

Effect of *in situ* soil moisture conservation and nutrient management practices on performance of rainfed cowpea

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2002 and 2003 at the demonstration fields of M.S. Swaminathan Research Foundation, Ariyamuthupatti, Pudukottai district of Tamil Nadu to study the effect of different *in situ* soil moisture conservation and nutrient management practices on soil moisture conservation, growth, yield and economics of cowpea under rainfed condition. Results showed that moisture conservation through ridges and furrows or tied ridges along with mulching recorded significantly higher growth and yield attributes, grain and haulm yields, nutrient uptake and net returns of cowpea. Significant grain yield of cowpea was obtained under ridges and furrows with mulching (715.9 kg/ha), and tied ridges with mulching (297.4 kg/ha) during 2002 and 2003, respectively. Enriched compost application had significant influence on growth and yield attributes, grain and haulm yields and nutrient uptake of cowpea. Enriched compost application during 2002 and integration of 50% inorganic fertilizers and 50% enriched compost during 2003 registered significantly higher grain yield (730.7 and 284.5 kg/ha) of cowpea over farmers' practice of no nutrient application, respectively.

Key words: Cowpea, Moisture conservation, Nutrient management, Nutrient uptake

Successful cultivation of rainfed pulses depends upon the management of natural resources like rainwater through proper *in situ* harvesting techniques and soil fertility by adding sizable quantity of organic manures along with limited inorganic fertilizers. Since soil moisture plays a crucial role in plant growth, mineral nutrition and microbial activity in soil, its availability has to be increased by conserving rainwater in the soil profile. In this context, *in situ* soil moisture conservation practices like ridges and furrows (R&F), compartmental bunding (CB), tied ridges (TR) and mulching are useful moisture conservation practices in dryland agriculture. Hulugalle (1990) reported higher grain yield of maize, millet and sorghum under tied ridging in both wet and dry years whereas in cowpea, response was observed only in dry years on rainfed *Alfisol* of Sahel region in Africa. Maurya and Lal (1981) reported higher grain yield of maize and cowpea under straw mulch as compared to flat bed in *Alfisol* region of Nigeria. Significant difference in the yield of ragi was noticed where enriched farm or industrial waste compost was used as compared to raw compost or without enrichment of compost

(Srikanth *et al.* 2000). Keeping this in view, a field experiment was conducted to investigate the effect of different *in situ* soil moisture conservation and nutrient management practices on productivity of cowpea under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted at the demonstration fields of M.S. Swaminathan Research Foundation, Ariyamuthupatti, Pudukottai district of Tamil Nadu during *rabi* season of 2002 and 2003 under rainfed *Alfisol* condition. The soil of experimental field was shallow to moderately deep, medium textured, acidic in reaction, non-calcareous and derived from lateritic parent material having physical properties such as bulk density, field capacity and permanent wilting point of 1.42 g/cc, 21.4% and 10.3%, respectively. The soil having pH of 5.32, was low in available N (222 and 180 kg/ha), medium in available P (14 and 11 kg/ha) and low in available K (90 and 88 kg/ha) during 2002 and 2003. The experiment was laid out in strip plot design with three replications. In main plots, four *in situ* soil moisture conservation practices e.g., Ridges and furrows (R&F), Compartmental bunding (CB), ridges and furrows + mulching, compartmental bunding + mulching were compared with farmer's practice of moisture conservation (disc ploughed once during pre-monsoon showers and subsequently country plough tillage at sowing) during 2002. In sub plots, 100% recommended NPK (12.5:25:0 kg NPK/ha), raw compost @ 2.5 t/ha and enriched compost @ 2.5 t/ha were compared with farmers' practice (no nutrient application). Based on the results of the first year experiment, there was a change in the treatment structure where tied ridges replaced the compartmental bunding and raw compost application was replaced by application of 50% inorganic fertilizers and 50% enriched compost.

