New Research Targets

Improved Management Strategies For Warm-Season Turf Pests

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The key to effective pest management, whether it be weeds, diseases, or insects, is a good basic understanding of the pest's biology and ecology. This includes the life cycle and any environmental circumstances that enhance the likelihood of the pest occurring. Furthermore, this basic understanding of the pest adds to our ability to effectively manage it by allowing us to exploit its weakness and to use control strategies in the most effective way. A good working knowledge about the pest is the foundation to environmentally-sound pest management programs. This information can be developed only through quality research programs dedicated to turfgrass pest management.

As one examines the warm-season turfgrass industry in the South and its supporting data base, there is a significant void of needed research information. This statement is not to put blame on anyone for having shirked their responsibilities, but rather is a statement of fact that reflects two important points about warm-season turfgrass in the South. First, all aspects of the industry have grown quite rapidly in the last twenty years and this growth has essentially outstripped the research resources to keep up with emerging problems. In North Carolina alone there are more than two million acres of turf and over 500 golf courses hosting more than 15.3 millions rounds of golf. The rapid increase in population in the South over the past twenty years has resulted in more subdivisions with home lawns, more parks, more athletic fields, more golf courses, sod farms, and commercial properties. Along with this has come the typical pest problems we had experienced all along. New problems occur from this increasing abundance of healthy, lush turfgrass. Examples of emerging pest problems will be discussed later in this article. In addition, the extended growing season in the South offers a longer season for a variety of pests to cause problems.

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Another factor that has influenced our ability to effectively manage warm-season turfgrass in the South has been a lack of turfgrass research programs with a long history of support to the industry. As compared to universities in the North and Mid-

PREDICTING BEETLE EMERGENCE

Target Degree Days	Base 50 degrees F.
N. Masked Chafer 1st Adults	898-905
N. Masked Chafer 90% Adults	1,377-1,579
S. Masked Chafer 1st Adults	1,000-1,109
S. Masked Chafer 90% Adults	1,526-1,679
Japanese Beetle 1st Adults	1,050-1,180
Japanese Beetle 90% Adults	1,590-1,925

Table 1. Degree day accumulations for emergence of scarab grub adults.

west, the agricultural universities in the South, as a general rule, have not had large, comprehensive turfgrass research programs in place for many years. Rather, many had small programs and, as the industry has grown, they are making every effort to grow with them. This means that in many cases there is not an extensive data base on pests and pest management from which to build. In some instances, we are still working to develop basic information data bases. This is a growing pain associated with an industry that has seen phenomenal growth.

While the problem of supporting a rapidly growing industry is certainly a good problem to have, it does challenges those involved in the development of pest management programs that are an integral part of maintaining the vitality of the industry. Additionally, new regulations and continued concern over pesticide use, human health, and the environment, fuel the need to develop new, alternative pest management strategies. We also are still quite unsure as to the overall impact the Food Quality Protection Act signed in 1996 will have on the turfgrass industry. The EPA is moving slowly on its implementation and no one is quite sure as to its impact other than the fact that we know it will impact the turfgrass industry.

Many pest problems on turf have increased in the past twenty years in the South.

As mentioned at the onset, our goal in the development of pest management programs is to base them on sound biological information. The better the researchers understand each pest, the more information can be passed along to you, the turfgrass manager, and ultimately, the better you can manage the pests that affect the turfgrass for which you are responsible. The importance of understanding the biology and ecology of the pests cannot be overstated. While pest occurrence has consistent trends in specific locations, there are always local variations that influence the timing and abundance of pest occurrence. A working knowledge of each pest can help you customize your pest control to obtain optimum results.

Increasing Insect Damage

Many pest problems on turf have increased in the past twenty years in the South. From an insect perspective, we have seen more damage from mole crickets, green June beetle grubs, twolined spittlebugs, and fire ants. The increase in fire ants is a direct reflection of their constant march across the South after their introduction into the U.S. Mole crickets are similar in that they have spread from the initial point of entry in south Georgia. While these insects would have spread regardless of the size and growth of the turf industry, the fact that there are more acres of lush, well maintained turf than ever before provides a quality habitat and food source for the crickets.

The twolined spittlebug is a good example of an insect taking advantage of the environment we create for it. The twolined spittlebug adult feeds on ornamentals, particulary several species of hollies. The spittlebug nymph feeds on turfgrass. Put the two together, as we usually have in any new subdivision, and we have provided the complete "buffet" for the insect in all of its life stages and created a very attractive site for pest outbreaks. Dr. Kris Braman, University of Georgia has conducted research on this pest that will help us better understand it and do a better job managing it.

