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TERMINAL REPORT

Soil-Water Management
IITA-SAFGRAD Project
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Program objectives

In general, the objectives of the soil-water management program has been to develop and define crop and soil management systems which are able to optimize the available soil and water resources in the Alfisols of the Sudan Savannah of the West African Semi-Arid Tropics (WASAT). More specifically, the program has had 2 major research thrusts:

1. Characterization of tied ridges in terms of soil physical, chemical and hydrological properties; and quantification of responses of the major crops of the West African Sudan Savannah to tied ridges in terms of water use, crop and root growth and yield.

2. Development of a minimum or zero tillage system, which would alternate with periods of grass or leguminous leys, for the West African Sudan Savannah. Emphasis was on minimizing herbicide use.

RESEARCH RESULTS:

1. Tied ridges: In general, program objectives were achieved, although responses of groundnut (Arachis hypogea) and sorghum (Sorghum bicolor) to tied ridges were not studied.

2. Only the first phase of development of a minimum tillage system was completed; i.e. identification of appropriate cover crops for the West African Sudan Savannah.

Tied ridges:

Tied ridges, ridges with earth bunds placed at right angles at intervals of 1-2m cause large yield increases in many crops of the West African semi-arid tropics. This is primarily due to reduction of water runoff, increased infiltration, and consequently greater water storage than with either open ridging or flat planting. Except During rain-free periods, differences in profile water content to a depth of 0.75m were of the order of 25-45mm. Tied ridging also results in superior soil physical properties. Surface clay contents on ridges and furrows of tied ridged plots were 36% and 121% greater than those within and between plant rows, respectively, of flat planted plots. Surface bulk density within plant rows of flat planted plots was 8-15% greater than on ridge slopes of tied ridged plots. Daily maximum soil temperature at a depth of 30 mm in dry soils was highest and lowest in ridge slopes and furrows of tied ridged plots. Soil temperature in flat planted plots was intermediate to those of ridges and furrows. Response patterns were similar in wet soils, although maximum soil temperatures observed were lower. Soil water retention is increased by tied ridging, and is greater in furrows. Soil chemical properties of tied ridges are superior to open ridges. In relation to open ridging, tied ridging resulted in greater levels of soil OM, exchangeable Ca, Mg, K, and total CEC.

Depth of rooting and subsoil root densities of cowpea (Vigna unguiculata), maize (Zea mays), millet (Pennisetum americanum) and cotton (Gossypium hiursutum) under tied ridging were superior

to either open ridging or flat planting in dry years, although cowpea root growth was reduced by tied ridging in wet years due to a high frequency of transient waterlogging. All crops under tied ridging were less likely to suffer from drought stress during rain-free periods. Yields of maize, millet and cotton are increased with tied ridging in all years, whereas in years of above-average rainfall tied ridging does not significantly increase grain yields of cowpea and bambara groundnut (Voandzeia subterranea). Disadvantages of tied ridging are crop losses in wet years in crops sensitive to waterlogging, instability of ridges in sandy soils, loss of water through deep drainage and high labour requirement. Loss of water can be minimized by intercropping shallow-rooted crops such as maize and cowpea with deep rooted companion crops. The labour constraint can be alleviated by mechanising construction of tied ridges. It is concluded, therefore, that tied ridges result in significant increases in soil and water conservation in the Sudan savannah of West Africa which are accompanied by significant yield increases.

Minimum tillage systems:

In relation to maize monoculture, sowing of Macroptilium artropurpureum and M. lathyroides as cover crops under a minimum tillage system where cover crop residue was retained as in situ mulch resulted in reduction of topsoil loss, increases in soil OM, C, C/N, exchangeable K, infiltration rate, soil matric potential and proportion of macropores (pore radius > 14.3μm), and decreases in soil temperature and proportion of micropores (pore radius < 2μm). These changes resulted in large increases in subsoil root growth, grain and DM yield of the following maize crop. (No herbicides were used at any time. Maize seeds were sown into 0.20m wide strip which was cultivated to a depth of 0.05m within plant rows). Significant improvements in soil properties, and maize root growth and yield increases also occurred with Psophocarpus palustris, Lablab purpureus and Echinochloa colona. Where either a bare fallow or Cajanus cajan preceded a maize crop, soil degradation and consequently large yield decreases occurred. Soil ameliorative ability of cover crop was primarily related to rapidity of formation of ground cover and subsoil root density. It was concluded, therefore, that among the cover crops studied M. artropurpureum and M. lathyroides were the most appropriate for the Alfisols of the West African Sudan Savannah.

