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report on
PLANT
DISEASE

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THE ECTOPARASITIC NEMATODES OF ILLINOIS

Plant-parasitic nematodes attack all crops grown in Illinois. Though no plant escapes injury, damage to corn and soybeans is noticed most often. Symptoms are most obvious on light colored or sandy soils, but damage occurs in all soil types. Nematodes were native to the Illinois prairie and are present in all cropland, usually in communities of several species. In fact, nematodes infest every cubic centimeter of nonsterilized soil in Illinois. Yield loss may occur anywhere in the state whenever populations of one or more species increase to damaging levels.

Plant-parasitic nematodes are microscopic roundworms averaging 1 mm in length at maturity (Figure 1). Most live in soil and feed on plant roots. Because they are so small and colorless, they are impossible to see in the soil or on roots, except two endoparasites: cyst and root-knot nematodes. The adult female stage of these nematodes swells into lemon and pear shapes, respectively, which can be seen with the naked eye. While endoparasites tend to be the most damaging forms, ectoparasitic nematodes constitute a wider range of genera and species in the soils of Illinois.

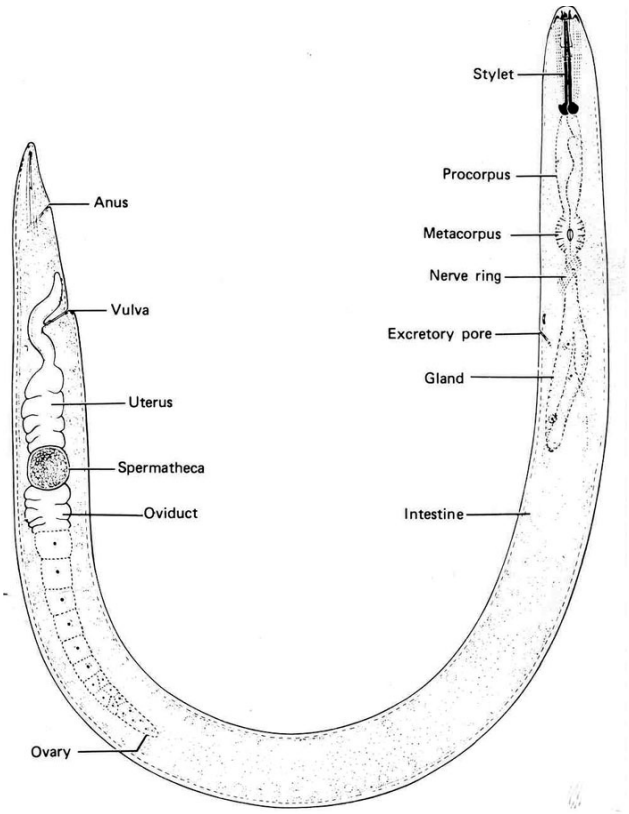

Figure 1. Typical plant-parasitic nematode (from Luc).

Symptoms

Figure 2. Field showing typical nematode damage.

A nematode problem usually is recognized by yellowing and/or stunting of patches of plants in a field, orchard, nursery, or other type of planting. Damage often is most severe in the centers of these patches and diminishes toward the edges to normal-appearing plants (Figure 2). Symptoms of drought or nutrient deficiency (nitrogen, phosphorus, potassium)may occur first in nematode-damaged areas during periods of water stress and/or high temperatures may occur on hot days and recover overnight. Because nematode damage can occur

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without aboveground symptoms, nematodes may be easily overlooked as a problem in crop production. A gradual decline in yield over a period of years often indicates a nematode problem. When plants are dug up, the roots may appear discolored; lateral roots may be short, stubby, and lacking fine feeder roots; and overall root systems may be reduced in size (Figure 3). Root symptoms often resemble dinitroaniline herbicide injury. When nematodes are suspected, a soil and root sample must be taken for analysis to confirm that they are the cause of the problem. Several other problems, including insect feeding, compaction, herbicide damage, and nutrient deficiency, easily can be confused with nematode damage.

Figure 3. Corn roots parasitized by needle nematode, Longidoridorus breviannulatus. Left, absence of fine feeder roots. Right, stunting, branching, and swelling at root tips (photo by B.J. Jacobsen).

