Effect of *in situ* moisture conservation practices and intercropping system on yield of rainfed maize in western zone of Tamil Nadu

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Abstract: Field experiments were conducted during North East monsoon season of 1999 and 2000 to study the effect on in situ moisture conservation practices like flat beds, ridges and furrows, tied ridges in maize based cropping systems (sole sorghum, sole maize, maize + cowpea 1:1, 2:1, 3:1 ratios) under rainfed vertisols at Tamil Nadu Agricultural University, Coimbatore. The results revealed that among the in situ moisture conservation practices, though tied ridges recorded higher grain yield, moisture use efficiency, and maize equivalent yield, ridges and furrows found to be highly economical (B:C ratio of 2.52 for ridges and furrows and 2.46 for tied ridges). Among the cropping systems, sole maize performed better during normal rainfall years. For low and early withdrawal of monsoon, maize can be recommended for higher productivity and profitability and maize + cowpea at 3:1 ratio suggested for higher crude protein yield.

Key words : Moisture conservation, Intercropping, Rainfed maize.

Introduction

Dryland farming has a distinct place in Indian Agriculture, occupying 68 per cent of the cultivable area and contributing 44 per cent to the food grain production. With the increasing demand for food, oilseeds and pulses by the ever growing human population, a dire necessity now arises to utilize the untapped drylands effectively. Constraint limiting crop production in drylands is lack of assured supply of available soil moisture throughout the cropping season due to low and erratic distribution of rainfall. Measures to conserve soil moisture may therefore, help to improve the productivity of dryland crops. Normally in drylands, seeds are sown under flat bed system. Due to extreme variations in rainfall with higher intensity causes runoff which inturn reduces the soil moisture and fertility of the soil. *In situ* moisture conservation practices are reported to provide an advantage in conserving the rainfall in soil profile and reducing the runoff by better water percolation, providing more opportunity time for ponded water to infiltrate in the soil and less runoff (Patil *et al.* 1994). In Coimbatore district, long duration rainfed sorghum (CO 1) is the traditional crop and the length of the growing season is not matching with the moisture availability period of 97 days (Balasubramanian *et al.* 1996). Sorghum is reported to be an uneconomic crop under rainfed conditions in Coimbatore region, as the mean productivity of the crop is low (958 kg ha^{-1}). Recent studies have indicated that maize is the most efficient crop with an average productivity of 1,625 kg ha^{-1} under rainfed condition. In Coimbatore district, rainfed crops are being raised only with North East monsoon rains. Climatic conditions are not conducive for raising legumes like blackgram and greengram during this season. Earlier studies showed that among the pulse crops, cowpea was found to be a promising crop during North East monsoon season and also had its ability to tolerate shade under intercropping situations. With this background, the study was undertaken to evaluate the performance of different rainfed maize based cropping systems under different *in situ* moisture conservation practices.

Materials and Methods

Field experiments were conducted at Eastern Block, Tamil Nadu Agricultural University Farm, Coimbatore during North East monsoon season of 1999 and 2000 in *vertisols* under rainfed conditions. The soil was sandy clay loam in texture with low available nitrogen (139.50 kg ha^{-1}), medium available phosphorus (15.12 kg ha^{-1}) and high available potassium (392.1

Table 1. Weather parameters prevailed at different stages of maize crop growth

Stage of crop	Max. temp (°C)	Min. temp (°C)	Mean solar radiation ($MJ/m^2/day$)	Total rainfall (mm)	Number of rainy days	Deviation from normal (%)
1999						
Vegetative	30.4	21.4	14.8	367.6	21	31.65
Flowering	29.7	20.9	15.1	41.6	3	
Maturity	29.1	20.5	15.1	18.4	3	
Total				427.6	27	
2000						
Vegetative	30.6	21.4	14.6	207.7	11	12.56
Flowering	29.0	19.8	14.6	63.5	5	
Maturity	29.2	18.5	17.5	12.8	2	
Total				283.4	18	

Mean rainfall : 324.8 mm (North East Monsoon) (94 years average)
Length of growing period : 97 days

kg ha^{-1}). Soil pH was 7.9, EC less than 0.45 m.mhos/cm, soil depth of 80-135 cm and water holding capacity of 100 mm/m depth of soil. Sorghum (CO 26), maize (CO 1) alone and in combination with cowpea CO 4 were evaluated at 1:1, 2:1 and 3:1 ratios along with in situ moisture conservation practices like flatbed, flat sowing followed by forming ridges and furrows, flat sowing followed by forming ridges and furrows and tieing. The treatments were tried in strip plot design with three replication. Fertilizer was applied at 40:20:0 for sorghum and grain maize and 12.5:25.0 kg N, P_2O_5, K_2O/ha for cowpea, respectivly. A seed rate of 15 kg ha^{-1} for sorghum, 20 kg ha^{-1} for maize and 10 kg ha^{-1} for cowpea was adopted. An interrow spacing of 45 cm for sorghum and maize and 30 cm for cowpea was adopted. The data on the rainfall received during the experimental period of 1999-2000 and 2000-2001 are presented in Table 1. The data on yield attributes, yield and economics are presented in Tables 2 and 3.

