thorough knowledge of the influence that these substances have on plant growth, is therefore of the utmost importance. Unfortunately, no final conclusions can be drawn regarding the precise nature of the effects produced by these substances or their over-all influence on soil productivity. This is because so many complex interactions occur and results obtained have been quite variable.

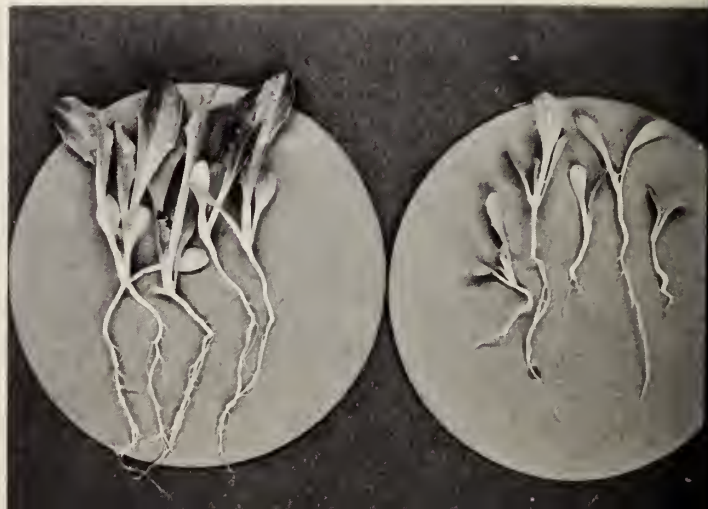
On the basis of the accumulated information it has been commonly accepted that, in general, the addition of plant residues to soil is desirable or even essential to maintaining or improving soil productivity. In the normal course of events, the plant debris that is plowed back into the soil is processed by the living soil population and many of the elements contained in the plant tissues are transformed or released and made available again to succeeding crops. Besides helping maintain soil fertility, the tilth and other physical and chemical characteristics of the soil are improved with a beneficial influence on plant growth. It has been found, however, that under some conditions the results are not always beneficial. In some instances, for example, growth of succeeding crop plants was depressed while incidence of root diseases was increased. This latter aspect will be considered at this time, namely, why and when adverse effects are produced. By knowing the reasons for these adverse effects, it may be possible to find means of avoiding them and thus more fully utilize the various beneficial effects that are imparted to the soil by crop residues.

As stated earlier, and a fact well known to farmers, plant residues are decomposed by soil microbes, and the constituent nutrients, particularly nitrogen, potassium and phosphate, are released into the soil and made available again to growing plants. Other chemical substances are produced during the decomposition process, such

The author is a plant pathologist with the CDA Research Station, Harrow, Ont.

CROP RESIDUES IN THE SOIL CAN BE TOXIC

Fig. 1—Seedlings watered with extracts from soil without (left) and with (right) decomposing plant residues.



as amino acids, sugars, vitamins, phenolic compounds and antibiotics. Many of these likewise are taken up by plant roots and may also affect plant growth. Most of these effects are beneficial. Among other things, they stimulate growth and increase plant vigor or, as in the case of certain antibiotics, help to control plant pathogens. On the other hand, it has also been found that during the decomposition of many plant residues, some substances are produced which can cause plant injury. This fact was clearly illustrated in some of our studies carried out in the laboratory and in the field at Harrow.

For our experiments, we chose some of the crops commonly used in the rotation practices such as rye, timothy, corn, barley and wheat. Each of these crops was plowed or disked in the conventional manner and allowed to decompose in the soil for periods up to 2 months. Land that was kept fallow was used as the control. From these soils, at 5-day intervals, we obtained water extracts and added them to growing plants or to germinating seeds. Some of the results are shown in Fig. 1, wherein the lettuce plants, on the right, were watered with extracts from soil in which plant residue from rye had been decomposing for 20 days. Those on the left, the controls, were watered with extracts from the fallow soil in which there were no decomposing plant residues. The lettuce plants treated with extracts containing rye decomposition products were stunted, their root system considerably reduced and some root injury was evident. When similar tests were carried out using germinating lettuce seeds (Fig. 2), again root injury was obtained. Furthermore,

there was no growth of root hairs, the seedlings did not develop further and most were killed. No such injury was obtained with extracts from fallow soil where growth was excellent.