DISTRIBUTION

Population densities of both individual nematode species and species complexes vary widely across a field. High populations usually occur in patches. This clustered distribution is diagrammatically illustrated by Figure 4. The pattern accounts for the typical aboveground symptoms of stunted and/or yellowed plants in small areas in the field.

The vast majority of plant-parasitic nematodes live in the upper 30 cm (one foot) of soil. However, in response to hot summer conditions and downward growth of primary roots, certain forms, such as needle nematodes, will move deeper into sandy soils, and late-season samples must be taken from a greater depth. Few nematodes are found in the top 2-3 cm (one inch) of cultivated soil because of extreme temperature and moisture fluctuations. One exception is golf course greens, where nematodes are often found in the top 2-3 cm.

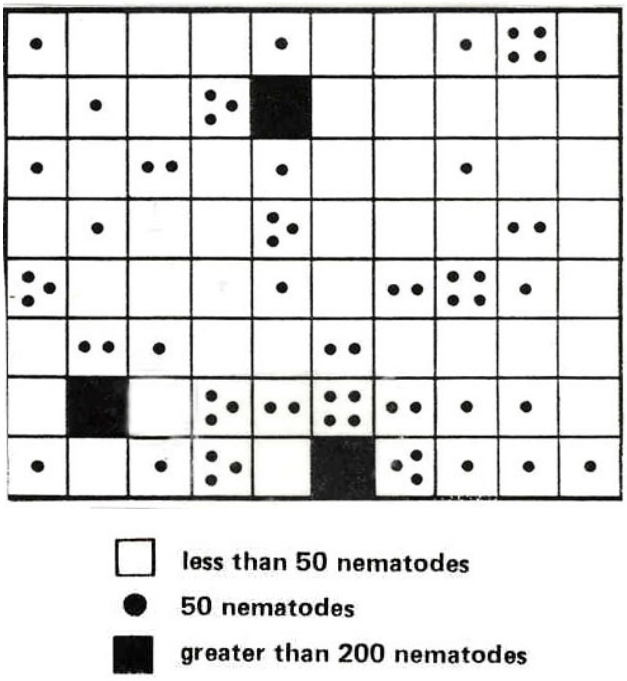

Figure 4. Plant-parasitic nematode distribution pattern – ten-acre field sampled 80 times. Each square represents one sample.

GENERALIZED LIFE CYCLES

Nematodes develop from eggs through four juvenile stages to adults and molt between each life stage (Figure 5). Depending on the species, either the first- or second-stage juvenile hatches from the egg. Juveniles and motile adults move in a wavelike motion in the soil searching for suitable host plant roots on which to feed. Ectoparasitic nematodes feed during all life stages once they hatch from the egg. In about half of the species, adults mate and females lay fertilized eggs. In other species, males do not exist, or are very rare, and are not needed for reproduction. Most nematodes complete their life cycles in about one month, but some species require up to a year. Nematodes feed ecto-, endo-, or semiendoparasitically. Ectoparasites insert their hollow spearlike feeding structure, the stylet (Figure 1), into a root from the outside. They then secrete enzymes into individual root cells, and ingest the partially digested cell

contents. Most ectoparasites are migratory and may move from one place to another to feed. A few, such as ring nematodes, are sedentary and rarely, if ever, move once they begin to feed. Endoparasitic nematodes feed entirely within the root. Migratory endoparasites,
such as lesion nematodes, alternately feed and move within the root. Sedentary endoparasites, such as root-knot nematodes, never relocate after a feeding site is established. Semiendoparasites, such as cyst nematodes, may feed ectoparasitically and endoparasitically during portions of their life cycles or, more commonly, with only the anterior head region embedded in the root. In any case, nematodes rarely travel more than 30 cm (one foot) a year in the soil.