Results and Discussion

The first year of cropping received 32.65 per cent higher rainfall (427.6) compared to normal rainfall of Coimbatore district (327.6 mm) and the distribution was also uniform during the crop growth stages resulting in a higher yield under sole cropping of maize than the rest of the treatments. During second year, the production was affected due to uneven distribution, coupled with poor rainfall (286 mm) compared to normal rainfall.

It is quite obvious that the plant, with good initial vigour and growth, is conducive for increased production of yield components. The yield components such as number of grain rows per cob, number of grains per row, cob length and shelling percentage were higher in tied ridges, which was comparable with ridges and furrows during the first year of study. The development of yields components *viz.* cob length, cob girth and grains started from the stage of cob initiation. Available soil moisture was higher upto 70 DAS under tied ridges and ridges and furrows which helped the cob development very effectively without any moisture stress from the day of cob initiation. On the other hand, during second year, the crop received 70.9 per cent (207.1 mm) of rainfall from sowing to 30 DAS. Lack of adequate soil moisture between 30 and 60 DAS, due to occurrence of prolonged dry spell affected the reproductive stage of maize. Drought experienced by the crop from cob initiation to flowering due to inadequate soil moisture, greatly affected the normal development of the cob, thereby affected the development of florets, size of the vegetative shoot (source) and grain formation, ultimately resulting in smaller cobs with less grain rows and number of grains (Suraj Bhan *et al.* 1998).

Table 2. Effect of *in situ* moisture conservation practices and cropping systems on growth and yield components of grain maize and cowpea

Treatments	Dry matter production (kg ha^{-1})		Cob length (cm)		Cob girth (cm)		No. of grain rows per cob		Shelling per cent	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
In situ moisture conservation practices										
M_1 Flat beds	8452	7325	15.6	10.2	13.5	7.5	13.3	12.8	75.3	68.9
M_2 Ridges and furrows	8954	7387	16.4	11.0	13.8	7.2	14.0	12.0	77.8	71.2
M_3 Tied ridges	9044	7416	16.4	10.9	13.9	7.6	14.1	12.3	77.1	71.8
SEd	101.6	228.3	0.17	0.54	0.22	0.73	0.10	0.70	0.85	0.81
CD (P=0.05)	282.2	NS	0.49	NS	NS	NS	0.29	NS	2.37	NS
Cropping systems										
S_1 Sole sorghum	8774	8467	-	-	-	-	-	-	-	-
S_2 Sole grain maize	10885	9174	15.9	9.4	13.5	7.2	13.2	12.1	75.7	67.0
S_4 Grain maize + cowpea 1:1	6705	5297	16.4	11.8	14.0	7.8	14.5	13.0	77.5	74.2
S_5 Grain maize + cowpea 2:1	8375	6642	16.2	10.9	13.7	7.3	14.0	12.1	77.0	72.3
S_6 Grain maize + cowpea 3:1	9343	7300	16.0	10.6	13.7	7.6	13.6	12.3	76.2	69.00
SEd	87.5	246.1	0.18	0.56	0.24	0.59	0.13	0.54	0.95	0.93
CD (P=0.05)	180.9	508.0	NS	1.77	NS	NS	0.28	NS	NS	1.94
Interaction M x S										
SEd	165.8	444.1	0.32	2.29	0.43	1.14	0.24	1.08	1.34	1.49
CD (P=0.05)	386.7	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x M										
SEd	146.4	426.1	0.31	2.09	0.43	1.03	0.23	0.94	1.29	1.42
CD (P=0.05)	302.0	NS	NS	NS	NS	NS	NS	NS	NS	NS

Significant variation in grain and stover yields on maize due to *in situ* moisture conservation practices was observed during 1999 only (Table 3). The yield increase from tied ridges and ridges and furrows was 26.1 and 24.6 per cent, respectively over flat beds. Tied ridges and ridges and furrows recorded higher moisture use efficiency as the result of higher and uniform availabilty of soil moisture throughout the crop growth, which encouraged both vegetative and reproductive growth of maize crop. Increase in growth due to higher proportion of synthates movement from source to sink, resulted in improvement of yield components like cob length, number of grain rows and shelling percentage. The actual moisture was not limiting upto 70 DAS under tied ridges and ridges and furrows (Table 3) provided favourable soil moisture environment for N, P and K uptake by the plants from soil through mass flow and diffusion processes and thereby resulted in higher nutrient uptake. As a result of this continued relay action, the yield under tied ridges and ridges and furrows was higher than that of flat sowing (Surakod and Itnal, 1998).

