nitrate was coulter-injected at identical total N rates as ESN applications to plots designated for UAN treatments. At the four to five-leaf stage of corn growth, identical rates of ESN or UAN were applied to plots that did not receive N fertilizer at planting. Corn grain yield was determined by harvesting the middle two rows of each plot with a small plot combine and adjusted to a uniform moisture of 15.5% for analysis. Each experiment (dryland or irrigated) was arranged as a randomized complete block with a 2 (N source) x 2 (application time) x 3 (N rate) factorial treatment structure and compared to an unfertilized control. Each treatment was replicated four times. All statistical analysis was performed using SAS version 9.1.

Cotton lint yield was unaffected by the N-strategy × N rate interaction, and the main effect of N strategy for cotton cultivated in an irrigated environment. The main effect of N rate positively influenced cotton lint yield. Averaged across N sources, cotton lint yields increased linearly as N rate increased. The greatest numerical lint yield (1506 lbs lint acre-1) was achieved from plots receiving 120 lbs N acre-1. However, N application rates of 60, 90, and 120 lbs N acre-1 produced statistically similar cotton lint yields. Nitrogen application at any N rate (30-120 lbs N acre-1) produced significantly more lint than the unfertilized control (0 lbs N acre-1). Regression analysis indicated that the rate of yield increase per unit of added N fertilizer was uniform among N strategies (1.3 lbs lint/lb N applied). Dryland cotton lint yields were unaffected by the main effects of N strategy, N rate or their significant interaction.

Corn grain yield was not influenced by the N strategy x N rate interaction, or the main effect of N rate when cultivated under dryland conditions. Dryland grain yield was significantly affected by the main effect of N strategy. Averaged across N rates, grain yields followed the numerical order of ESN applied at planting > ESN applied at V4 > UAN applied at planting > untreated control > UAN applied in a split-application. ESN applied at planting produced the greatest overall mean grain yield of all N sources, but mean grain yields were not statistically different from either ESN application at V4 or UAN applied at planting. Corn grain yield produced under an irrigated environment was not influenced by the main effects of N strategy, N rate, or their significant interaction.

Limited responses to N application were observed in both cotton and corn trials cultivated in either dryland or irrigated environments. In general, application of ESN produced similar cotton lint or corn grain yields when compared to UAN applied at similar total-N rates. Additional research is needed to determine if ESN is suitable as an alternative N source for Midsouth cotton and corn producers.

Program 10C-2

▸ Should We Be Worried About Higher Temperatures In Crop Production?

Presented by Derrick Oosterhuis

Professor of Crop Physiology, University of Arkansas

With global warming and climate change, high temperature stress has become a major factor affecting crop growth and yield. However, there is uncertainty about how serious this will be on the growth and yield of crops. Temperature is a primary controller of the rate of plant growth, developmental events, and fruit maturation, but extreme temperatures can adversely affect growth and therefore yield. Cotton in its native state grows as a perennial shrub in a semi-desert habitat, and as such requires warm temperatures. It is generally thought that because cotton is a warm season crop it should thrive in hot conditions. However, even though cotton originates from hot climates, it does not necessarily yield best at excessively high temperatures, and a negative correlation has been reported between yield and high temperature during boll development.

The Temperature Range for Cotton

The ideal temperature range for cotton is reported to be 68-86oF, but the average daily maximum temperature in the US Cotton Belt during boll development is almost always well above this.

Once temperatures reach about 95°F, plant growth rate and photosynthesis begin to decrease.

Elevated temperatures can affect all stages of cotton development, but the crop seems to be particularly sensitive to adverse temperatures during reproductive development.

The effects of high temperature on germination, seedling growth and vegetative growth and crop development have been well documented, but the effects on flowering and fertilization are less clear.

Environmental stress during floral development is a considered a major reason for the disparity between actual and potential yields. Recent research has shed light on why and how high temperature affects yield development.

Events Occurring in the Flower

The day of anthesis is a critical event in the reproductive development of cotton. The flower opens as a white flower at dawn with pollination reported to occur between 0700 and 1100 h and germination within 30 minutes following pollination. The pollen tube extends through the transmitting tissue of the style and fertilization of the ovule occurs between 12 and 24 h later. Because a number of reproductive processes must occur in a highly concerted fashion for fertilization to occur, sexual reproduction is only as tolerant to heat stress as the most thermosensitive process. As a consequence, the yield of plant species with reproductive structures of agricultural importance is exceptionally sensitive to high temperature stress during flowering.

Heat stress can limit fertilization by inhibiting both male and female gametophyte development, and subsequent pollen germination, and pollen tube growth and fertilization of the ovules. Much of the sensitivity of reproductive organs to heat stress has been attributed to the sensitivity of the (female) microgametophyte to temperature extremes. In contrast with female reproductive tissues, mature (male) pollen grains exhibit no acclimative response to heat stress. Due to the inability of mature pollen grains to effectively respond to adverse environmental conditions, numerous studies have focused on pollen tube elongation responses to high temperature.