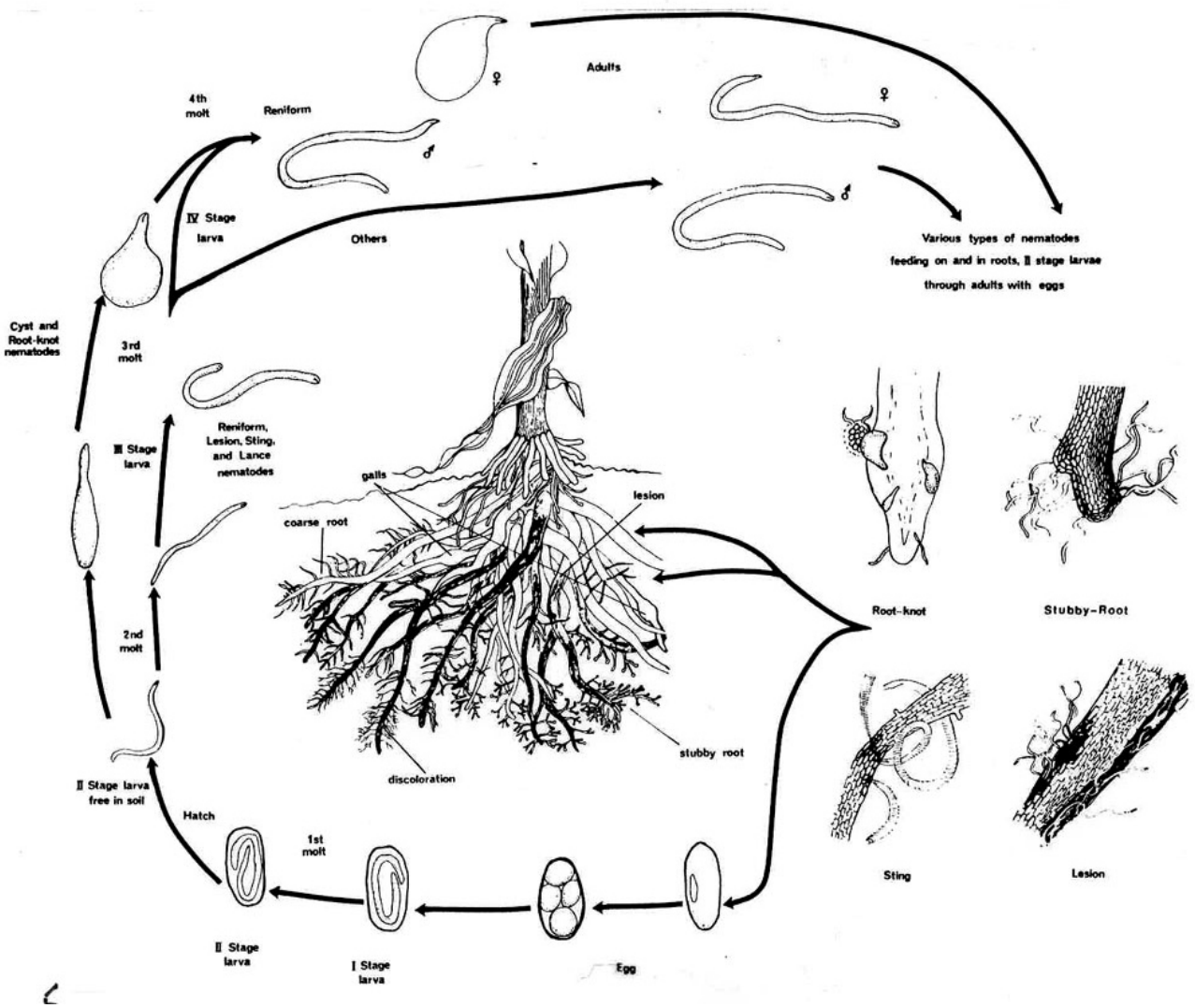

Figure 5. Generalized life cycles of six genera of nematodes that feed on corn (drawing by Tina Ekstrom).

STUNT AND SPIRAL NEMATODES

Stunt (*Tylenchorhynchus*) and spiral (*Helicotylenchus*) nematodes are cosmopolitan in Illinois. These nematodes tend to browse throughout the root systems of plants. They present few problems for growers of annual agronomic crops (Table 1), though both forms can be found in virtually every field. Stunt nematodes compose the greatest number of species among ectoparasitic nematodes and occasionally cause minor damage to corn. Spiral nematodes may contribute to stress on corn, soybeans, and other row crops during hot, dry weather but rarely cause yield loss even at high population levels. Populations sometimes reach high levels on clovers and other perennial forage crops and can cause stand decline and yield loss, particularly in the southern part of the state. Both nematodes are most damaging to turfgrasses: stunt nematodes primarily on bentgrass, and spiral nematodes mainly on bluegrass.