Table 3. Effect of *in situ* moisture conservation practices and cropping systems on yield and economics of grain maize and cowpea

Treatments	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Maize equivalent yield (kg ha^{-1})		Available soil moisture at 70 DAS (mm)		B:C ratio	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
In situ moisture conservation practices										
M_1 Flat beds	1929	948	4575	3734	2098	1082	1.24	0.00	2.47	1.61
M_2 Ridges and furrows	2405	988	5474	3978	2611	1126	14.22	0.00	2.52	1.38
M_3 Tied ridges	2434	945	5729	3968	2645	1083	16.40	0.0	2.46	1.27
SEd	73	82	128	150	51	83	Data statistically not analyzed			
CD (P=0.05)	203	NS	366	NS	134	NS				
Cropping systems										
S_1 Sole sorghum	1778	565	6037	5664	1778	565	7.80	0.00	1.58	0.84
S_2 Sole grain maize	3002	1224	6857	5521	3002	1224	8.93	0.00	2.52	1.38
S_4 Grain maize + cowpea 1:1	1832	799	3698	1865	2205	1073	14.64	0.00	1.89	1.11
S_5 Grain maize + cowpea 2:1	2159	1054	4529	2584	2516	1292	11.35	0.00	2.10	1.28
S_6 Grain maize + cowpea 3:1	2509	1160	5171	3846	2756	1331	10.38	0.00	2.34	1.37
SEd	98	117	156	133	65	112	Data statistically not analyzed			
CD (P=0.05)										
Interaction M x S										
SEd	81	199	138	212	113	193				
CD (P=0.05)	187	NS	314	NS	251	NS				
S x M										
SEd	71	202	132	230	113	195				
CD (P=0.05)	147	NS	273	NS	233	NS				

During second year, neither the growth characters nor the yield components were altered by different *in situ* moisture conservation practices studied. Soil moisture storage or available soil moisture decreased rapidly from third week after sowing due to prolonged dry spell and early cessation of rainfall. Moisture stress affected the dry matter production and yield components. In the present investigation it may be due to inhibition of photosynthesis, transpiration and translocation of photosynthates from source to sink (Bonnett, 1979). Variability in rainfall is the greatest hazard to crop production in rainfed areas and the yield are adversely affected with the above or below average rainfall (Manohara and Subramanian, 1993). In the second year there was no rainfall after laying of tied ridges and ridges and furrows. Hence, there is no difference in available soil moisture between the treatments, resulted in non-significant result in growth characters, yield components and yield.

Maize raised as sole crop produced higher grain and stover yields as against intercropping with cowpea at 1:1, 2:1 and 3:1 ratios. The additional grain yield under sole maize was 38.9, 28.8 and 16.4 per cent during 1999 and

34.7, 13.8 and 5.0 per cent during 2000, respectively than under maize intercropped with cowpea at 1:1, 2:1 and 3:1 ratios.

Grain and stover yields of maize were higher in sole maize treatment due to maintenance of 100 per cent population as warranted by the treatment, while in the intercropping systems, due to 1:1, 2:1 and 3:1 row arrangement of maize and intercrops, comparatively lesser base crop population was maintained. With increase in population, there was an increase in grain yield. In the present investigation, when maize was grown as sole crop, there was an increae in drymatter production as a result of better solar radiation interception and utilisation and better moisture availability (Khola *et al.* 1997; Pandey *et al.* 1999). During second year, the grain yield was lower among the cropping systems. This was mainly due to moisture stress at silking and grain formation stages since the crop received only 76.3 mm rainfall from 30 DAS to harvest.

From this study, it can be concluded that among the *in situ* moisture conservation practices evaluated, though tied ridges recorded higher grain yield under normal and uniform distribution of rainfall (427 mm), ridges and furrows was found to be highly economical. Under normal and well-distributed rainfall condition, sole grain maize (CO 1) can be recommended for higher productivity and profitability. Under low rainfall and early withdrawal of monsoon, maize + cowpea intercropping system at 3:1 ratio is recommended for higher crude protein yield.

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