A similar situation is observed in those areas where Japanese beetles are a problem. The adults love to feed on a variety of ornamentals, including crape myrtles, roses, purple leaf and other plums, golden sycamores, witchhazels, and many varieties of grapes. When used in the landscape these plants can attract the beetles into the turf area. Since Japanese beetles fly during the day and their eggs require sufficient soil moisture to prevent dessication, the beetles seek out areas that appear to have good soil moisture (eg. areas where the turf is quite green and lush).

Once again, the environment created through landscaping and turf maintenance increases the likelihood of pest outbreaks.

Forecast models have been developed in the North and Midwest to predict the emergence of the Japanese beetles in the spring and these have been quite accurate. Since much of an insect's development is based on how warm it is or degree day accumulation, some of these models can be used in the South. Our research in the southern coastal areas of North Carolina have shown that the same model is an accurate predictor of Japanese beetle emergence in the South (Table 1). The newer chemistries for preventative grub control make timing more critical than ever. Consequently, accurate information on beetle emergence can help us to plan applications.

Perhaps one of the most troublesome pests in the South and one of the most challenging to manage (along with fire ants) has been mole crickets. Numerous researchers throughout the Southeast are currently investigating management of this pest with studies on the pests biology and control with both conventional and biological products. Much of the challenge of managing this insect arises from the fact that it is a soil insect pest and its subterranean nature makes most of its habits and activities unknown to the turfgrass manager. Soil insects, as a general rule, are also more difficult to control because the turf, thatch , and soil often act as a buffer, which protects them from the control agent. The rest of this article will attempt to illustrate how a better understanding of pest biology, ecology, and even behavior is critical in developing cost-effective and environmentally-sound management strategies for this, or any other pest. While the focus may be on mole crickets, the need to understand the pest and the benefits from doing so are true for all pests in a good IPM program.

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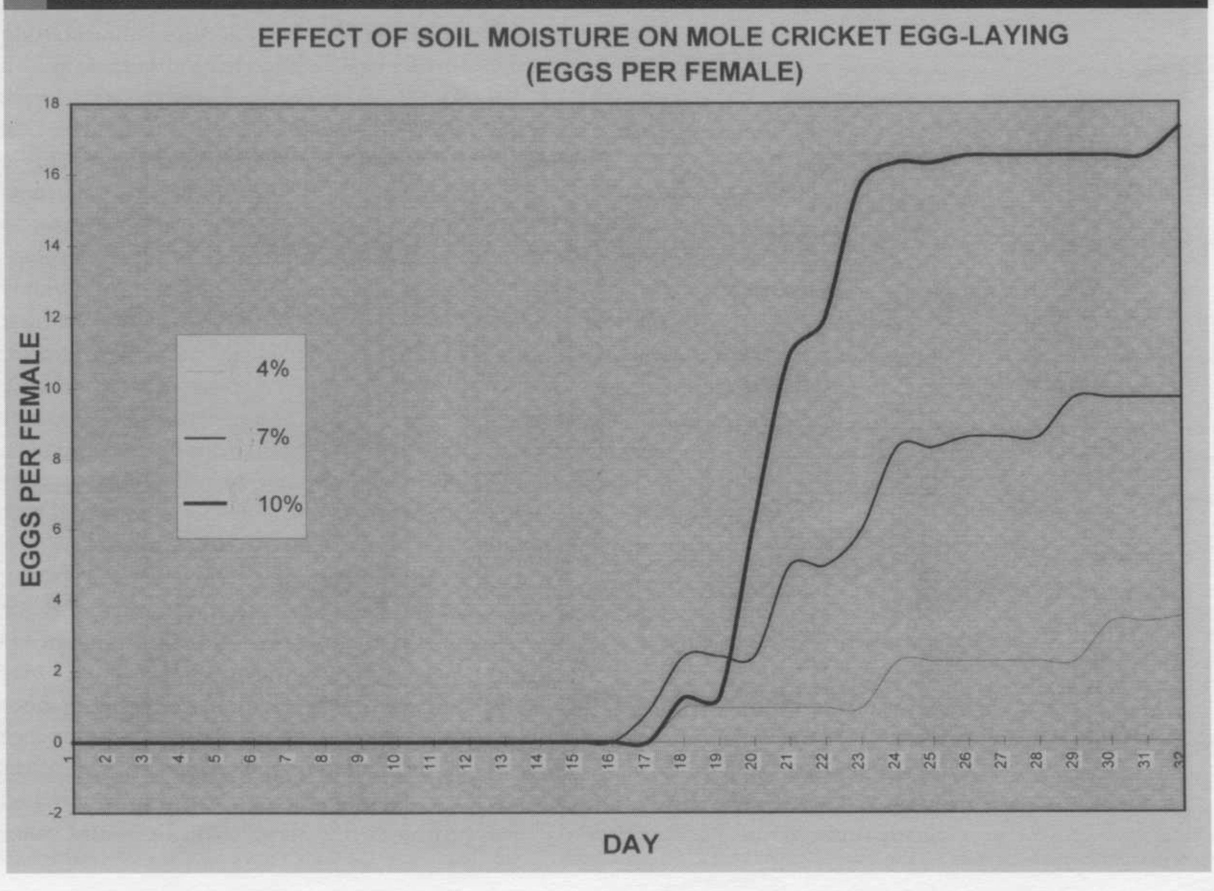
Mole crickets have become one of the most frustrating and expensive insect pests to control, particularly in golf course settings. However, in many areas they also are a problem on sod farms, home lawns, athletic fields, and commercial properties. Most products do not provide the kind of

