PN-AAQ 802
86312

The Soil Management
Collaborative Research
Support Program

Management Entity Office
Box 7113, North Carolina State University
Raleigh, NC 27695-7113 USA
Phone (919) 515-3922 • FAX (919) 515-3942
CGNET: TropSoils • BITNET: rghsl@NCSUVM

July 28, 1993

8/5/93

Document Acquisitions
POL/CDIE/DI
Room 303 SA-18
Agency for International Development
Washington DC 20523-1803

ATT: Referred Publications supported by Project No. 9311311, Soil Management Collaborative Research Support Program under Grant No. DAN-1311-G-00-1049-00

Enclosed are two (2) copies of one (1) technical publication from the Soil Management Collaborative Research Support Program, Project No. 9311311, under Grant No. DAN-1311-G-00-1049-00.

Sincerely,

Roger G. Hanson

Roger G. Hanson
Director

RGH:br

Enclosures

cc: Dr. Charles Sloger

Proceedings of the International Conference/Challenges in Dryland Agriculture: A Global Perspective. ICRISAT-West Africa Niamey, Niger 1988

69 Contour Strip Rainfall Harvesting for Cereal Grains Production in the Sahel

C. G. Zaongo[1], C. W. Wendt[2], and L. R. Hossner[1]
[1]Texas A&M University, TROPSOILS, Soil and Crop Science Department
College Station, TX 77843-2474; and
[2]Texas Agricultural Experiment Station, Route 3, Box 219, Lubbock, TX 79401-9757

Introduction

Over the past 20 years, millet (*Pennisetum* sp.) and sorghum (*Sorghum* sp.) production has decreased in the Sahel (Little et al., 1987) resulting in massive famines and population migration. The primary causes of crop failure are sandy infertile soils and insufficient and irregularly distributed rainfall. Unless management practices are developed to make more efficient use of rainfall, the increasing food requirements of this region can no longer be met on a sustained basis.

Contour Strip Rainfall Harvesting (CSRH) is a potential management technique to conserve and make more efficient use of rainfall. The objectives of this study were to determine (1) whether CSRH has potential to increase millet and grain sorghum production and (2) the effect of fertilization and plant density on CSRH.

Materials and Methods

The experiment was conducted in Niger (West Africa) at Kala Pate, N'Dounga, and Chikal (Payne, 1987), which received 464, 354, and 218 mm of rainfall and had soil pH values of 4.5, 6.3, and 5.7, respectively.

The CSRH technique consisted of a series of parallel and alternating runoff areas covered with polyethylene sheets and cultivated strips. Runoff areas and cultivated strips were 100 cm wide on millet plots and 80 cm wide on sorghum plots.

Pearl millet (*Pennisetum americanum* L. K. Schum) and grain sorghum (*Sorghum bicolor* (L.) Moench) were cultivated under identical environmental conditions. Factors in the split plot experimental design included two levels of water management (CSRH and traditional), two levels of fertilization (none and 22.2 kg P_2O_5/ha before planting plus 45 kg N/ha in split applications) and plant densities of 10,000 and 15,000 seed hills/ha for millet and 11,000 and 16,000 seed hills/ha for sorghum. Cultural practices and harvesting were done manually as on local farms.

Soil water was determined gravimetrically. Root distribution was measured in situ after harvest using the trench method (Bohm, 1979). The face of a trench (100 cm wide x 250 cm deep) was divided into grids of 10 by 10 cm and washed to expose the root ends which were later counted.

Results and Discussion

The effects of the different factors on millet grain yield are given in Table 1. At all sites, CSRH and fertilizer significantly increased grain yields, but plant density had no effect on millet yield. Figures 1, 2, and 3 show that the interactions between CSRH and fertilizer resulted in significant increases in millet yields at all locations.

Sorghum grain yield response patterns were similar

Table 1. Millet grain yield as affected by rainfall management, fertility, and plant density at the three locations.

Treatment		Site: Kala Pate	N'Dounga	Chikal
		kg/ha		
Rain management:	Traditional	464 a[a]	923 a	401 a
	CSRH	1019 b	1667 b	644 b
Fertilization	No fert.	641 a	1135 a	476 a
	Fertilization	841 b	1455 b	569 b
Plant density:	Low	786 a	1216 a	518 a
	High	697 a	1374 a	527 a
Mean		792	1280	523

[a] Means within location and treatment followed different letters are significantly different ($P < 0.05$).

Table 2. Grain sorghum grain yield as affected by rainfall management, fertility, and plant density at the three locations.

