# Chapter I

# INTRODUCTION

# Chapter I

# Introduction

## OVERVIEW:

Drought occurrence in Virginia since 1980 has caused severe reductions in corn (*Zea mays* L.) grain yields, and significant economic losses to farmers. Cropland harvested for corn during the 1980's decreased from 247,000 hectares to 138,000 hectares (Thornsbury et al., 1993). Virginia is a grain deficit area with respect to grain produced versus grain consumed (Gilliam and Boswell, 1984; Alley et al. 1996). Virginia has a large livestock industry that continues to increase and offer excellent regional grain prices relative to national prices. However, an alternative grain crop is needed for corn because the generally higher (relative to national levels) corn prices that growers obtain do not offset the effects of drought stress on corn grown on many soils. Growing an alternative grain crop that has similar yield potential and nutrient value as corn, a lower water requirement, and higher water-use efficiency as compared to corn, may aid in reducing the drought risk and grain deficit in Virginia.

### CONTEXT OF PRESENT RESEARCH:

Grain sorghum (*Sorghum bicolor* L. Moench) has been a relatively small acreage crop in Virginia. It has been recognized as a more drought tolerant crop (Bennett et al., 1990; Khosla et al., 1995) and an alternative to corn. Currently sorghum is grown on about 6,000 to 10,000 hectares in Virginia, mostly under no-tillage systems, for erosion control and for more efficient use of available-soil-water. However, the land area of sorghum has not increased over the years because growers did not have access to adequate, equitable markets for grain sorghum, and also because of lack of production practices to increase yields in seasons with sufficient rainfall. Producing high grain yields in seasons with adequate soil moisture (30 year average rainfall is 130 to 145 mm per month in July and August in the Virginia coastal plain) is essential for grain sorghum to become part of the rotation with winter wheat and double-crop soybeans.

A major component of successful crop production is the availability of adequate plant nutrients, especially nitrogen (N) to which grain sorghum is most responsive. Relatively little research has been done in the humid mid-Atlantic region to develop full-season N fertilizer recommendations for dryland grain sorghum grown in no-tillage production systems.

No-tillage has gained popularity because of its potential conservation of energy, soil, and water (Touchton and Hargrove, 1982; Langdale et al., 1978; Gallaher, 1977). However, one factor that continues to be a problem in high residue (no-till) farming is N fertilizer management (Lamond et al., 1991). No-till systems often exhibit suppressed yields because of reduced N availability (Rao and Dao, 1996). This occurs because of slower mineralization (Phillips et al., 1980), greater N immobilization (Rice and Smith, 1984), denitrification (Rice and Smith, 1982), and volatilization (Terman, 1979). Also, below optimum soil temperatures in no-till environments can lower the nutrient availability in the early part of the growing season (Gordon and Whitney, 1995). All these complexities with N fertilizer management in no-tillage systems suggest the need for more research for improved utilization of fertilizer N.

Nitrogen fertilization in humid regions, and in the humid mid-Atlantic and southeastern states in particular, is more critical than for any other region in the United States (Gilliam and Boswell, 1984). The potential for N leaching is very high in this region, as the majority of crops are grown on sandy coastal plain soils. These soils are well drained, fine loamy, siliceous, thermic Paleudults, with low organic matter content (generally <2%) and have sandy to sandy loam surface. Therefore, it is generally assumed that profile mineral-N in this region is too transient to permit reliable use of profile mineral-N data for prediction of crop response to N fertilization (Gilliam and Boswell, 1984; Bundy and Malone, 1988; and Scharf and Alley, 1994). However, results from several recent studies in this region have shown that residual soil mineral-N can contribute to N requirements (Scharf and Alley, 1994; Alley et al., 1996).