FIGURE 1. EFFECT OF SOIL MOISTURE ON MOLE CRICKET EGG LAYING



control desired with a single application. The cost and time involved with multiple applications is frustrating for the turfgrass manager and the resulting damage, despite control efforts, often exceeds tolerable levels. We also observe a lot of variability in the level of control with the same product from year to year and from one location to another. Based upon the research focusing on white grubs in turf conducted by Dr. Mike Villani at Cornell University there was reason to believe that mole cricket behavior in the soil played an important role in control agent effectiveness. His studies, in collaboration with several colleagues, found grub activity and ultimately grub control was influenced by soil type, soil moisture, and a variety of other environmental characteristics that influenced the behavior of the grub in the soil. It seemed quite possible that a more mobile soil insect, such as the mole cricket, might have greater control over its destiny when subjected to a variety of control agents.

The ability to identify high risk areas subject to mole cricket infestations would allow turfgrass managers to target their efforts more efficiently.

Our studies have revealed that mole crickets are not only well adapted to take advantage of the turf environment we produce, but are also quite well adapted at withstanding many of the control efforts we throw at them. Mole cricket egg survival is better under higher soil moisture conditions (Figure 1). This is similar to the scenario we see with the Japanese beetles selecting those areas where the turf is greener and lush. Mole crickets prefer those areas and the males use areas with adequate soil moisture to develop their "calling chamber". Chambers built in moist soil project sound more efficiently and enhance the likelihood of mating. The females often lay eggs near the site of mating and thus take advantage of the higher soil moisture which improves the likelihood of egg survival.

Other factors that mole crickets consider when determining areas to infest are not clearly understood. We are currently conducting studies that are investigating a variety of soil factors that could influence site selection and or survival of the mole crickets. Parameters under investigation include turf cover, soil moisture, soil texture, soil color, pH, and organic matter. The ability to identify high risk areas subject to mole cricket infestations would allow turfgrass managers to target their efforts more efficiently to those sites most likely to be infested.

Recent studies have also attempted to determine if degree day or heat unit accumulations can be used to forecast or predict mole cricket egg hatch and development as previously mentioned for the Japanese beetle. Since most control options work best when applied to newly-hatched nymphs and since these nymphs are hidden in the soil, timing of treatment is critical, yet often difficult. There is considerable variation from one year to the next in the timing of egg hatch (Figure 2) and this can mean the difference between success and failure of a treatment.

Our efforts to predict egg hatch based solely on degree day accumulations starting on January 1 have been disappointing in that we have not been able to target a very narrow range of degree days that coincide with peak egg hatch. This is probably a reflection of the fact that varying percentages of mole crickets enter the winter as nymphs and adults each year and development during the winter varies considerably based upon the temperatures in November and December. Unlike areas in the North, biological activity does not necessarily come to a halt in the winter. This makes it somewhat difficult to use January 1 as a starting point, which assumes development has come to a stop at that point and that it will be consistent from year to year.