Subsequent studies were designed to obtain information regarding the formation of the plant-injurious substances (phytotoxins); where and how they were formed, whether their formation was associated mainly with the decomposition of plant residues and what was the nature of their activity in the soil. Some of these studies were conducted in root observation boxes in which one side of the box is made of glass. Using such boxes, it is possible to observe roots as they grow through the soil. We showed the root system of a tobacco plant growing in soil that did not contain freshly decomposing crop residue. The root system was extensive and the roots were vigorous and healthy. In another observation box, the same soil was used except that some rye residue was mixed with the soil and allowed to decompose for 20 days before the tobacco was planted. As was evident, in this instance the root system was considerably reduced. Many of the roots were injured or killed and careful examination showed that most of the injury occurred in those sections of the root growing near the decomposing rye residue.

In some tests, the glass front of the boxes was carefully removed and the decomposing residue was separated out and extracted with water. When such extracts were tested on lettuce or tobacco seedlings, injury similar to that mentioned above was obtained. These results strongly indicate, therefore, that crop residues during their decomposition may give rise to substances highly in-

Fig. 2—Germinating lettuce seed treated with extracts from decomposing rye residues. Note root injury.



Fig. 3—Results of laboratory tests of Burley 1 tobacco.



injurious to growing roots and that the injury is most severe on those roots that are closest to the decomposing residue. Similar results can often be seen on plants growing in the field where root injury is often observed to be most severe on roots that are found growing close to clumps of freshly decomposing plant residue.

We also studied another aspect of this problem, namely, the relationship between plant residues and plant pathogens in the soil. Some of our field studies showed that black root rot of tobacco caused by a fungus, *Thielaviopsis basicola*, is often more severe in those areas of the field where large quantities of rye residue have been added to the soil. This is illustrated in Fig. 4. The tobacco variety shown is Burley 1 which normally is highly resistant to black root rot. In this instance, however, plants growing in some areas of the field are stunted and there appears to be a breakdown of resistance to the disease. On closer examination, it was observed that the areas where breakdown of resistance occurred contained large amounts of freshly decomposing rye residues. These results were confirmed in the laboratory by using extracts from decomposing rye residues as described earlier. In these tests, (Fig. 3, plants left to right), we treated one group of Burley 1 tobacco plants with extracts of soil that did not contain decomposing rye residues and, as shown, the roots were white and healthy. The next group of plants was treated with extracts of decomposing rye residues, but these extracts were diluted so that very little root injury was obtained. Another group was treated with the dilute toxic extracts and then the roots were inoculated with the black

root rot fungus and the final group was inoculated with the fungus alone. As is shown in Fig. 3 (second plant from right), black root rot was very severe in the inoculated plants that were treated with the rye decomposition extracts. Those plants that were inoculated with the pathogen alone (extreme right) exhibited their normal resistance and very little black root rot was evident on the roots.

Let's briefly summarize some of the other more interesting findings that have been obtained in the 12 years that this study has been in progress. For example, the decomposition of plant residues is not always accompanied by the formation of substances that cause plant injury. The extracts obtained during the early stages of decomposition, i.e. when the plant residues had been decomposing in the soil for 5 to 30 days, usually produced the most plant injury. Soil type, soil condition, type and amount of plant residue added to the soil were found to be very important factors in determining whether or not plant injury was obtained and the severity of the injury. For example, it was discovered that when a given type of plant residue is allowed to decompose under excessively wet conditions, or in heavy soils where aeration is poor, the resulting decomposition products would most likely be highly toxic to plants. When the same plant residue is allowed to decompose under normal moisture conditions or in well aerated soil the decomposition products would not be injurious. The studies revealed also that the toxic substances, even when formed, do not persist in the soil for very long and usually are inactivated in less than 2 weeks.