Formation of ridges and furrows was done with a spacing of one meter between two ridges. Tied ridges were formed by blocking the furrows manually with earthen bunds at 1.5 m intervals. Mulching was done with locally available crop residues of groundnut, horse gram, and mung bean and sugarcane trash at the rate of 2.5 t/ha on dry weight basis at 15 days after sowing (DAS). Compost was prepared from locally available crop residues and sugarcane trash and pressmud obtained from local sugar factory by adding cellulolytic fungi *Trichoderma viride* @ 5 kg per tonne of raw materials and enriched with addition of rock phosphate @ 25

kg, ZnSO₄ @ 2.5 kg and biofertilizers, *Phosphobacteria* and *Azospirillum* @ 200 g each per tonne of material at the time of preparation. Nutrient content of raw compost was 1.46% N, 0.55% P and 0.87% K. Enriched compost contained 1.68 and 2.07% N, 0.69 and 0.71% P and 0.91 and 0.83% K during 2002 and 2003, respectively. The recommended dose of nitrogen and phosphorus @ 12.5 and 25 kg/ha and recommended dose of raw compost and enriched compost @ 2.5 t/ha were applied on the slope of the ridges according to treatment schedule. Cowpea variety Pusa 152 was used in this experiment. Soil moisture was determined at 0-30 cm depth by gravimetric method during critical stages of the cropping period.

RESULTS AND DISCUSSION

Rainfall - grain yield

The total rainfall received during the cropping period was 162 and 132.4 mm in *rabi* 2002 and 2003 which was distributed over 7 rainy days. There was enough rain just after the sowing resulting in better germination of cowpea during both the years. The mean grain yield of cowpea was 605 kg/ha in 2002 and 265 kg/ha in 2003. Though the total rainfall received during 2003 was only 29.6 mm less than the previous year, the yield was considerably reduced due to uneven distribution during the cropping period. During 2002, the first 50 days enjoyed well-distributed rainfall. A rainfall of 54.2 mm during flowering and pod development stages was helpful in development of yield attributes, which directly contributed to higher yield of cowpea.

During 2003, uneven distribution of low rainfall caused significant yield reduction. Nearly 60% of rainfall was received in the first 15 DAS and the entire rainfall occurred in the first 35 days (Fig 1.). The critical period of pod formation and pod filling stages (last 45 days of cropping period) did not receive any rainfall. This caused soil moisture deficit and the crop suffered from water stress. Water stress affected numerous metabolic, physiological and biochemical processes in the plants and reduced the photosynthetic activity and translocation of photosynthates from source to sink (Turner and Begg 1981). The yield attributes such as number of pods,

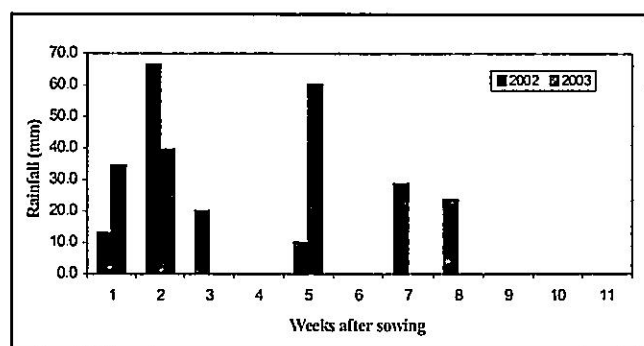


Fig 1. Weekly rainfall distribution during cropping period

number of seeds and test weight reduced causing reduction in yield of cowpea in 2003. There was a 7-day reduction in crop duration in 2003 as compared to 2002 due to terminal drought.

Available soil moisture dynamics

The beneficial effect of different *in situ* soil moisture conservation practices could be seen in available soil moisture content at different stages of observations (Table 1). At seedling stage, there was sufficient moisture during both the years. Ridges and furrows with mulching recorded 4.8% and 2.7% higher soil moisture over farmers' practice of moisture conservation during 2002 and 2003, respectively. During maturity stage, sufficient soil moisture was recorded during 2002 that was reflected on grain yield whereas during 2003, low soil moisture resulted in poor grain yield. Even during 2003, tied ridges with mulching registered 2.1% more soil moisture over farmers' practice which could be the reason behind yield increment. Mulching along with ridges & furrows and tied ridges was found to increase soil moisture availability than the treatments without mulching because mulch produced greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water apparently contributes to soil moisture gains. Increased soil water content was recorded under mulching. This has been also reported by Sharma and Parmar (1998). The farmers' practice of moisture conservation registered lower soil moisture during the cropping period mainly because sealing of surface by falling rains resulted in more runoff loss and less infiltration.