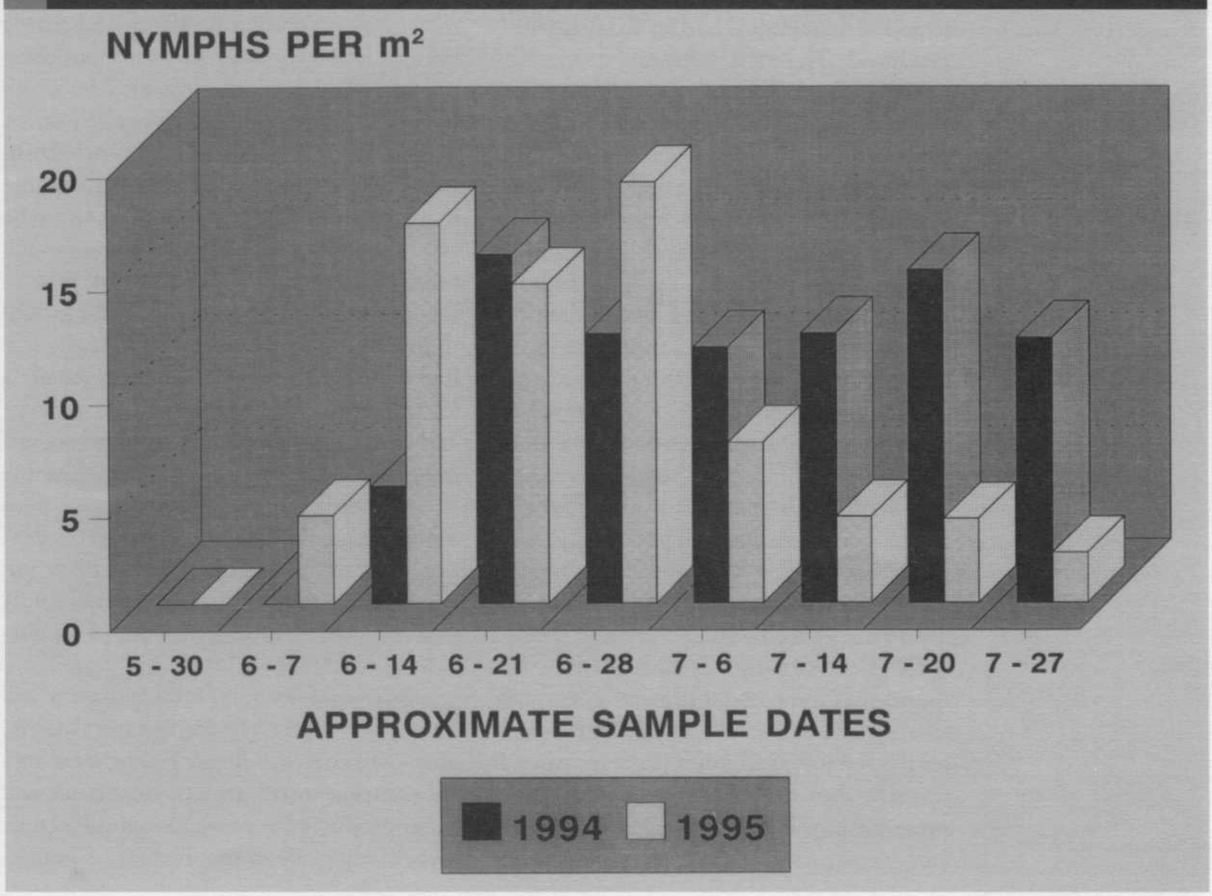
Rather than using January 1 as a starting point, we are investigating the use of major mating flight peaks as a starting point for degree day accumulations (Figure 3). Once mating occurs, it is more likely we can monitor degree days to predict egg-laying, egg hatch, and nymph development. Monitoring mating flights can be automated through the use of acoustic sound caller traps and daily counting of captured individuals. This research continues to provide an early warning system for mole cricket infestations.

Further research to investigate the reason behind the considerable variation we observe in control by the same products from one location to another focused on the effects of both post and pre-irrigation regimens. Despite comparing such dramatic difference such as pre-irrigation of plots, post-irrigation of plots, both pre and post-irrigation of plots as compared to no irrigation at all, no significant or consistent trends were noted. To the causal observer it only made sense that adequate watering to move the insecticide down into the soil would provide better control than where the pesticide was allowed to dry on the surface by avoiding all irrigation. In addition, studies were conducted to investigate the use of subsurface application equipment to apply the insecticide directly into the soil where the cricket resides. This would put a higher percentage of the product in close proximity of the pest, reduce pesticide breakdown from ultraviolet degradation, less binding of pesticide in the thatch, and possibly reduce microbial breakdown. While we observed a general effect of increased efficacy with this application technology, the results were often somewhat subtle and ultimately tell us that poor control was not simply a matter of the control agent not getting down in the soil where the mole cricket would be exposed.