Treatment		Site		
		Kala Pate	N'Dounga	Chikal
		kg/ha		
Rain management:	Traditional	321 a*	1140 a	288 a
	CSRH	501 a	1814 b	312 b
Fertilization:	No fert.	274 a	1204 a	255 a
	Fertilization	547 b	1751 b	345 b
Plant density:	Low	334 a	1035 a	257 a
	High	486 a	1920 b	346 b
Mean		411	1477	300

*Means within location and treatment followed by different letters are significantly different ($P < 0.05$).

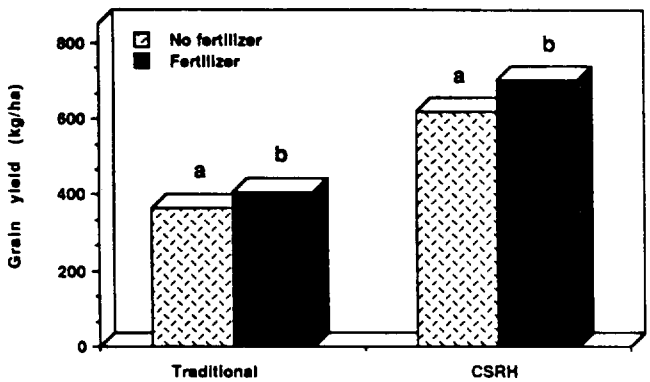

Figure 1. Millet grain yield as affected by the interaction between rainfall management and fertilization at Kala Pate. Bars within water management treatment capped by different letters are significantly different (P< 0.05)

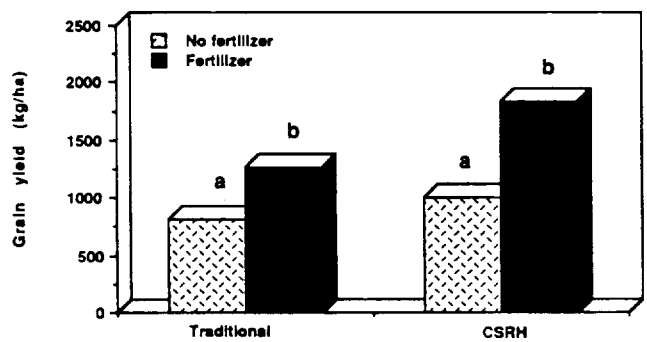

Figure 2. Millet grain yield as affected by the interaction between rainfall management and fertilization at N'Dounga. Bars within water management treatment capped by different letters are significantly different (P< 0.05).

to those of millet (Table 2). However, unlike millet, plant density had a significant effect on sorghum grain yield at N'Dounga and Chikal. Grain yield increased from 1035 to 1920 kg/ha at N'Dounga, and from 257 to 346 kg/ha at Chikal with the higher plant density. The largest yield increases were due to fertilization and rainfall management.

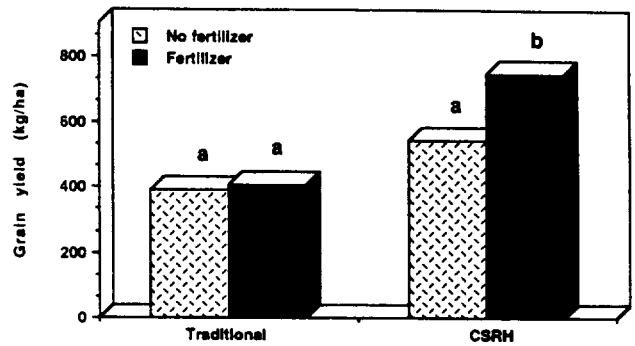

Figure 3. Millet grain yield as affected by the interaction between rainfall management and fertilization at Chikal. Bars within water management treatment capped by different letters are significantly different (P< 0.05).

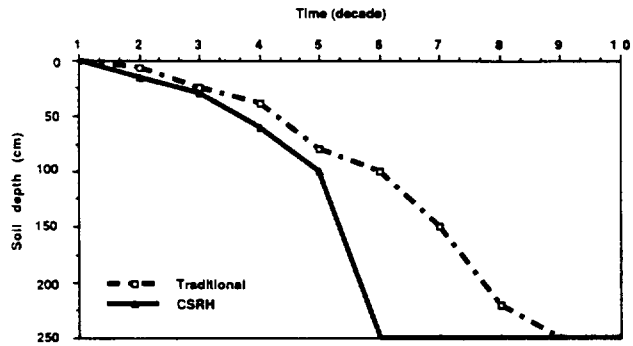

Figure 4. Wetting front of the different water management systems at N'Dounga. Time axis is divided into pentades (Periods of 10 days) starting the first day of June.