Meisinger et al. (1987) reported contribution of residual nitrate to the spring N needs of wheat in a corn/wheat cropping system on the eastern shore of Maryland. Fox et al. (1989) reported 21mg $NO_3$-N $kg^{-1}$ of 0.3 m of surface soil as a critical level for separating responsive from non-responsive sites for corn in Pennsylvania. Scharf and Alley, (1994) reported a wide range of soil mineral N being retained over winter (19-167 kg N $ha^{-1}$) in a 0-1.2 m deep profile at nine locations cropped to winter wheat in the Virginia coastal plain. In a more recent study Alley et al. (1996) reported high levels (76-150 kg $ha^{-1}$) of soil mineral-N in a 0-0.9 m deep profile on typical coastal plain soils being utilized for no-till grain sorghum production in Virginia. These research studies suggest a need for a system that could account for the soil mineral-N when making N fertilizer recommendations.

Another possible means to increase the efficiency of fertilizer N for humid regions is to split-apply the fertilizer N. Fox et al. (1986) applied the fertilizer N as a side-dress application several weeks after the emergence of corn. The side-dress application has maximized the efficiency of fertilizer N in most situations (Piekielek and Fox, 1992; Fox et al. 1986; Aldrich, 1984; Olsen and Kurtz, 1982). Also, the presence of plants at the time of side-dressing application reduces $NH_3$ volatilization loss by shading the soil surface and by absorption of some of the evolved $NH_3$ (Harper et al., 1983).

Since the period of rapid growth and nutrient uptake by sorghum plants occurs about 35 days after emergence (Vanderlip, 1993), side-dress application at this stage is feasible and could enhance grain yield and N-use efficiency of the crop.

Nitrogen-use efficiency of crops under dryland condition depends largely on plant available soil water that depends on rainfall. Erratic rainfall patterns during the growing season greatly limit the grain yields in Virginia. Frequent thunderstorms and rainfall events during the early part of the growing season cause potential N leaching losses, and possibly luxurious vegetative crop growth, which significantly increases the daily crop water use. Consequently, plants can experience severe water stress during long dry periods of no rainfall causing leaf senescence and poor head development. Crop N and water needs at mid-bloom growth stage (a period of rapid growth and nutrient uptake by sorghum plants) are very high and occur about 60 days after emergence (Vanderlip, 1993, Khosla and Persaud, 1997). Availability of additional N to plants at this growth stage by side-dress application using a high clearance applicator could promote proper head development, and enhance grain yield and N-use efficiency of the crop.

In summary, research is needed to develop a full-season N management program for dryland grain sorghum production in Virginia. Optimum side-dress N coupled with starter band-N applications, and a method to include soil mineral residual N in fertilizer N recommendation system for dryland grain sorghum holds promise to increase yields and farmer profits while reducing the potential for non-point source pollution from N fertilizer.

**REFERENCES:**


Aldrich, S. 1984. Nitrogen management to minimize adverse effect on the environment. p. 663-673. *In* R.D. Hauck (ed.) Nitrogen in crop production. ASA, Madison, WI.

Alley, M.M., R. Khosla, P.H. Davis, and D.E. Brann. 1996. Rate and placement of nitrogen and phosphorus fertilizer for efficient and environmentally sensitive grain sorghum. *In* 1996 Fluid Fertilizer Foundation Fluid Forum Proceedings. Scottsdale, AZ.

Bennett, W.F., B.B. Tucker, and A.B. Maunder. 1990. Mordern Grain Sorghum Production. p.3-9. Iowa State University Press, Ames IA.

Bundy, L.G. and E.S. Malone. 1988. Effect of residual nitrate on corn response to applied nitrogen. Soil Sci. Soc. Am. J. 52:1377-1383.

Fox, R.H., J.M. Kern, and W.P. Piekielek. 1986. Nitrogen fertilizer source and method and time of application effects on no-till corn yields and N uptakes. Agron. J. 78:741-746.

Fox, R.H., G.W. Roth, K.V. Iversen, and W.P. Piekielek. 1989. Soil and tissue nitrate tests compared for prediciting soil nitrogen availability to corn. Agron. J. 81:971-974.

Gallaher, R.N. 1977. Soil moisture conservation and yields of crops no-till planted in rye. Soil Sci. Soc. Am. J. 41:145-147.

