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Effect of Moisture Conservation Practices on Water Use, Micro-Climate and Productivity of Intercropping in Dryland Vertisols

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ABSTRACT

The effectiveness of four land configuration tillage practices; compartmental bunding, ridging, broad bed furrow and flat bed, on soil moisture conservation, crop micro-climate and production were investigated at Coimbatore under *sorghum + pigeonpea* and pearl millet + cowpea intercropping system. Compartmental bunding and broad bed furrow recorded 17.3% and 11.4% higher soil moisture over traditional flat bed. These practices also created favourable micro-climate conditions. During a relatively low rainfall year (1991-92), compartmental bunding had greater growth and yield of sorghum and pigeonpea intercropping, whereas during a high rainfall year (1992-93), broad bed furrow increased the grain yield of sorghum and pearl millet base crops by 34% and 30%, respectively, over traditional flat bed. Intercrop of pigeon pea in sorghum + pigeonpea system behaved similar to sorghum and was highly compatible. But cowpea in pearl millet + cowpea system behaved differently.

Introduction

In semi-arid Indian drylands, growth and yield of crops are highly influenced by the soil moisture than any other single input. In most areas of the peninsular India, intercropping systems are recommended to improve the stability of cropping under Vertisols (Black soils). However, low yields of the component crops or some times empty harvests are routine experience of the farmers due to low and erratic rainfall.

Land configuration tillage practices reduce the risk of crop failure quite appreciably (Aina et al., 1991; Reddy et al., 1992). Few contrary results are also reported (CRIDA, 1990; Gibbered, 1996). However, on vertisol of peninsular India, these practices have not been thoroughly investigated on the stable intercropping systems. Most of the work was limited to few areas and focused primarily on the effect of land configuration techniques on *single crop alone without considering intercropping* systems (Balasubramanian et al., 1982; Reddy et al., 1992). This paper presents the effect of different land configuration tillage practices on water conservation, crop micro-climate, growth and yield of sorghum+ pigeonpea and pearl millet+cowpea intercropping systems under extremely varying seasonal precipitation.

Materials and Methods

Field experiments were conducted in Coimbatore (11° N latitude and 77° E longitude) on well drained medium deep black soil (Vertisol) with sandy clay loam texture. The experimental design was a randomized block with four treatments replicated four times. The treatments were :

CB : Compartmental bunding : check basins of 6 m x 5 m size with bunds of 15 cm height was formed with bullock-drawn bund former before sowing.

RD : Ridging : seeds were sown on the grade and the ridges were formed for each and every row of the crop manually on 30 days after sowing (DAS).

BBF : Broad bed furrow : beds of 120 cm width and on the both sides of beds 30 cm wide, 15 cm deep channels were made by using tractor-drawn broad bed furrow former.

FB : Traditional flat bed (control) : sowing was done on ploughed field without any supporting practice for moisture conservation.

Experimental field was ploughed twice with country plough and therafter land configuration practices were imposed. All the treatments were imposed on the same site with an individual plot size of 100 square meter area. Effect of land configuration techniques were tested in sorghum + pigeonpea intercropping system during 1991-92 (1st year). Both sorghum + pigeonpea and pearl millet + cowpea intercropping systems were studied in 1992-93 (2nd year).

Soil moisture changes were monitored on selected days at 45cm depth by gravimetric method. Root length, leaf area index (LAI) and dry matter production, grain yield and straw yield were recorded from the net plot for component crops in the respective intercropping system. Canopy relative humidity, stomatal conductance, transpiration rate and canopy temperature were recorded using Li-Cor (Model Li-6000) steady state porometer. Interception of photosynthetically active radiation (PAR) was recorded using line quantum sensor (Model Li-Cor, Li-191 SA). The percentage of light interception was calculated based on the relative light transmission in different strata of the system.