Future Research needs:

1. Quantification of responses of local and improved varieties of groundnut and sorghum, and improved varieties of millet to tied ridges.

2. Responses of intercropping systems to tied ridges.

3. Evaluation of tied ridge system at on-farm level and quantifying reasons for the yield gap between research station and farmers' fields.

4. Characterization of rock and earth bunds, 'holes' and other systems of soil and water conservation in terms of soil physical, chemical and hydrological properties.

5. Long-term studies of minimum or zero tillage systems with respect to length of cropping and fallow periods, changes in soil properties over time, economic viability, etc.

Problems/Constraints

1. Lack of technical support during a major part of the project. In spite of numerous requests a technical assistant (observateur) was hired only in June 1987, 2 years after commencement of the soil water management programme in May 1985.

2. Insufficient equipment. Again, in spite of numerous requests essential field equipment was purchased only in May 1987.

3. Poor support from the parent programme, i.e. the Resources and Crop Management Programme (RCMP) An interest was taken in the IITA/SAFGRAD Soil-water management programme by the RCMP only subsequent to July 1986.

Publications:

1. Hulugalle, N.R. (1987). Effect of tied ridges on soil water content, evapotranspiration, root growth and yield of cowpeas in the Sudan Savannah of Burkina Faso. Field Crops Res. 17: In Press.

2. Hulugalle, N.R. and Rodriguez, M.S. (1988). Soil physical properties of tied ridges in the Sudan Savannah of Burkina Faso. Expl. Agric 24: In Press.

Other Reports:

1. Hulugalle, N.R., de Koning J., and Matlon, P.J. (1987). Soil and water conservation with rock bunds and tied ridges in the Sudan Savanna of Burkina Faso. Manuscript submitted for publication.

2. Hulugalle, N.R. (1987). Preliminary evaluation of shrubs for alley-cropping systems in the Sudan Savannah of Burkina Faso. Internal Commun., IITA/SAFGRAD, Ouagadougou, Burkina Faso.

3. Hulugalle, N.R. (1987). Soil water management research in SAFGRAD Project Phase I, 1985-86. Paper presented at Workshop of National Scientists working on Maize and Cowpea Improvement in West and Central Africa, March 23-27, Ouagadougou, Burkina Faso.

4. Hulugalle, N.R. (1988). Properties of tied ridges in the Sudan Savannah of the West African semi-arid tropics. Paper presented at the 5th International Soil Conservation Conference, 18-29 January, 1988, Bangkok, Thailand.

5. Hulugalle, N.R. (1987). Effect of undersowing Stylosanthes hamata cv. Verano on soil properties and growth of maize (Zea mays (L.) cv. SAFITA-2) under tied ridging in the Sudan Savannah of Burkina Faso. Submitted for internal review.

6. Hulugalle, N.R. (1987). Intercropping millet (Pennisetum americanum Leek) and bambara groundnut (Voandzeia subterranea (L.) Thouars) on tied ridges in the Sudan Savannah of Burkina Faso. Submitted for internal review.

7. Hulugalle, N.R. (1988). Growth of millet (Pennisetum americanum) under tied ridging in the West African Sudan Savannah. Paper presented at the Australian Soiety of Soil Sci (Inc.), Nat. Soils Conf., May 9-12, 1988. Canberra, ACT, Australia.

8. Hulugalle, N.R. (1987). Effect of cover crop on soil physical and chemcial properties of an Alfisol in the Sudan Savannah of Burkina Faso. Submitted for internal review.

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