The mean sorghum grain yield was higher than millet at N'Dounga (1477 versus 1280 kg/ha). This indicates that under more favorable soil and rainfall conditions, sorghum has a higher grain production potential than millet. At other locations, millet yielded more than sorghum, indicating that millet is better adapted under low soil pH (Kala Pate) or low rainfall conditions (Chikal).

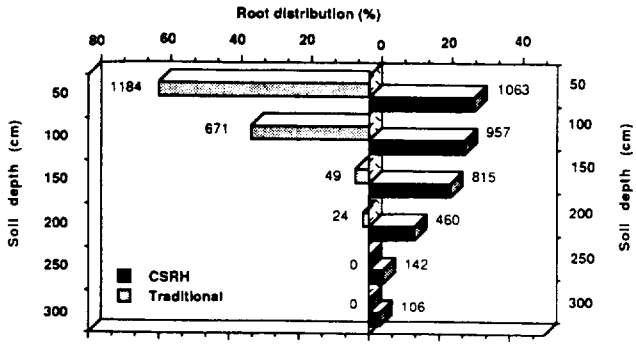

Figure 5. Root distribution of millet at the end of the growing season as affected by water management treatments. Number capping each bar represents the total number of root ends observed in the corresponding soil layer.

The wetting front was always deeper in the soil profile (Fig. 4) with CSRH. It reached 250 cm at the end of July with CSRH and, in traditional management, it did not reach that level until the end of August. The root data supported the wetting front data (Fig. 5). Without CSRH, maximum and effective rooting depth were 200 and 110 cm; with CSRH, these depths were 300 and 220 cm, respectively. Soil water content was always higher with CSRH (Fig. 6). CSRH provided 41% more total water and 64% more available water than the traditional method. This is comparable to the 50% increase obtained by Dunham (1983) using a technique of soil hill-in-furrow and black polyethylene sheets.

Summary and Conclusions

The CSRH technique increased rooting depth and soil water storage. About 41% more water was harvested by CSRH as compared to the traditional method. Millet grain yield increased 119% at Kala Pate, 81% at N'Dounga, and 61% at Chikal. Sorghum grain yield was increased 56, 59, and 19%, respectively. Fertilization significantly increased grain yield at all sites. Positive interactions between fertilization and CSRH indicated that a high level of either factor in the absence of the water was ineffective. The CSRH technique offers promise for more

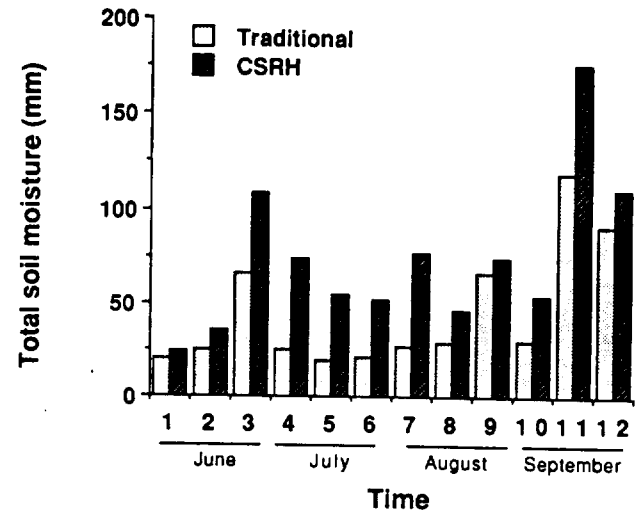

Figure 6. Soil moisture content at Kala Pate under the water management treatments. Time axis represents pentades (periods of 10 days) starting the first day of June.

efficient use of the limited rainfall received in the Sahel, especially when used in conjunction with N and P fertilizers where soil chemical problems are not severe. Research is needed on materials that can be used to adapt this technique economically and socially to increase food production in the Sahel.

References

Bohm, W. 1979. Methods of studying root systems. Berlin: Springer Verlag.

Dunham, R.J. 1983. Exploitation of early rains by a traditional cultivation technique in West African Savanna. Soil Tillage Research 17:113-133.

Little, P.D., M.M. Horowitz, and A.E. Nyerges. 1987. Lands at risk in the third world. Local level perspectives. Boulder, Colorado: Westview Press.

Payne, W.A. 1987. Water balance of sandy soils of Niger, West Africa. M.S. Thesis, Texas A&M University, College Station, Texas.

4