Results and Discussion

Soil moisture storage and water use

Among the treatments compartmental bunding (CB) and broad bed furrow (BBF) recorded 17.3% and 11.4% higher moisture content, respectively over traditional flat bed during 1991-92 under sorghum + pigeonpea intercropping system (Figure 1a). In 1992-93, compartmental bunding treatment stored higher moisture up to 40 DAS than broad bed furrow under sorghum + pigeonpea system (Figure 1b) because of impounding of rainfall for long time facilitating more infiltration. Thereafter on 65 DAS CB recorded 9% less moisture than BBF due to breach of bunds as a result of heavy rainfall (108 mm on November 15th) which resulted in run-off loss to a considerable extent. Ridging also stored appreciable quantity of moisture but not as effective as the BBF and CB land configurations. The result was in the same direction in the pearl millet + cowpea system during 1992-93 (Figure 1c). Higher run-off in the flat bed system might be the reason for reduced moisture content at all the stages, irrespective of intercropping systems.

Greater water use (205 mm) and water use rate (1.86 mm day^{-1}) were observed with compartmental bunding during 1991-92, whereas in 1992-93, it was with BBF practice for both the intercropping systems (Table 1). Compartmental bunding had greater rainfall use efficiency in 1991-92 under sorghum + pigeonpea system. But during 1992-93, maximum values were associated with broad bed furrow land configuration (18.6 and 14.6 kg dry matter ha^{-1} mm^{-1} for sorghum + pigeonpea and pearl millet + cowpea systems, respectively). Lower rainfall use efficiency was associated with

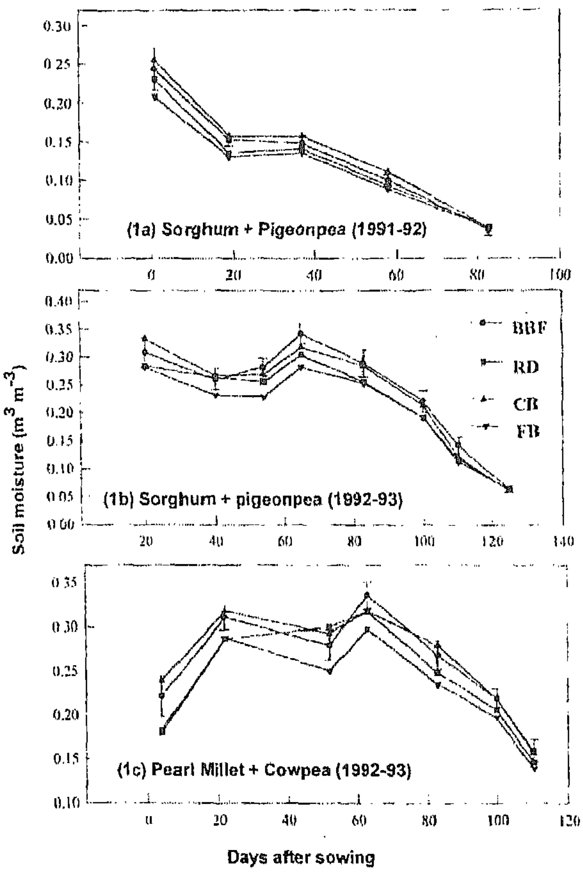

Fig. 1. Soil moisture changes in intercropping systems

flat bed land configuration irrespective of years of study and intercropping systems. Between the intercropping systems, sorghum + pigeonpea utilised more rainfall compared to pearl millet + cowpea system.