Pollen germination and pollen tube growth

Both pollen germination and tube growth are strongly influenced by high temperature. The sensitivity of pollen tube growth to high temperature is thought to be a major cause of low yields for crops with valuable reproductive structures. The optimal temperature across a range of cotton cultivars for pollen tube growth is cited as 82-90°F, with a strong correlation between maximum pollen tube growth and boll retention. Pollen germination has a much broader temperature range of 82-99°F, suggesting pollen germination may not be as sensitive to high temperature as pollen tube growth. Successful pollen tube growth and subsequent fertilization of the ovule is a prerequisite for seed formation in cotton, because seeds with their associated fibers are the basic components of yield.

Carbohydrates and Antioxidants

The leaf supplies the necessary carbohydrates for growth. In cotton, subtending leaves are the primary sources of carbohydrate supplied to subtended bolls. Heat stress affects both leaf growth and photosynthesis , and therefore the carbohydrate and energy supply in the pistil of the flower. We have shown that the energy demands of growing pollen tubes cannot be met under heat stress due to decreased source leaf activity. In general reproductive development and yield are more sensitive to high temperature stress than photosynthesis in a number of plant species.

Tolerance to High Temperature

Recent studies have suggested that the thermostability of major source leaves may correlate with reproductive thermostability by insuring sufficient photosynthate allocation to developing reproductive units under high temperature. Numerous studies have illustrated the need for antioxidant enzymes in acquired photosynthetic thermotolerance. Maintaining a sufficient antioxidant enzyme pool prior to heat stress is an innate mechanism in cotton for coping with rapid leaf temperature increases that commonly occur under field conditions. In heat-stressed pistils, a calcium-augmented antioxidant response interferes with enzyme production needed for normal pollen tube growth. Our results show that reproductive thermotolerance in cotton is closely associated with elevated pre-stress antioxidant enzyme activity in the pistil which may protect against rapid temperature fluctuations that commonly occur under natural field conditions. Furthermore, genotypic differences in ATP and calcium content of the cotton pistil are strong determinants of genotypic thermotolerance in cotton.

Influence of Water Stress

High temperatures can have both direct inhibitory effects on growth and yield, and indirect effects due to high evaporative demand causing more intense water stress. Plant water deficit stress often coincides with high temperatures, but with irrigation and adequate precipitation this is not always a problem. It is difficult to separate the exacerbating effects of water deficit on temperature stress.

Conclusions

The cotton crops experience periods of high temperatures during flowering and boll development in excess of the optimal range for growth, and this places a stress on reproductive development resulting in lowered yields. The sensitivity of pollen tube growth to high temperature, and not pollen germination or subtending leaf photosynthesis, is concluded to be a major cause of low yields. In addition, it appears that innate reproductive thermotolerance in cotton is closely associated with elevated pre-stress antioxidant enzyme activity in the pistil.

Program 12C-2

▸ Management Strategies And Zone Creation For Site-Specific Application Of Nematicides In Fields With Multiple Nematode Pests

Presented by Dr. Charles Overstreet
Professor and Specialist, LSU AgCenter

Cotton producers in the mid-South have been experiencing serious nematode problems for many years. The Southern root-knot nematode and reniform nematodes are our two most important nematode pests of cotton. Usually, there are only one of these two pests present in a field. In recent years, a lot more fields are showing up with fairly large populations of both nematodes in the same field. Rotation to corn is suspected of being the primary reason for some of these changes that are occurring in production fields. In the past, cotton was not rotated very often. Reniform nematode is likely to be an invasive species from the tropics that came to the U.S. in the early to mid-1900's. Problems with this nematode didn't start showing up in cotton until about the 1960's. Reniform nematode seemed to displace Southern root-knot in a number of fields and locations where it had been previously found to cause problems. However, the root-knot did not disappear but remained at lower levels. Corn is a poor host for reniform nematode but seems to be a fairly good host for the Southern root-knot. Rotation with corn enabled root-knot nematode to resurge in these fields and develop into a serious problem again.

There does appear to a strong impact of soil texture to either nematode occurrence and distribution or damage potential to cotton. Soils that are very sandy are the most favored for Southern root-knot and also require the fewest nematodes to cause injury. As the sand content decreases or clay content increases, higher levels of Southern root-knot are needed to cause considerable damage. Soil profile has turned out to be extremely important. The deep sands are the ones most damaged by nematodes. Sand that overlays a heavier clay soil may not be as seriously impacted. Reniform nematode is not nearly as particular about soil texture. It occurs in the lightest soils and can be found in high populations in soils that have a fairly high percentage of clay. The amount of damage caused by reniform does follow a similar trend to Southern root-knot nematode except the damage range does extend to a much higher percentage of clay.

When trying to decide what to do in one of these fields that have both types of nematodes present, management zones may offer the best solution. First, determine where in the field nematodes are occurring and have some idea of population levels. Zone sampling based on soil texture is one of the best methods to determine types and levels of nematodes. Either the Veris 3100 Soil EC Mapping System or EM 38 can be used to accurately divide fields into different soil zones. Both systems measure electrical conductivity (EC) of the soil which