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Natural Resources Management on Sustainable Productivity of Rainfed Pigeonpea (*Cajanus cajan* L.)

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Abstract: A field experiment was carried out to study the effect of natural resources management viz., rainwater and soil on productivity and soil fertility of pigeonpea under rainfed *alfisol* ecosystem. Different improved *in situ* soil moisture conservation practices for rainwater management and nutrient management practices for soil management were compared with farmers' practice of moisture conservation and no nutrient application. Results showed that moisture conservation through tied ridges along with mulching recorded significantly higher soil moisture at all the critical stages of pigeonpea. Improved grain yield (475.5 kg/ha), water productivity (8.9 kg/ha-cm), energy efficiency (15.63), Specific energy (102.7 MJ kg^{-1} of grain) have obtained under tied ridges with mulching. Post harvest soil nutrient status was improved under mulched plots. In soil management treatments, enriched compost application had significant influence on grain yield (471.2 kg/ha), nutrient uptake and soil nutrient status (221.1, 27.6 and 87.8 kg/ha NPK respectively).

Key words: Moisture conservation, Nutrient management, Productivity, Soil fertility.

INTRODUCTION

Rainwater and soil are the important natural resources in rainfed agriculture. In India, more than 40% of food grains, 95% of coarse grains and pulses, 75% of oil seeds and 70% of cotton are being produced in rainfed condition. Inadequate soil moisture availability and poor soil fertility are the most important factors that affect partial or total failure of rainfed crops with the occurrence of mild to severe drought during cropping periods. Degradation and mismanagement of these natural resources pose a great tragedy in recent times, these resources should be conserved and utilized to the maximum possible extent[10]. The successful cultivation of pigeonpea depends upon the management of natural resources like rainwater through proper *in situ* rainwater harvesting techniques and soil fertility by adding sizable quantity of organic manures along with limited inorganic fertilizers. Since soil moisture plays crucial role in plant growth, mineral nutrition and microbial activity in soil, its availability has to be increased by conserving as much as rainwater in the soil profile. In this context, *in situ* soil moisture conservation practices like ridges and furrows, compartmental bunding, tied ridges[5] and mulching are useful moisture conservation practices in rainfed agriculture. Mulching is an important practice that increases the infiltration of rainwater into the soil through runoff control and increasing opportunity time to infiltration, reduces the evaporation loss, control weeds infestation and improve the yield of field crops[1,8]. Reuse of farm waste through composting has found effective in maintaining soils fertility in rainfed regions and increasing the crop productivity[13]. Keeping this view, a field experiment was planned to investigate the effect of different *in situ* soil moisture conservation and nutrient management practices on productivity of pigeonpea under rainfed condition.

MATERIALS AND METHODS

The field experiment was carried out at the demonstration fields of M. S. Swaminathan Research Foundation, Ariyamuthupatti, Pudukottai district of Tamil Nadu during *Kharif–rabi* season (August, 2003 to January, 2004) under rainfed *alfisol* condition. The experiment was laid out in strip plot design with three replications. In main plots, four different *in situ* soil moisture conservation practices (M_2-Ridges and Furrows (R&F), M_3-Tied Ridges (TR), M_4-Ridges and Furrows+Mulching, M_5-Tied Ridges+Mulching) were compared to M_{1-} farmers' practice of moisture conservation (disc ploughed once during pre-monsoon showers and subsequently country plough tillage was given once during sowing). In sub plots, N_2-100% Recommended NPK (12.5:25:0 kg NPK/ha), N_3-50% inorganic fertilizers (6.25:12.5:0 kg NPK/ha) and 50% enriched compost (1.25 t/ha) and N_4-Enriched compost @ 2.5 t/ha were compared to N_1-Farmers' practice (No nutrient application).