Canopy micro-climate

Favourable effect of broad bed furrow and compartmental bunding on the micro-climatological parameters of sorghum and pearl millet was clearly evident (Table 2). Compartmental bunding had 7.1% greater relative water content (RWC) of sorghum than traditional flat bed in 1991-92. The canopy relative humidity of CB treatment was 69.8% followed by 68% with broad bed furrow. The flat bed had lowest values. In 1992-93, broad bed furrow land configuration had greater values of RWC (83%), canopy RH (67%), stomatal conductance (0.612 cm s^{-1}) than compartmental bunding with sorghum. The pearl millet also followed similar trend. Transpiration rate was 45.8% higher for sorghum under compartmental bunding

Table 1. Water Use, water use rate and rainfall use efficiency of intercropping systems

	CB	RD	BBF	FB
Sorghum + Pigeonpea (1991-92)				
Water use (mm)	205	186	196	174
Water use rate (mm day^{-1})	1.86	1.69	1.78	1.58
Rainfall use efficiency (kg dry matter ha^{-1} mm^{-1})	22.7	21.7	22.3	20.8
Sorghum + Pigeonpea (1992-93)				
Water use (mm)	463	437	469	380
Water use rate (mm day^{-1})	3.65	3.44	3.69	2.99
Rainfall use efficiency (kg dry matter ha^{-1} mm^{-1})	18.3	17.4	18.6	15.8
Pearl Millet + Cowpea (1992-93)				
Water use (mm)	394	371	396	318
Water use rate (mm day^{-1})	3.46	3.25	3.47	2.79
Rainfall use efficiency (kg dry matter ha^{-1} mm^{-1})	14.4	14.0	14.6	13.4

Table 2. Effect of land configuration tillage practices on canopy micro-climate of the base crops

Treatments	Relative water content (%)	Canopny relative humidity (%)	Stomatal conductance ($cm^{-1}s^{-1}$)	Transpiration rate (me $cm^{-1}s^{-1}$)	Canopy temperature (^{0}C)
Sorghum 1991-92 (51 DAS)					
CB	83.6	69.8	0.610	17.5	33.9
RD	74.9	66.0	0.498	12.9	34.7
BBF	81.3	68.0	0.531	13.8	34.6
FB	76.5	62.4	0.428	12.0	35.6
Sorghum 1992-93 (75 DAS)					
CB	82.9	65.0	0.589	15.6	34.4
RD	81.6	63.2	0.570	14.9	34.6
BBF	83.0	67.5	0.612	16.9	33.8
FB	77.1	59.0	0.513	13.6	36.0
Pearl Millet 1992-93 (75 DAS)					
CB	82.6	68.0	0.517	13.4	33.8
RD	81.5	67.1	0.469	12.8	34.2
BBF	82.8	71.0	0.508	14.0	32.6
FB	76.7	63.3	0.493	11.4	35.4

than flat bed and corresponding canopy temperature reduction under this treatment was 5.0% in 1991-92. However, in 1992-93, sorghum recorded 24.3% greater transpiration rate and 6.5% reduction in canopy temperature with BBF over the flat bed. Favourable values of micro-climatic parameters under compartmental bunding and broad bed furrow may be due to higher soil moisture content (Choudhury and Federer, 1984). Increased PAR interception by sorghum and pearl millet crops were recorded under the BBF and it was closely followed by CB (Table 3). The per cent reduction

Table 3. Photosynthetically Active Radiation (PAR) interception (%) by component crops of intercropping systems at 60 days after sowing during 1992-93

Treatments	Photosynthetically Active Radiation interception (%)				Total dry matter production (t/ha)
	PAR inteception by sorghum	PAR available for pigeonpea	Available PAR intercepted by pigeonpea	Total PAR intercepted	
			Sorghum + Pigeonpea		
CB	49.6	50.4	62.7	81.2	10.43
RD	46.2	53.8	61.2	79.1	9.91
BBF	53.9	46.1	63.8	83.3	10.58
FB	40.3	59.7	54.3	72.7	9.03
			Pearl millet + Cowpea		
CB	49.6	50.4	62.7	81.2	8.07
RD	46.2	53.8	61.2	79.1	7.85
BBF	53.9	46.1	63.8	83.3	8.15
FB	40.3	59.7	54.3	72.7	7.49

