Chapter V

SUMMARY AND CONCLUSIONS

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Climatic conditions over 3 years of research work were variable. Rainfall was much below average in 1995 and 1997 (average rainfall ranges between 100-150mm per month based on 30 years rainfall data). This was not atypical of Virginia climatic conditions observed in the last 10 to 15 years. The early part of the growing season (May-June) in 1995 was conducive for germination, emergence and vegetative growth. Temperatures were above the critical temperature of $\geq 10\ ^{o}C$ for grain sorghum growth. Grain sorghum stand on both soils, Pamunkey sandy loam, and Conetoe loamy sand were excellent. However, the months of July and August were extremely hot and dry and plants were severely water stressed. Year 1997 was dry throughout the growing season with very little rainfall, 203 mm and 260 mm occurred at two sites, Atlee and Kempsville soils, respectively. Water stress symptoms on plants were observed on almost all the sites at some point during the growing season. However, water stress symptoms were more prominent in 1995 and 1997 and were particularly evident on the plants growing on the Conetoe loamy sand, Bojac sandy loam, and Atlee very fine sandy loam. The year 1996 was good overall with normal to above average rainfall ($\geq$ 550 mm) during the growing season at all four locations.

Grain yields over three years on eight different sites varied from as low as 1.7 Mg ha^{-1} to as high as 11.9 Mg ha^{-1}. An overall average of the highest yield at eight locations was 7.98 Mg ha^{-1} and is testimony to good cultural practices and adequate fertility levels for other plant nutrients. The sorghum crop was highly responsive to N fertilizer applications (the difference between the check yield and the highest yield was >3 Mg ha^{-1}) at three sites, moderately responsive (yield response between 1 and 3 Mg ha^{-1}) at one site, non-responsive (no treatment yield more than 1 Mg ha^{-1} above or below the check yield) at two sites, and negatively responsive (treatments having yields $\geq$1 Mg ha^{-1} below the check yield) at two sites.

Results from the study on rate and time of fertilizer N application indicated that optimum rate of starter-band-N fertilizer needed in combination with side-dress N applications depends on residual soil mineral-N at planting. Little or zero starter-band-N should be applied in conjunction with side-dress-N applications of 130 kg of N ha^{-1} for soils testing high in mineral-N ($\geq$ 50 kg N ha^{-1} in the top 0.3m of surface soil) at planting. However for soils testing low in mineral-N at planting, a starter-band-N supplement of 40 kg N ha^{-1} in conjunction with 130 kg N ha^{-1} side-dress N should optimize the sorghum grain yields. The study indicated that grain sorghum responds well to later side-dress N applications even in presence of significant levels of soil mineral-N ($\geq$ 50 kg N ha^{-1} in the top 0.3 m of surface soil) at planting. The challenge therefore is to synchronize the N applications with plant N need in conjunction with plant-available-soil-water.

A two-year study during 1996 and 1997 was conducted on five different soils to determine the response of grain sorghum yield to late side-dress N application. It was hypothesized that matching fertilizer N applications to crop need by partitioning total N application into several doses and applying each dose at the time of plant N need will improve grain yield and the grain N-use efficiency. Results from the study indicated that sorghum grain yields did respond to the partitioned side-dress N applications in soil testing low in residual mineral-N. The study also indicates that partitioning of side-dress N application depends on the residual mineral-N level present in the soil. Non-responsiveness of grain sorghum yields to late side-dress N application on four out of five soils utilized in the study was mainly due to high levels (>107 kg N ha^{-1}) of residual mineral-N. More research is needed on multiple sites to confirm this finding and to quantify the mineral-N levels present in the soil at the time of second side-dressing (at the mid-bloom growth stage) that result in responsive and non-responsive sites. This study further reiterates the importance of including soil mineral-N levels in N fertilizer recommendations.

The experiments on residual soil mineral-N influence on sorghum response to applied N found a broad range of soil mineral-N levels at different experimental sites. Soil mineral-N levels at planting varied from 83 kg N ha^{-1} to 131 kg N ha^{-1}, and from 72 kg N ha^{-1} to 197 kg N ha^{-1} at side-dressing. These levels of soil mineral-N show that mineral-N is not as transient during the growing season as generally assumed. These levels were also sufficient to have substantial effects on the N fertilizer requirement of the grain sorghum crop. The grain yield increase due to applied N ranged from 2.03 to 4.92 Mg ha^{-1} and was inversely correlated with residual soil mineral-N measured to a soil depth of 0.9m at planting. Such strong negative correlation ($r^2 = 0.94$) greatly supported the hypothesis that residual soil mineral-N is not as transient during the growing season as it is generally assumed in the humid mid-Atlantic region. The study also presented the "Associated N Fertilizer Equivalency" concept to include soil mineral-N as an integral part of the N fertilizer recommendations of grain sorghum. The N fertilizer recommendations based on the ANFE values were quite close for two out of four sites as compared to the N rates at which the maximum yields were obtained in this study. The ANFE fertilizer recommendation rates were 41 and 45 kg ha^{-1} more efficient as compared to the traditional method of N fertilizer recommendation based on yield goal. However, more research is needed on several different sites with varying levels of residual soil mineral-N to develop a stronger relationship between soil mineral-N and the ANFE. The finding suggests that the ANFE concept has potential to consider soil mineral-N as an integral part of the fertilizer N recommendation system in the humid mid-Atlantic region.

Efficiency of fertilizer placement method could not be evaluated extensively in these experiments. Lack of yield response to N fertilization on four sites in 1995 and 1997, and to starter-band-N on three out of four sites in 1996, prevents any assessment of the efficiency of the fertilizer placement methods on seven site-years.

However, broadcast N applications were as efficient as band placed and side-dress N applications at one experimental site at which rainfall occurred soon after planting.

Overall, grain sorghum yield of 4.0 Mg ha^{-1} in an extremely dry year (1997) and 8.9 Mg ha^{-1} under good rainfall year (1996), and the estimated profit associated with N fertilization is encouraging to the growing of grain sorghum. Proper N fertilization that integrates residual soil mineral-N and partitioned N application improve the potential for producing a profitable crop.