Formation of ridges and furrows were done with a spacing of 100 cm in between two ridges. Tied ridges were formed by blocking the furrows manually with

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earthen bunds at 1.5 m intervals. Mulching was done with locally available crop residues viz., groundnut, horse gram and green gram and sugarcane trash at the rate of 2.5 t/ha on dry weight basis at 15 days after sowing. Compost was prepared from locally available crop residues and pressmud obtained from local sugar factory by adding cellulolytic fungi *Trichoderma viride* at 5 kg per tonne of raw materials. For enrichment, addition of rock phosphate at 25 kg, $ZnSO_4$ at 2.5 kg and biofertilizers, *Phosphobacteria* and *Azospirillum* at 200 g each were added per tonne of materials at the time of preparation. Enriched compost was contains 1.73% N, 0.86% P and 0.95% K. The recommended dose of nitrogen and phosphorus at the rate of 12.5 and 25 kg/ha and recommended dose of enriched compost at the rate of 2.5 t/ha were applied on the slope of the ridges according to treatment schedule. Semi-spreading, indeterminate type variety *Vamban* 2 was used in this experiment. The total rainfall, evapotranspiration and number of rainy days during the cropping period were 531.8 mm, 460.6 mm and 25 days in *kharif-rabi*, 2003, respectively.

Observation on available soil moisture at 0-30 cm depth was recorded by gravimetric method during critical stages of the cropping period. The sustainable indicators such as Water Productivity (WP) Energy Efficiency (EE), Specific Energy (SE) were worked out and soil fertility status were worked out. Water productivity was worked out by dividing the grain yield with total rainfall. Energy efficiency was worked out taking in account in the input and output energy for each treatment[2]. Specific energy of the treatment was calculated in terms of energy required to produce a kg of main product and expressed as MJ kg^{-1}[3]. Soil samples were collected from 15 cm depth at post harvest stage for nutrient analysis.

RESULTS AND DISCUSSIONS

Available soil moisture dynamics: Among the different *in situ* soil moisture conservation techniques, tied ridges with mulching conserved 1.8, 1.2 and 3.3% more soil moisture over farmers' practice at seedling, flowering and maturity stages of pigeonpea respectively (Fig.1). Irrespective of ridges and furrows or tied ridges, mulching treatments recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains. Ridges and furrows or tied ridges have conserved the rainwater through reduced runoff loss, increased infiltration[14,11] over farmers' practice of moisture conservation. Tied ridges recorded more soil moisture than ridges and furrows because of its still local conservation by the ties, which is an improvement over traditional ridges and furrows where the rainfall could be lost as runoff[9]. The farmers' practice of moisture

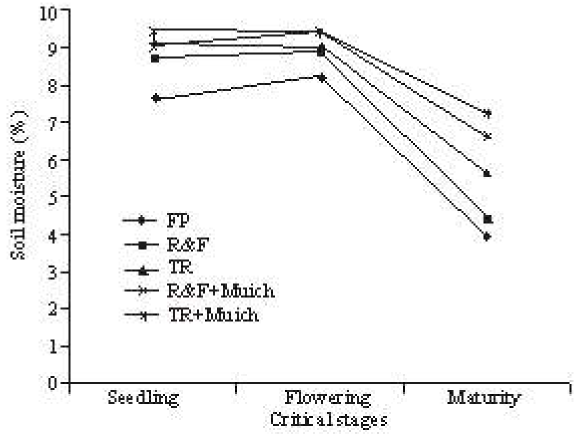

Fig. 1: Effect in situ rainwater harvesting on available soil moisture (%) at 30 cm depths in pigeonpea critical growth stages.

conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration.

Productivity: Grain productivity of pigeonpea was significantly higher under tied ridges with mulching (475.4 kg/ha), followed by ridges and furrows with mulching (454.5 kg/ha) over farmers' practice of moisture conservation (Table 1). The increment in yield was due to the availability of higher soil moisture for longer period under ridges and furrows or tied ridges along with mulching, resulted in better root growth, nutrient uptake, growth and yield attributes and yield of rainfed crops[9]. Farmers' practice of moisture conservation produced lower grain yield (292.3 kg/ha). Among nutrient management practices, application of enriched compost has registered significantly higher grain yield (471.2 kg/ha) than recommended dose of inorganic fertilizers and farmers' practice of no nutrient application. This was followed by integration 50% inorganic fertilizers and 50% enriched compost (442 kg/ha). It could be ascribed to the fact that application of enriched compost supplied all the macro and micronutrients readily as well as slowly for longer period. Further, compost application might have played a major role in improvement of physical, chemical and biological properties of soil[4], improvement in the water holding capacity of soil[15] and improved soil health by reducing the soil hardening, collectively resulted in increased growth and yield of pigeonpea under rainfed condition.