Although many questions still remain unanswered and much more work is necessary, the practical aspects of the results of these studies to agricultural production are obvious. For example, the time of plough down of a cover crop or the incorporation of plant residues may be critical for the best growth of the succeeding crop, thus planting should be delayed until the peak of toxicity has passed. In summary, it should be emphasized that although the beneficial far outweigh the detrimental aspects associated with plant residues, the fact that residues can be detrimental should be kept in mind. Thus, as more information on all the diverse relationships and possibilities associated with plant residues and organic amendments becomes available, their beneficial potential can then be more fully utilized. ●

Fig. 4—Section of field with Burley 1 tobacco. Note that plants in some areas are stunted.



ASTER YELLOW

A DISEASE OF CEREALS



Fig. 1—Barley plants infected with aster yellow virus. Note leaf symptoms and sterile heads on tillers.

L. N. CHIYKOWSKI

Six years ago, the title of this paper would have been considered a typographical error. Although well known for many years as a disease of vegetables and ornamentals, aster yellows was not known in cereals. All cereals, in fact, were considered to be immune to infection by this leafhopper-transmitted virus. The infection of Vantage barley in Minnesota in 1960 followed in 1963 by the infection of Ramsey durum wheat at the Plant Research Institute, Ottawa, disclosed for the first time the susceptibility of cereals. Unknown, however, was the extent of this susceptibility.

During the past two years, greenhouse experiments for studying the effect of two common strains of aster yellows virus on various varieties and types of barley have disclosed some interesting facts.

Dr. Chiykowski is a plant virologist with the Plant Research Institute, Ottawa, Ont.

Twenty-four varieties of barley fed on by six-spotted leafhoppers (*Macrosteles fascifrons*) carrying aster yellows virus, were found susceptible to both strains of virus (Table 1). With the celery-infecting strain, infection ranged from 35% in Dover to 84% in Keystone. With the non-celery-infecting strain, infection ranged from 33% in Olli to 95% in Champlain. There did not appear to be any relationship between barley type and the percentage of plants that became infected.

Early symptoms of the disease appear in about 21 days and consist of bright-yellow patches or blotches on the older leaves. The newer leaves are light green and are rolled backward. Because the internodes are shortened, leaves arise close together and give the plants a bushy appearance (Fig. 2). These plants usually fail to head and die prematurely. When virus development is comparatively slow, plants may reach heading before symptoms appear. Then the plant displays not only leaf symptoms, but misshapen and distorted heads which are sterile (Fig. 3). The awns

may become shortened and leaflike and the head then appears as a cluster of small leaves. The disease is hard to recognize if infected plants reach heading and produce a normal head on the main culm while tillers display typical leaf symptoms or sterile heads (Fig. 1). These symptoms may take up to 60 days to appear. In a field of headed grain, these infected plants cannot be seen readily and losses in yield would be hard to determine.

Greenhouse experiments are now being carried out on the reaction of wheat to aster yellows virus. Results show that all varieties tested (Cascade, Lemhi, Pelissier, Ramsey, Selkirk, Stewart and Thatcher) are susceptible to both strains of virus. Early symptoms in wheat appear in about 26 days as yellow spotting at the tip of the leaf. As this spotting continues, the leaf may become almost entirely yellow with green areas scattered throughout. Some purpling may occur along the leaf edges. Leaves of infected plants appear to droop downward from their point of attachment



to the stem. Plants infected when young remain small and die rapidly. Few infected plants were observed to head, but when they did, the heads were sterile. Unlike heads of infected barley plants, these infected heads of wheat did not become deformed. Rather, they remained small and the awns, normally pointing upward and close together, grew away from the head. There also appeared to be some elongation of the awns.