Table 4. Effect of land configuration techniques on growth and yield of Sorghum + Pigeonpea intercropping system during 1991-92

Treatments	Sorghum (main crop)			Pigeonpea (intercrop)		
	Root length (cm)	LAI	Straw yield (q ha^{-1})	Leaf area (cm^2/plant)	Pods/ plant	Grain yield (kg ha^{-1})
CB	38.5	3.60	35.2	286	7.4	20.7
RD	36.7	3.00	33.6	263	6.9	18.6
BBF	37.9	3.21	34.5	277	7.2	19.1
FB	35.3	2.83	32.2	246	6.3	17.8
LSD (0.05)	1.9	0.35	2.2	14	0.6	2.5

Table 5. Effect of land configuration techniques on grain yield (kg ha^{-1}) of component crops of intercropping systems during 1992-93

Treatments	Sorghum + Pigeonpea		Pearl millet + Cowpea	
	Sorghum	Pigeonpea	Pearl millet	Cowpea
CB	2174	140.4	1707	78.2
RD	1995	134.9	1600	82.7
BBF	2255	139.5	1747	75.7
FB	1681	126.1	1313	83.6
LSD (0.05)	268	12.5	228	7.1

of PAR interception by flat bed over the BBF was 13.6 for both sorghum and pearl millet. The available PAR for intercrops was higher under the flat bed. However, intercrops utilised only a small percentage of available light.

Growth and yield

Growth and yield of sorghum + pigeonpea system (Table 4) during 1991-92 were significantly different ($p<0.05$). Greater root length, leaf area index (LAI) and straw yield of sorghum and growth, yield characters of pigeonpea were associated with the compartmental bunding (CB) land configuration compared to other practices. During the first year study (1991-92), sorghum did not produce ear heads till harvest because of prolonged drought and very low rainfall (152.6 mm). However, pigeonpea managed to produce grain yield because of the inherent drought resistance than sorghum.

During second year (1992-93), grain yields of both sorghum and pearl millet significantly ($P<0.05$) varied with moisture conservation practices (Table 5). Broad bed furrow system increased the grain yield of sorghum and pearl millet by 34% and 30% respectively over traditional flat bed method. BBF and CB were not significantly different. Ridging (RD) and flat bed (FB) were not found to produce more yields as they retained less rain water than either broad bed furrow or compartmental bunding.

Higher yield of pigeonpea was associated with compartmental bunding (140.4 kg ha^{-1}) and was comparable with broad bed furrow (139.5 kg ha^{-1}) and ridging (134.9 kg ha^{-1}) during 1992-93 (Table 5). Consistent reduction in yield was observed in flat bed due to low moisture regime. This result implied that the intercrop pigeonpea also followed the trend of its base crop (Sorghum). In pearl millet + cowpea system 10% higher grain yield of cowpea was recorded with flat bed system over broad bed furrow. More leaf area and dry matter production of pearl millet under BBF system might have reduced the grain yield of cowpea due to shade effect.

Higher yield of sorghum and pearl millet base crops under either broad bed furrow or compartmental bunding resulted because of increased root density, which facilitated extraction of more available nutrients and ultimately resulted in higher yield (Nicou *et al.*, 1993).

Conclusions

Compartmental bunding and broad bed furrow have been effective in conserving sufficient soil moisture to support crop growth even during drought situations. However, the performance of broad bed furrow and compartmental bunding varied with rainfall pattern. In low rainfall year (1991-92), compartmental bunding stored higher moisture and it led to favourable micro-climate and higher yield of component crops. In a high rainfall year of 1992-93 broad bed furrow increased soil moisture and productivity of both sorghum + pigeonpea and pearl millet + cowpea intercropping systems. However, intercrop cowpea under pearl millet base crop recorded higher yield under flat bed system. But with respect to total productivity, broad bed furrow and compartmental bunding are always superior than that of ridging and traditional flat bed methods irrespective of intercropping systems and rainfall pattern.

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