Table 1. Effect of *in situ* soil moisture conservation on available soil moisture dynamics (%) at different stages of rainfed cowpea at 30 cm depth

Treatment	Year	Sowing	Seedling	Flowering	Maturity
Farmers' practice	2002	17.0	15.8	6.2	8.5
	2003	9.4	11.8	8.5	3.1
Ridges & furrows (R & F)	2002	17.5	17.6	9.0	11.5
	2003	9.1	11.6	8.8	3.4
Compartmental bunding (CB)	2002	17.0	16.9	9.0	10.9
	2003	9.4	11.6	10.2	3.9
R & F + mulching	2002	16.9	17.7	11.0	13.8
	2003	9.6	11.9	11.2	4.6
CB + mulching	2002	17.2	18.0	10.9	13.6
	2003	9.4	12.8	11.8	5.2

Growth and yield characters

Significant increase in plant height (44.4 and 41.4 cm) and root length (22.0 and 22.2 cm) was recorded under ridges and furrows with mulching during 2002 and tied ridges with mulching during 2003 (Tables 2 and 3). This is mainly because of moderation in soil hydro-thermal regime under mulching, which favours better development of roots, and increased meristematic activity leading to more foliage development, greater photosynthetic rate, nutrient uptake and consequently

growth characters of cowpea than raw compost and farmers' practice of no nutrient application.

Yield attributes such as number of pods per plant, seeds per pod and 100-seed weight were improved remarkably with ridges and furrows or tied ridges along with mulching as compared to farmers' practice of moisture conservation (Tables 2 and 3). This could be attributed to the reason that increased soil moisture content by ridges and furrows or tied ridges along with mulching would have facilitated more nutrient

Table 2. Effect of *in situ* soil moisture conservation and nutrient management practices on performance of rainfed cowpea (2002)

Treatment	Plant height (cm)	Root length (cm)	Pods/ plant	Seeds/ pod	100- seed weight (g)	Grain yield (kg/ ha)	Nutrient uptake (kg/ha)		
							N	P	K
Moisture (M)									
Farmers' practice	31.6	16.32	5.82	9.21	9.46	572.2	24.5	6.0	13.4
Ridge & furrow (R&F)	39.5	19.26	6.53	9.62	9.59	662.8	27.8	6.7	17.7
Compartmental bunding (CB)	37.5	18.74	6.27	9.32	9.50	627.8	26.2	6.4	15.2
R & F + mulching	44.4	22.03	7.67	10.45	10.01	715.9	30.8	7.1	23.6
CB + mulching	41.6	21.45	7.59	10.43	9.94	688.9	29.0	6.8	19.5
CD (P=0.05)	4.30	2.21	0.88	0.89	0.41	49.5	2.7	0.6	1.6
Nutrient (N)									
Farmers' practice	31.7	17.78	5.07	9.06	9.35	560.1	21.8	5.2	13.3
Rec. NPK	40.7	20.23	7.44	10.09	9.86	691.3	31.5	7.5	16.6
Raw compost	38.2	18.95	6.44	9.68	9.55	632.1	26.4	6.4	18.4
Enriched compost	45.2	21.28	8.09	10.40	10.03	730.7	30.9	7.4	23.5
CD (P=0.05)	3.00	1.39	0.46	0.90	0.26	32.3	2.3	0.6	1.6

Table 3. Effect of *in situ* soil moisture conservation and nutrient management practices on performance of rainfed cowpea (2003)