Although most varieties of barley tested were found highly susceptible to aster yellows virus, this experimental result was brought about by confining a number of virus-carrying leafhoppers on a small number of seedlings kept under controlled light and temperature. Under field conditions less infection would be expected. Even so, during the summer of 1964, infection reached nearly 5% in some fields of barley in Manitoba. It is not likely that aster yellows will ever result in crop failure in cereals, but if viruliferous leafhoppers were to become abundant when crops are very young, serious losses could result. ●

TABLE 1. SUSCEPTIBILITY OF BARLEY VARIETIES TO TWO STRAINS OF ASTER YELLOWS VIRUS.

Variety and type		Per Cent Infected	
		Celery- infecting strain	Non-celery- infecting strain
Keystone	6 row feed	84	90
Brant	6 row feed	80	51
Vantage	6 row feed	78	71
Champlain	6 row feed	77	95
Montcalm	6 raw malt	73	76
Traill	6 row feed	70	60
Nord	6 row feed	67	60
York	6 row feed	63	67
Husky	6 row feed	63	60
Jubilee	6 row feed	59	56
Olli	6 row malt	59	33
Kindred	6 row malt	55	77
Parkland	6 row malt	53	78
Gateway	6 row malt	52	51
Herta	2 row feed	51	83
Fort	6 row feed	48	92
Trophy	6 row malt	45	68
Hudson	6 row, winter, feed	45	71
Charlottetown	2 row feed	44	81
Wolfe	6 row feed	43	79
Hannchen	2 row milling	43	63
OAC 21	6 row malt	42	87
Kenate	6 row, winter, feed	40	59
Dover	6 row, winter, malt	35	68

Fig. 2—Far left: Early infection of barley seedlings causes bushy, stunted plants (right). Healthy plants (left).

Fig. 3—Left: Bushy heads affected with virus are usually distorted and sterile. Left to right: Healthy plant; three unhealthy plants.



RUST

A CONSTANT THREAT TO FLAX

J. A. HOES and H. TYSON

Flax rust came to the fore again in 1962 when scientists at the Morden Experimental Farm discovered race 300 in southern Manitoba. This race attacks the varieties Marine, Arny, Cree and Sheyenne, and it posed a serious problem especially because Marine was widely grown not only in the Canadian prairie provinces but also in North Dakota and Minnesota in the United States.

During 1963, race 300 spread throughout the flax-growing regions of Manitoba, and was also found in southeastern Saskatchewan and in North Dakota. The possibility of an epidemic in the 1964 season was great. To combat the danger, susceptible varieties were removed from the recommended list and added to it was the American variety Bolley, the later primarily meant as a substitute for the early variety Marine. In addition, the dangerous rust situation was widely publicized both here in Canada and in the adjoining U. S. flax-growing regions of North Dakota and Minnesota. As a result, the Manitoba acreage planted to susceptible varieties dropped from 60% in 1963 to 13% in 1964 and similar gratifying results were obtained in the United States.

Rust caused little damage in 1964 and the shift from susceptible to resistant varieties is one important factor. The late start of rust development in the spring of 1964 is another. Some late planted fields of susceptible varieties suffered

Dr. Hoes is a plant pathologist and Dr. Tyson is a flax specialist at the CDA Experimental Farm, Morden, Man.

appreciable rust damage, however. Our surveys in Manitoba and eastern Saskatchewan during 1964 indicate that large amounts of race 300 along with other races are still widespread and farmers planting any susceptible variety in 1965 take a great risk.

Rusts other than race 300 are prevalent in the Canadian flax growing regions; the overall effect of the races on varieties grown in Canada is summarized below:

RESISTANT VARIETIES	SUSCEPTIBLE VARIETIES	
Bolley	Arny	Victory
Raja	Cree	Viking
Noralta	Crystal	
Norland	Marine	
Redwood	Redwing	
Redwood 65	Royal	
Rocket	Sheyenne	

Rust has been a constant threat to flax since the decade of 1930-1940 when it appeared on Bison and, when in 1941 and 1942, rust became epidemic owing to more favorable temperature and moisture conditions. The flax breeder accepted the challenge, and the rust-resistant variety Koto resulted. It was released in 1943, but new rust appeared in the same year and Koto had to be abandoned. Dakota, at first resistant to rust, was released in 1946 but a new rust attacked it severely in 1948. The latest episode in the struggle for rust resistance has been the appearance of race 300 mentioned above.