Investigation into variation in control by the same products from one location to another focused on the effects of both post and pre-irrigation.

Similar results were obtained in evaluations of various biological control agents. The use of the fungal pathogen, *Beauveria bassiana*, has shown promising but extremely variable results in field testing. Previous trials over a number of years found the use of a variety of entomogenous nematode

FIGURE 2. EMERGENCE OF SMALL MOLE CRICKETS IN 1994 AND 1995.



products to provide, at best modest, and at times, poor control of crickets. Current trials are investigating the use of various surfactants and even sublethal doses of conventional pesticides to enhance the performance of the *Beauveria* fungal pathogen products. However, this extreme variability in the use of most all products, conventional or biological, suggests a much greater need to understand cricket behavior and responses to such treatments rather than a blind attempts at improving performance through application techniques.

Studies found that mole crickets avoid insecticide treated soil and construct their tunnels in such a fashion as to minimize exposure.

Recent research has used radiography and wax castings to monitor mole cricket tunneling activity and behavior. Large boxes of soil containing mole crickets are used to determine mole cricket tunneling characteristics. Once the mole crickets acclimate to the box and after completing their tunnel structures, the boxes are subjected to radiography and an X-ray image is produced. The most damaging species, the tawny mole cricket, consistently produces the same type of tunnel structure with a "Y" shaped branch near the soil surface This consistent and uniform tunnel construction would indicate this characteristic is important for mole cricket survival. Even when a tunnel structure is partially destroyed, the cricket will rebuild it in a similar fashion. Validation of this tunnel structure in the field has been confirmed through wax castings. Pouring melted wax down tunnels in the field and subsequent excavation following hardening of the wax has produced tunnels similar in structure to those found in the laboratory radiograph boxes. This confirms that the laboratory and X-ray findings closely simulate real world activities.

Further studies with insecticide treated soil in the laboratory and subsequent X-rays found that mole crickets avoid insecticide treated soil and construct their tunnels in such a fashion as to minimize exposure. It appears that the crickets can detect the presence of the insecticide and either seek areas near the surface without insecticide or move deep into the soil. This has significant implications for control and might certainly help explain the significant variability we observe in control efficacy. Moreover, this response may be dose related. In other words, the higher the rate of application, the greater the avoidance response. Such behavior may explain why we occasionally observe a reverse rate response. In other words, the lower rate of insecticide sometimes works better than the higher rate. We have also observed similar interactions with the use of biological materials. This help us understand why proper rates and applying products under the right environmental conditions are so important. Such information is critical in our efforts to improve mole cricket management programs. Only through such information are we able to develop the type of precision control programs we need for the future that are both economically and environmentally sound.

The mole cricket project helps illustrate the complexity of effective pest management. As we already know its not just a matter of spraying a pesticide and sitting back to let it work. It is much more complicated. And, with the loss of older products, the development of newer chemistries, and increased regulations, our knowledge of pest biology and ecology will only become increasingly important. Many of the new products and biological materials are much more specific as to the stage of pest to which they should be applied and the conditions under which they work best. To utilize these new products most effectively a knowledge of the pest's biology, ecology, and behavior is gong to be standard operating procedure. Hopefully the example given by the mole cricket research serves as a model to utilize such information in pest management programs. Research at universities throughout the South are rapidly building data bases of similar support information for all pests of turf.

As new information is developed it will be important for turfgrass managers to keep abreast of these findings. The new biological controls, insect growth regulators, and other products are going to require an new level of vigilance in monitoring pest abundance and distribution. They might also require knowledge upgrades about the pests we battle each year. The benefit from all this is improved pest control, less need for retreatment, and the most environmentally sound approach to best management practices obtainable. Those benefits make everyone happy and is good for the industry as a whole. This article also illustrates that being a turfgrass manager is going to get more complex and continuing education will be critical.

With all of that said, I believe the future is exciting and promising. Never before in the South have we have more people working on turfgrass and branching out into areas of biotechnology and high technology turfgrass management. Its going to be an exciting industry to be a part of.

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Recent research has used radiography and wax castings to monitor mole cricket tunneling activity and behavior.

FIGURE 3. SOUND TRAP CATCHES OF MATING ADULT MOLE CRICKETS.