Gilliam, J.W., and F. Boswell. 1984. Management of nitrogen in the South Atlantic states. p.691-705. *In* R.D. Hauck (ed.) Nitrogen in crop production. ASA, Madison, WI.

Gordon, W.B., and D.A. Whitney. 1995. Starters bump sorghum yields 18 percent. Fluid J. 3:11-13.

Harper, L.A., V.R. Catchpoole, R. Davis, and K.L. Weir. 1983. Ammonia volatilization: Soil, plant, and micro-climate effects on diurnal and seasonal fluctuations. Agron. J. 52:104-107.

Khosla, R., N. Persaud, N.L. Powell, and D.E. Brann. 1995. Water use of sorghum on a marginal soil in eastern Virginia. *In* Appendix 1. p.11. Agronomy abstracts. ASA, Madison, WI.

Khosla, R., and N. Persaud. 1997. Performance of a commercial resonant frequency capacitance probe: II. Measurement of water use of dryland crops. Commun. Soil Sci. Plant Anal., 28(15&16), 1347-1357.

Lamond, R.E., D.A. Whitney, J.S. Hickman, and L.C. Bonczkowski. 1991. Nitrogen rate and placement for grain sorghum production in no-tillage systems. J. Prod. Agric. 4:531-535.

Langdale, G.W., A.P. Barnett, and J.E. Box, Jr. 1978. Conservation tillage systems and their control of water erosion in Southern Piedmont. p. 20-29. *In* J.T. Touchton and D.G. Cummins (ed.) Proc. of the 1st Southeastern No-tillage conference. Univ. of Ga, College of Agric. Special Pub. No. 5.

Meisinger, J.J., R.F. Mulford, and and J.S. Stangarone. 1987. Effects of residual N on winter wheat in Maryland. p. 209. *In* Agronomy Abstracts. ASA, Madison, WI.

Olsen, R.A., L.T. Kurtz. 1982. Crop nitrogen requirements, utilization and fertilization. *In* F.J. Stevenson (ed.) Nitrogen in agricultural soils. Agronomy 24:567-604.

Phillips, R.E., R.E. Blevins, G.W. Thomas, W.W. Frye, and S.H. Phillip. 1980. No-tillage agriculture. Science (Washington, D.C.) 208:1108-1113.

Piekielek, W.L., and R.H. Fox. 1992. Use of chlorophyll meter to predict sidedress nitrogen requirements for maize. Agron. J. 84:59-65.

Rao, S.C. and T.H. Dao. 1996. Nitrogen placement and tillage effects on dry matter and nitrogen accumulation and redistribution in winter wheat. Agron. J. 88:365-371.

Rice, C.W., and M.S. Smith. 1982. Denitrification in no-till and plowed soils. Soil Sci. Soc. Am. J. 46:1168-1173.

Rice, C.W., and M.S. Smith. 1984. Short time immobilization of fertilizer nitrogen at the surface of no-till and plowed soils. Soil Sci. Soc. Am. J. 48:295-297.

Scharf, P.C., and M.M. Alley. 1994. Residual soil nitrogen in humid region wheat production. J. Prod. Agric. 7:81-85.

Terman, G.L. 1979. Volatilization of nitrogen as ammonia from surface applied fertilizers. Organic amendments and crop residues. Adv. Agron. 31:189-223.

Thornsbury, S., D.E. Brann, D. Kenyon, and J. Baker. 1993. Competitive corn production potential in Virginia’s coastal plain. Rural economic analysis program, Department of Agricultural Economics, Virginia Tech, Blacksburg, VA 24061.

Touchton, J.T., and W.L. Hargrove. 1982. Nitrogen sources and method of application for no-tillage corn production. Agron. J. 74:823-826.

Vanderlip, R.L. 1993. How a sorghum plant develops. Cooperative extension service. Contribution No. 1203, Kansas Agricultural Experiment Station, Manhattan, Kansas.