Apart from importation of races from other continents, new flax rust races appear because the fungus is able to mutate, i.e., it can change spontaneously and because it reproduces sexually,

i.e., it "breeds". At the same time, a variety susceptible to the new race is required in order that it can establish itself. Flax rust, unlike stem rust of wheat, only needs one host: flax. All five spore stages are produced on flax and the orange-red uredospores in summer give rise in late summer and fall to black teliospores through which the parasite overwinters. The red spores are found on leaves, the black spores on stems. In spring the teliospores germinate, sexual reproduction takes place and eventually uredospores are produced again. Absence of any susceptible variety completely disrupts its life cycle and its fate would be total elimination. The use of resistant varieties is therefore the most efficient means of control.

Resistance to different races of rust is based on different resistance genes, and the best insurance in breeding for resistance is the use of different genes for resistance. Arny, Cree, Marine and Sheyenne all depended for their resistance on the same resistance gene and this is why they all succumbed to the new race. The more different resistance genes a given variety possesses, the more difficult it is for the rust to breed a race that is able to attack such a variety.

At the Morden Experimental Farm we are presently incorporating several resistance genes into Marine to convert it into a variety with a firm base for rust resistance while retaining the earliness and high yield which made it so popular in the past. A more immediate prospect of finding rust resistance combined with desirable agronomic characters lies in intensive selection among the progeny of Marine crossed with Redwood and other varieties. Some promising selections are already being tested in preliminary regional trials. ●

Left: Flax with uredial pustules of rust on undersides of leaves.

Right: Close-up of flax leaf showing uredial pustules.





Analysis of nitrogenous soil on technicon auto-analyzer.

F. J. SOWDEN

The fertility of the soil depends, to a large degree, on its supply of available nitrogen. In most soils, the amount of readily available nitrogen is quite small and is present largely as nitrate and exchangeable ammonia. Most of the reserve supply of nitrogen of a soil is held in various types of organic compounds. This reserve supply is decomposed slowly by microorganisms to become the major source of the nitrogen available to plants (other than that added as fertilizer or fixed from atmospheric nitrogen by microorganism). The primary source of most of the organic nitrogen of soils is undoubtedly plant and animal residues and this nitrogen when originally added to the soil was largely protein. However, free protein would be rapidly decomposed in soil and it was thought at one time that most of the soil nitrogen was combined as a lignin-protein complex. As more information has accumulated this idea has been modified or abandoned.

From a practical point of view, we could perhaps manage the soil nitrogen better if we knew more about the chemistry and biochemistry of the materials with which we are working, and an improved knowledge of the chemistry of the organic nitrogen of the soil would improve our understanding of the soil system. For this reason we in the Soil Research Institute, have been making a fairly intensive study of the nature of

the soil nitrogen. Modern micro and semimicro methods make this work possible since relatively small amounts of soil can be used and the methods are much faster. These methods are, for the most part, adopted from protein chemistry.

By treating the soil with acid, we can divide the total nitrogen into four groups: the insoluble nitrogen fraction, amino acid, amino sugar, and ammonia nitrogen. In this way a fair idea of the general nitrogen distribution can be obtained. We have found that in general the amino acids in soil are the same as those found in an 'average' protein. The amino acid distribution, that is the ratio of one amino acid to another, is also similar to that of a normal protein. Quite small amounts of some 'non-protein' amino acids are sometimes found. There is a difference, however, in the ratio of amino acid nitrogen to total nitrogen found in different soils; this varies from a high of about 60 per cent in some soils to a low of 25 per cent in others. In general, the more decomposed the material the lower the percentage of amino acids; for instance, it is higher in the A horizon than in the B.