NEEDLE, STUBBY-ROOT, DAGGER, AND STING NEMATODES

These nematodes are serious pathogens of many crops (Table 1). All prefer to feed at or near the root tips of plants. Feeding causes root devitalization, the most severe type of root injury, and induces stubby primary and lateral roots and coarse root systems lacking feeder roots. Necrotic spots resulting in root discoloration are also common. Stubby-root (*Trichodorus* and *Paratrichodorus*) and sting (*Belonolaimus*) nematodes are most damaging in the southern states and are limited to sandy soils of coarse outwash and alluvial parentage. Stubby-root nematodes occur in sandy soils throughout Illinois, but damaging populations are encountered only occasionally on corn, small fruits, and nursery propagative material. Sting nematodes are restricted to extreme southern Illinois, where they have been found occasionally damaging corn. Needle nematodes *(Longidorus*) are the largest of the plant-parasitic nematodes, ranging up to 1 cm in length. In general, they occur in all soils but are parasitic principally on woody perennials in undisturbed environments. However, one species, the corn needle nematode, is the most economically damaging of the ectoparasitic nematodes in Illinois (Figure 3). It occurs only in the major river basins of the state and, like the stubby-root and sting nematodes, is restricted to sandy soils. Limited in its host range almost entirely to grasses, this nematode can be devastating to corn, severely stunting and killing young seedlings early in the season. Its distribution within sandy areas is highly correlated with continuous corn and fields with grassy weed problems. Dagger nematodes (*Xiphinema*) are cosmopolitan in Illinois. These nematodes usually are the most abundant form around roots of woody plants in undisturbed soil. They are thought to be a major contributor to winter injury and premature decline of trees and shrubs. Although dagger nematodes can cause damage to both annual and perennial herbaceous plants in prairie (loess) soils, high populations and resulting yield losses are found most commonly in soils of coarse texture.

LANCE NEMATODES

Lance nematodes (*Hoplolaimus*) are widely distributed, but only one species occurs in Illinois. Though initially ectoparasitic, these nematodes are found partially or totally embedded in more soft-tissued roots. They can be damaging to a wide range of plants including trees and shrubs, turfgrasses, forage legumes, and annual row crops in all soil types. Yield losses in corn and soybeans, however, generally occur only in sandy soils.

RING, SHEATH AND PIN NEMATODES

Ring (*Criconemella*), sheath (*Hemicycliophora*), and pin (*Paratylenchus*) nematodes are rather sedentary ectoparasites that feed throughout root systems of plants. They cause little damage to most of their many plant hosts, even at high population levels (Table 1). All three forms are parasitic primarily on perennial plants in undisturbed soil. Ring and sheath nematodes are seldom found in cultivated cropland but occasionally damage turfgrasses and woody plants when populations become very high. The tiny pin nematodes are less than 0.5 mm in length, and are the smallest and least damaging of the obligate plant-parasitic nematodes. Though commonly found in all fine-textured soils, economic populations have never been encountered on annual crops and only rarely been encountered on perennial crops in Illinois.

OTHER STYLET-BEARING NEMATODES

Many other forms of stylet-bearing nematodes, whose feeding habits are virtually unknown, occur in Illinois soils. All have very weak stylets and are assumed to feed primarily on soil fungi. They probably play a major role in maintaining a natural balance of lower plants in the soil ecosystem. All, however, are potential parasites of higher plants and occasionally may browse ectoparasitically on thin-walled root hairs, causing minor injury to plant roots.

COLLECTING AND SUBMITTING SOIL AND ROOT SAMPLES

Obtaining a "good sample" may be time consuming and difficult and appear costly, but a diagnosis and recommendation are only as good as the sample that is taken. The best times to sample are about one month after emergence or right after harvest for annuals and around mid-June for perennials. Samples can be taken from an entire field or planting, or from pockets of obvious damage ("hot spots"). They can be collected with a core sampler, narrow-bladed trowel or shovel, and a bucket.

