GENETIC AND ENVIRONMENTAL FACTORS AFFECTING PRODUCTIVITY OF COTTON

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Abstract

The yield of any crop is dependent upon the environment in which we expect it to grow and the management practices we impose on the cropping system. Current estimates are that about 70% of the variation in yield from year to year is dependent upon the environment and only 30% of the variation is subject to management. The major environmental constraints include the weather, the soil system, and pests. Management practices must be designed and implemented to minimize the risk of adverse environmental conditions drastically reducing yields, and maximize the opportunity to take advantage of above average environmental conditions during the growing season. Physiology is a study of developmental and metabolic systems that are responsible for growth and development of any organism. Current physiological research which is designed to develop a comprehensive understanding of those developmental and physiological processes most responsible for crop growth and productivity should produce a better production system.

Our crop physiology research program at Texas Tech University has two major goals. One is to educate future scientists in the area of basic plant physiology as it pertains to genetic and environmental control of plant growth and development. The second goal is to develop a comprehensive understanding of the yield limiting physiological processes and the opportunity to genetically improve these processes and to develop management systems which will reduce the risk of adverse environmental conditions drastically affecting the plants ability to maintain productivity.

On the Texas High Plains, the supply of water throughout the growing season is the single greatest environmental limitation to attainment of genetic yield potential. About half of the total planted acreage is dryland and subject to the vagaries of the weather. The other half has some irrigation water to supplement the rainfall. The potential evapotranspiration rate averages about 10mm/day during the growing season. Even under irrigated conditions, periods of water stress exist during the growing season, reducing yield.

We have spent a considerable amount of our research time determining the cotton plants response to water stress and defining the order of limitations in developmental and physiological processes. We have determined that the crop growth rate is reduced by water stress due to reductions in leaf production (primarily sympodial leaves) and size, as well as reductions in the photosynthetic rate. The cotton plant, having an indeterminate growth habit, doesn't produce leaves on the axillary branches when it senses an impending limitation in the water supply. This limits the number of fruiting sites that are produced. Water stress during the latter half of the fruiting period results in loss of developing fruit due to reductions in both reduced C and N. We have determined that the water supply from first square (6-7 leaf stage) until first flower is the most critical in producing fruiting sites that will produce fruit that will have time to mature in our short growing season. The photosynthetic rate reductions observed with increasing water stress are due to both stomatal and non-stomatal factors. Water stress does result in reduced stomatal conductance; however, as conductance declines, the leaf temperature increases and photorespiration increases accordingly, reducing net CO_2 reduction. Also, increased leaf temperature reduces carboxylation activity of RuBPCOase, both of which reduce the amount of carbon available for growth each stress day.

Based upon the understanding of the cotton plants response to water stress, new have evaluated both genetic and management strategies to maximize productivity and water use efficiency within the constraints of the High Plains environment. The greatest opportunity to increase yield and water use efficiency appeared to reside in better management systems. Current commercial production systems are wasting almost half of the total water resource by bare soil evaporation. The traditional 40" row spacing at plant populations usually in excess of 5-6 plants per foot of planted row, results in considerable plant-to-plant competition and resultant water stress. Narrow rows and reduced plant populations in the row increased light interception by the plants, reduced evaporation from the ground, and increased dry matter and fruit mass per unit ground area. Irrigation water management had a great influence on productivity and water use efficiency. Water applications at a 4-6 day frequency was more efficient than at 10-12 day frequency. Replacement of 80% of the actual evapotranspiration an a 4-6 day frequency produced maximum yields in most years. The application on nitrogen in the water at a rate of 10 pounds of N per inch of water up to the fourth week of flowering greatly increased productivity and water use efficiency.

We are of the opinion that modifications in the production system can increase yield without any additional resource requirements. We believe that at present our yields reflect about 65% of the potential within the limits of the environment and resource supply. Genetic gain is possible in some physiological practices, but progress will be slow.

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