The ammonia nitrogen in these hydrolyzates increases as the proportion of amino acid nitrogen decreases. The amino sugars usually contain 5-10 per cent of the total nitrogen; this percentage often increases during decomposition of organic matter and in some instances with depth in the profile. Glucosamine and galactosamine are the only amino sugars that have been identified in soil hydrolyzates; the ratio of glucosamine to

Dr. Sowden is an organic chemist with the Soil Research Institute, Ottawa, Ont.



ORGANIC NITROGEN IN SOILS

Effect of nitrogen (left) and lack of nitrogen (right) on cereal growth.

galactosamine varied from 1.6:1 to 4:1. The higher ratios were found where one would expect to find a higher proportion of fungi relative to bacteria. The amino sugars are probably synthesized by microorganisms; they occur in the polysaccharides formed by bacteria and in bacterial cell walls. Chitin, which is found in many fungi, is a polymer of glucosamine.

We have also made some preliminary investigations to see how the amino acids are combined in soil and have found that at least a fair proportion of them are combined through peptide bonds as they are in protein. The amounts of free amino acids in soils are very small and would account for much less than 1 per cent of the total. This amount increases on freezing the soil. If the soil is extracted with an organic solvent (like carbon tetrachloride) before or during the extraction of the free amino acids there may be a 25-100 fold increase in the amount of amino acids extracted (but still less than 1 per cent of the total). The freezing of the soil (and the organic solvent) may rupture microbial cells and thus release some amino acid material. These free amino acids may be readily available to microorganisms for conversion to ammonia and nitrate.

From a practical point of view, one of the more important problems is to devise a reliable and simple test to measure the nitrogen-supplying power of the soil that could be used in assessing fertilizer requirements. The most frequently used, and probably the best, method is to measure the

ability of the soil to form nitrate under carefully controlled conditions. The chief fault of this test is that it is time-consuming. Some more rapid chemical tests have been devised but they are not very satisfactory. The reasons for this are fairly obvious; we still know very little as to how the ammonia, amino acids and amino sugars are combined in the soil and if one assumes, as the evidence now available suggests, that the ammonia and amino acid nitrogen is the ultimate source of much of the available nitrogen, the question is still not solved. An average soil containing 0.2% total nitrogen would contain 2,000 lb. per acre of amino acid and ammonia nitrogen; obviously most of this is not available in any one season. The proportion available would depend on the rate of breakdown by microorganisms, the amount utilized by the microorganisms themselves, and ammonification and nitrification rates. Each of these processes depend on soil temperature, moisture and aeration—to name some of the factors. Obviously, devising a simple chemical method to measure nitrogen availability is no easy task.

We are trying to devise simpler methods to measure the nitrogen distribution in soils and to see if indeed the ammonia and amino acid nitrogen is the source of most of the available soil nitrogen. We are also continuing our studies of how the ammonia and amino compounds are combined in soils. This should aid in our understanding of the soil system and (hopefully) some fractions might be found that are the source of at least a significant part of the available nitrogen. ●



Above: Diamondback moth larva hangs from its own silken thread. (Probably a defence mechanism).



Right: Diamondback moth larvae feed on underside of rape plant leaf. (Larva on left is full-grown.)

INSECT CONTROL

A COMPLEX PROBLEM IN RAPESEED PRODUCTION

L. G. PUTNAM

Fields of rape grown for oilseed production are usually hosts to many species of insects. Some are potentially harmful; others are beneficial, mostly because they are living on the harmful ones. Of the potentially harmful insects some, like those mentioned later, occasionally become numerous enough to become pests, while others, like the imported cabbage worm, a nuisance to cabbage growers, has failed to amount to anything serious in rape fields. Rape seems to be more frequently affected economically by insect pests than other oilseed or cereal grain crops in the Prairie Provinces. It is quite probable that the experiences of some growers with insect pests have been quite discouraging.