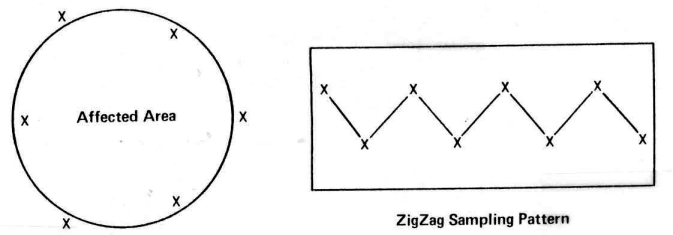

Figure 6. Sampling patterns for nematodes. X represents one subsample; left, for diagnosis of stunted or yellowed areas; right, for five-acre analysis.

Sampling an entire planting requires considerable effort and expense – **but** it is beneficial because it provides a more realistic picture of field-wide nematode distribution than sampling only pockets of damage. Each sample should represent about ten acres and consist of 12-24 subsamples (proportionately fewer for smaller plantings). Subsamples should be taken to a depth of 15 to 20 cm (6 to 8 inches), depending on the root growth habit of the plant. Sampling should follow a zig-zag pattern (Figure 6).

Often growers do not notice a problem until there are areas of severe stunting and yellowing in the planting. To sample a heavily damaged area, at least a dozen subsamples should be taken from the affected area. In young stands of annual plants (up to six weeks after planting), the center of the area with the most severely damaged live plants should be sampled. In more advanced stands and in perennial plantings, subsamples should be taken from the periphery of the area (Figure 6) – not the center – because the highest population levels usually will be around the margins. A similar size sample from a nearby "healthy" area can be very helpful in evaluating the problem. After the subsamples are gathered and mixed, a sample of one quart of soil and a handful of roots should be sealed in a sturdy plastic bag. The sample must be kept cool (less than 27°C or 80°F) and submitted to the University of Illinois Plant Clinic or other appropriate diagnostic laboratory as soon as possible. Essential background information on the problem should be included.

Table 2. Numbers of Nematodes Used as Guidelines to Help Determine if a Nematode Population is at or Above the Action Threshold

Nematode	Threshold numbers per 100cc of soil*
Needle (*Longidorus*), corn only	5-25
Stubby-root (*Paratrichodorus*)	50-100
Root-lesion (*Pratylenchus*), preplant soil only	50-100
Root-lesion (*Pratylenchus*), per g of dry roots	500-1000
Dagger (*Xiphinema*)	50-100
Lance (*Hoplolaimus*)	40-150
Stunt (*Tylenchorhynchus*)	150-300
Spiral (*Helicotylenchus*)	300+
Ring (*Criconemella*)	300-600

*These numbers are guidelines only but can cause moderate to very severe damage; thresholds often must be increased or decreased, depending on plant species and cultivar, age of plant, season of sampling, soil texture, cultural practices, weather conditions, and other biotic and abiotic factors.

Table 1. Nematode Genera Associated with Nematode Problems in Illinois, Their Importance, and Type of Damage

Genus	Importance[a]	Type of damage	Some other hosts common to Illinois
Pratylenchus (Root-lesion)	1-B	Smaller-than-normal root system. Darkened and discolored roots. Moderate stunting.	Grasses, cereals, legumes, vegetables, tree fruits, strawberry, and pines. Host range varies for different species of root-lesion nematodes.
Hoplolaimus (Lance)	2-B	Reduced root system. Darkened and discolored roots. Moderate stunting and chlorosis.	Grasses, legumes, tomato, pepper, pines, and many others.
Xiphinema (Dagger)	2-B	Severe planting stunting and chlorosis. Few fine feeder roots.	Grasses, legumes, ornamentals, strawberry, trees, and many others.
Helicotylenchus (Spiral)	2-C	Smaller-than-normal root system. Root decay. Mild stunting.	Grasses, cereals, legumes, tomato, strawberry, peach, pines, and many others.
Tylenchorhynchus (Stunt)	2-C	Smaller-than-normal root system. Moderate stunting, and chlorosis.	Grasses, cereals, legumes, tomato, pepper, and many others.
Longidorus (Needle)	2-A	Severe stunting and chlorosis. Severe root pruning. Root system consists mainly of short, stubby, thickened side roots that appear somewhat swollen.	Grasses, potato, grape, lettuce, celery, and many others.
Paratrichodorus (Stubby-root)	3-A	Stubby lateral roots. Coarse roots. Excessive upper roots. Severe stunting and chlorosis.	Grasses, legumes, tomato, potato, cabbage, beet, ornamentals, and many others.
Belonolaimus (Sting)	3-A	Severe stunting and chlorosis. Small, coarse, devitalized root system	Grasses, cereals, legumes, potato, cabbage, strawberry, pines, and many others.