Treatment	Plant height (cm)	Root length (cm)	Pods/ plant	Seeds/ pod	100- seed weight (g)	Grain yield (kg/ ha)	N uptake		
							N	P	K
Moisture (M)									
Farmers' practice	29.1	15.2	3.73	7.64	8.30	169.7	14.0	3.8	7.2
Ridge & furrow (R & F)	34.4	18.6	4.40	8.13	8.87	208.5	16.5	4.5	9.0
Tied ridge (TR)	35.5	20.2	4.59	8.40	8.84	223.2	17.2	4.7	9.5
R & F + mulching	40.8	21.9	5.27	8.88	9.37	279.0	20.4	5.5	12.3
TR + mulching	41.4	22.2	5.38	8.95	9.32	297.4	21.6	6.0	13.8
CD (P=0.05)	4.40	2.16	0.58	0.51	0.62	29.1	2.4	0.5	1.3
Nutrient (N)									
Farmers' practice	24.7	17.1	3.72	7.84	8.44	156.6	12.3	3.3	6.6
Rec. NPK	36.5	18.8	4.66	8.41	8.92	237.9	18.4	5.12	9.8
50% NPK+ 50% Enriched compost	43.4	21.7	5.28	8.83	9.22	284.5	20.9	5.8	12.5
Enriched compost	40.2	20.9	5.03	8.61	9.07	263.2	20.1	5.4	12.5
CD (P=0.05)	2.65	1.69	0.24	0.56	0.43	20.3	1.3	0.4	1.1

better growth parameters of cowpea. Similar results have been reported by Gupta and Gupta (1986) who recorded increased root length and dry weight in cowpea under mulching. Enriched compost application showed increase in all the

uptake by plants. The favourable influence of mulching on pigeonpea was also reported by Prasad *et al.* (2000). In nutrient management practices, enriched compost application and 50% inorganic fertilizers and 50% enriched compost application

resulted in increased yield attributes of cowpea during 2002 and 2003. These results are in close conformity with the findings of Yadav *et al.* (1992) who reported that enriched compost application increased the number of pods per plant in mungbean.

Grain yield

The results on the effect of moisture conservation and nutrient management practices on grain yield of cowpea were found significant in both the years of experiment (Tables 2 and 3). Grain yield was significantly higher under ridges and furrows with mulching (715.9 kg/ha) during 2002 and tied ridges with mulching (297.4 kg/ha) during 2003. The increment in yield was due to the availability of higher soil moisture under ridges and furrows or tied ridges along with mulching, which helped the soil to retain moisture for longer period resulting in better root growth, nodulation capacity, weed suppression, growth parameters, yield attributes and finally yield of cowpea. These results corroborate the findings of Selvaraju *et al.* (1999) who obtained 14% more grain yield of rainfed sorghum under tied ridges. Farmers' practice of moisture conservation produced lower grain yield (572.2 and 169.7 kg/ha) during both the years.

In nutrient management practices, application of enriched compost (730.7 kg/ha) during 2002 and integration of 50% inorganic fertilizers and 50% enriched compost (284.5 kg/ha) during 2003 registered significantly higher grain yield than the recommended dose of inorganic fertilizers and farmers' practice. It could be ascribed to the fact that application of enriched compost supplied all the macro and micronutrients readily for longer period. Further, compost application might have played a major role in improvement of physical, chemical and biological properties of soil, improvement in the water holding capacity of soil (Venkateswarlu 1987) and improved soil health by reducing the soil hardening. This collectively resulted in increased growth and yield of cowpea under rainfed conditions.

Nutrient uptake

Significantly higher N, P and K uptake under ridges and furrows with mulching during 2002 (30.8, 7.1 and 23.6 kg/ha) and tied ridges with mulching during 2003 (21.6, 6.0 and 13.8 kg/ha) were registered over farmers' practice of moisture conservation. Higher nutrient uptake under mulching treatments might be due to that moderation in soil hydrothermal regime might have favoured a better root development. The increased nutrient uptake under mulching in acid *Alfisol* at Himachal Pradesh has been reported by Sharma and Parmar (1998). In general, nutrient uptake was higher during 2002 than 2003.

Enriched compost application registered significantly higher nutrient uptake of 30.9, 7.4 and 23.5 kg/ha NPK during 2002. During 2003, application of 50% inorganic fertilizers and 50% enriched compost was found to be superior in nutrient uptake (20.9, 5.8 and 12.5 kg/ha NPK). Increased nutrient uptake can be attributed to increased nitrogen fixation through the application of enriched compost. Further, releasing of organic acids from compost might have increased the solubility of native soil nutrients and subsequently increased the uptake. Similar results were reported by Mathan *et al.* (1994) who opined that enriched farmyard manure increased the NPK uptake in pigeonpea.

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