In our investigations at the CDA Research Station, Saskatoon, we have found that the most serious insect pests of rape are the caterpillars of the diamondback moth, *Plutella maculipennis*, the

Bertha armyworm, *Mamestra configurata*, and the beet webworm, *Loxostege stricticalis*. These insects usually do not injure the plants much by defoliation alone; they become destructive when they attack the pods. Therefore, they are pests of rape when it is in advanced development. In the early seedling stage, newly emerged stands are sometimes attacked by red turnip beetles, *Entomoscelis americana* and recently, in some districts, by flea-beetles, *Phylloteta*, probably *pusilla*. All these pests are partly or completely specialized for feeding on plants, such as rape, related to cabbage, turnips, etc. In addition, rape is also susceptible to some of the more general pests, such as the subterranean cutworms.

Our research has shown that the more important insect pests of rape fluctuate in numbers from year to year, presumably for reasons that have nothing to do with supplies of suitable food. We are primarily concerned with understanding how these other factors affect abundance. If we can identify and understand them adequately, we might be able to develop a procedure for protecting crops by means other than insecticides.

The author is a specialist, in charge of cutworm and rapeseed insect research, CDA Research Station, Saskatoon, Sask.

Secondly, if occasional eruptions of economic infestations cannot be prevented, knowledge even a few weeks in advance of their occurrence would be useful. Finally, the now widespread concern about insecticide residues has made it necessary to search for non-persistent poisons to replace those that controlled the pests so readily before.

The diamondback moth is perhaps the most interesting insect inhabitant of rape fields to deal with in detail. It is not a very impressive insect; its full-grown larvae are pale green, slender, and not over half an inch long. To be destructive, the larvae have to become very abundant. This can happen rapidly as a generation, from egg to egg, requires only three to four weeks. Thus, the diamondback can complete several generations even in the short season of our Prairie Provinces. It does not overwinter in our latitudes, and must therefore re-establish itself each year by immigration of the first generation of parent moths. In our experience, it has never failed to do this, but resulting numbers of larvae have varied from scarce to something enormous.

Timing in relation to the development of its host crop is of prime importance to the question of whether or not serious damage results. Rape pods can be damaged either by partial destruction of whole young pods, or by peeling of more advanced ones. As the leaves age and the pods grow tough with ripening, the plant becomes inhospitable to the diamondback. Therefore, the period during which the host crop is susceptible to damage is rather limited, being perhaps the last two weeks of July. Whether there will be enough diamondbacks to be destructive at this time will depend upon the abundance of female moths of the preceding generation late in the month of June. Sufficient numbers could occur either as the result of a build-up of breeding stock initiated by immigrant moths of one or two generations earlier, or as the immediate result of a new and sufficiently heavy immigration of moths. We consider the latter to be the more likely cause, and believe it was responsible for the outbreak in 1962. In our studies we found that immigrants arriving in May or early June usually found too few host plants, (these were likely to be destroyed by tillage), and their progeny were too few and heavily parasitized to produce sufficient moths to start an outbreak after only one or two generations.

We are continuing our study into immigration of the diamondback moth because it is not completely known for the Prairie Provinces. The moth

is not a strong flier. Elsewhere in the world, it has been well established that moths of this species can be carried on the wind for hundreds of miles. Patterns of air flow suitable for the transport of small insects from south to north are known to exist in North America, and it seems obvious that diamondback moths must be among such insects. Even when the number of moths landing per acre is relatively small, as we have found is usual with the first immigration, the total number must be huge, because there is evidence that a large part of the arable area of the Prairie Provinces is blanketed by immigrant moths at about the same time. Therefore, although the whereabouts of the take-off area is not exactly known, it can be imagined as vast and well stocked with host plants at the critical time of year.