[a]The number indicates how commonly the genus is involved in nematode problems in Illinois: 1-very common, 2-occasionally, 3-rarely. The letter indicates its potential for damage: A-very damaging; B-moderately damaging, C-damaging only at high populations.

Control

Specific control recommendations from the University of Illinois Plant Clinic at Urbana are based on nematode counts, soil type, fertility levels, cropping practices, yield potential, control costs, and crop value. The following general suggestions will help maintain nematode populations below economic levels:

1. **Maintain optimum growing conditions**. Damage by nematodes is greater on plants that are under stress from other factors. Damage can be reduced, or in a few cases eliminated, by providing plants with optimum growing conditions, including adequate moisture, nutrients, and soil aeration at all times. Controlling other diseases and insects also reduces plant stress. Occasional deep plowing of crop land will break up subsoil hardpans that restrict root growth and render plants less tolerant of nematode parasitism.

2. **Rotate crops.** Most nematodes have wide host ranges. Nonetheless, crop rotation usually inhibits population buildup because plant species vary considerably in suitability as hosts for individual nematode species. Some nematodes have very restricted host ranges, in which case rotation is a highly effective means of control. The corn needle nematodes, for example, are significantly reduced by a one-year rotation to nonhost soybeans. Rotation is of limited benefit unless weeds also are controlled. In some cases, the host status of weeds has not been as well defined. If growers are in doubt about the host status of weeds they should contact specialists in nematology or extension on the agricultural experiment station staff.

3. **Treat soil with dry or moist heat.** This method is commonly used to control nematodes and other soilborne pathogens in the greenhouse and the home. The method is economical and is highly effective if performed correctly. However, its application is limited to relatively small quantities of soil. Nematodes are killed by exposure to temperatures 40° to 50°C (104° to 126°F), depending on the species. Any method that will thoroughly heat the soil and plant residues above these temperatures will kill the nematodes. One such method is solar heating – covering the ground with clear plastic. Steaming of soil is an efficient method for greenhouses. Baking small quantities of soil in an oven at 82°C (180°F) for 30 minutes or 71°C (160°F) for 60 minutes also is effective.

4. **Apply nematicides**. The use of chemicals to control nematodes can be effective and economical, especially where high-value crops are involved. Preplant fumigation with volatile nematicides may be necessary to control replant and other nematode diseases in orchards, nurseries, strawberry beds, and other areas. In certain situations, use of the broad-spectrum but costly fumigants such as methyl bromide or chloropicrin may be desirable. The specific situation dictates whether the expense of fumigation is warranted. Fumigants are not economical for field and forage crops in Illinois. They should not be used except by certified, professional pesticide applicators trained in handling and applying soil fumigants.

   Certain nonvolatile, granular- or liquid-nematicides are effective for some annual row crops, such as corn and soybeans, and vegetables (see Illinois Agricultural Pest Control Handbook); and for flowers, ornamentals (nonwoody and woody), trees and shrubs, turfgrass and home garden vegetable crops (see Illinois Urban Pest Management Handbook). Both publications are revised annually and available at your nearest Extension Office. Always refer to the pesticide label, contact your pesticide dealer, or check with your nearest Extension unit, or with University specialists for up-to-date information on usage. Legal usage varies for other crops. Most are HIGHLY TOXIC AND MUST BE APPLIED ONLY BY CERTIFIED PESTICIDE APPLICATORS.