As long as the grower produces oilseed crops attractive to the diamondback moth, he is exposed to forces over which he has no control, since an outbreak is an event that may develop within one generation of breeding. He can only hope to be alerted in sufficient time to protect his rape crops with insecticides. Unusually large numbers of diamondback moths caught in light traps, together with direct observation of uncommonly numerous moths in the habitat, can provide the first 'alert'. It is not a simple matter to develop a method for early evaluation of the numbers of larvae because when newly hatched, they feed within the tissues of the leaf. Later stages, which feed from the under-surface of leaves, can be detected by careful search, and a practical survey method will probably have to be based on such a tedious technique.

In chemical control, we can report some good news because there are good prospects of switching from the effective but enduring DDT to some less persistent organic phosphate. Also, since the diamondbacks in our crops have no long-term future, nothing we do to them here is likely to bring about resistance to insecticides in the basic stock from which they originate, in their permanent wintering area much further south. Regarding their insect parasites, we do not anticipate any harm from damaging them along with their hosts, because, soon after the normal time of application of any insecticide, the crop becomes too mature for diamondbacks in any case. Provided we can avoid residues, there is not, therefore, much reason for concern about the harmful results that have followed on the heavy and consistent use of insecticides for the control of other insects, and mites, in some other crops. ●

EAR TO THE GROUND

INTERESTING RESEARCH HIGHLIGHTS



Gardner at the CDA Experimental Farm, Fort Vermilion, Alta., shows the value of plastic mulch for tomatoes.

PLASTIC MULCH SUCCESS—Plastic mulch is highly recommended for growing the more tender and heat-loving vegetables, says F. S. Nowosad, Research Coordinator on Northern Agriculture, C.D.A. Ordinary, clear, two-gauge polyethylene vapor barrier, 36 inches wide is stretched flat on the surface of the ground a few days before the transplants are ready to set out. This warms up the soil by an average of 4 degrees, firstly by trapping the heat from the sun, and secondly by reducing the evaporation of moisture from the soil surface, a process which normally cools the soil. Plants are set in place through slits cut in the plastic and nature does the rest.

By using plastic mulch at Fort Simpson, N.W.T., "Arctic First" sweet corn was ready for the table one week earlier and produced 40 per cent more than without plastic. "Red-Sugar-Lump" watermelons at Fort Vermilion were ready for harvest by mid August, "Marketeer" cucumbers at Hay River were ready early and produced heavily; "Bush Beefsteak" tomatoes at Fort Liard ripened on the vine—all because they were grown on plastic mulch.

HARVESTING FROZEN CORN FOR SILAGE—A yield increase of only .07 tons/A. dry matter was gained by delaying the harvest of frozen field corn 31 days at Brandon, Man., in 1964.

On the night of August 12-13 air temperature was 32° and grass minimum temperature dropped to 24°.

Field corn was badly damaged by frost.

Field silage harvested on August 13 produced .90 tons/A. dry matter compared with .97 tons when cut on September 14. Dry matter percentages were 12.1 and 16.0 respectively.

AUTOMATION REACHES LIGHT TRAPS—An automatic device for segregating light trap insect catches at pre-determined time intervals has been designed at the CDA Research Station, St. Jean, Que.

The design is such that this device can operate beneath various types of light trap, and collect the material dry or in fluid. The prototype was tested extensively during the summer of 1964 for a special study of nocturnal flight activity of Trichoptera. A Robin Moth trap bulb and entry cone were used and the insects were collected in alcohol. The timing apparatus functioned reliably during all-night catches, and thus demonstrated its usefulness for studies of this kind.

STILL THE CHAMP—Crested wheatgrass seeded in 1948 in the Riske area of Kamloops, B.C., is still yielding more than native vegetation.

Yields for 1960, 1962, 1963 and 1964 were: Crested wheatgrass 477 lb/acre; Native vegetation 210 lb/acre.

Native vegetation increased to 293 lb/acre and wheatgrass decreased to 410 lb/acre in 1964, when rainfall was above average.