Maximum water productivity of pigeonpea was recorded under tied ridges with mulching (8.9 kg of grain cm^{-1} of rainwater) in moisture conservation practices and enriched compost application (8.9 kg of grain cm^{-1} of rainwater) in soil management. Availability of higher soil moisture under mulching produced increased grain productivity[16] resulted higher water productivity.

Table 1: Effect of *in situ* soil moisture conservation and nutrient management practices on sustainable production of pigeonpea

Treatments	Grain productivity (kg/ha)	Water Productivity (kg /ha/ cm)	Energy Efficiency	Specific Energy (MJ kg^{-1} of grain)
Moisture (M)				
Farmers' Practice	292.3	5.5	11.38	111.63
Ridges & Furrows (R&F)	353.6	6.6	12.23	106.53
Tied Ridge (TR)	393.7	7.4	13.45	105.98
R& F + Mulching	454.5	8.5	15.18	103.08
TR + Mulching	475.4	8.9	15.63	102.7
CD (P=0.05)	42.6	Not statically analyzed		
Nutrient (N)				
Farmers' Practice	271.2.	5.1	14	111.3
Rec. NPK	391.2	7.4	12.5	106.1
50% NPK+ 50% Enriched compost	442	8.3	13.6	103.7
Enriched compost	471.2	8.9	14.2	102.8
CD (P=0.05)	21	Not statically analyzed		

Table 2: Effect of *in situ* soil moisture conservation and nutrient management practices on nutrient uptake and post harvest soil fertility status of pigeonpea.

	Nutrient uptake (kg /ha)			Post harvest Soil fertility (kg /ha)		
Treatments	N	P	K	K	P	K
Moisture (M)						
Farmers' Practice	30.1	6.1	10.6	155.2	16.9	44.8
Ridges & Furrows (R&F)	36.7	7	14	162.2	18.9	52.2
Tied Ridge (TR)	41.4	7.5	17.1	178.4	21.4	56.8
R& F + Mulching	50	8.8	24.1	205.1	25.2	69.9
TR + Mulching	52.8	9.3	27.8	219.2	26.8	78.3
CD (P=0.05)	6.5	1.3	2.3	40.8	2.8	14.8
Nutrient (N)						
Farmers' Practice	26.1	4.7	11.2	145.5	14.5	35.1
Rec. NPK	40.8	7.9	15.9	162.4	21.1	44.8
50% NPK+ 50% Enriched compost	49.9	8.9	22.1	207.1	24.2	73.8
Enriched compost	52	9.4	25.8	221.1	27.6	87.8
CD (P=0.05)	2.5	0.4	2.4	35.4	2.7	6.8

Energy: Energy efficiency of the moisture conservation techniques revealed that application of mulch irrespective of ridges and furrows or tied ridges has increased the energy out put resulted in improved energy efficiency (Table 1). Tied ridges with mulching (15.63) registered the maximum energy efficiency whereas farmers' practice of moisture conservation registered the minimum energy efficiency (11.38). Higher energy efficiency of 14.2 was recorded with enriched compost application in nutrient management treatments.

Specific energy that is the minimum energy required to produce one kg of grain was observed under improved moisture conservation treatments.

Minimum specific energy of 102.7 MJ kg^{-1} of pigeonpea under tied ridges with mulching in moisture conservation and 102.8 MJ kg^{-1} of pigeonpea under enriched compost application in nutrient management practices was recorded. Lower energy efficiency and higher energy requirement to produce a kg of grain were found with farmers' practice of moisture conservation and no nutrient application.

Nutrient uptake: Moisture conservation through tied ridges with mulching has showed significantly higher N, P and K uptake of 52.8, 9.3 and 27.8 kg/ha respectively (Table 2). Higher nutrient uptake under mulching treatments possibly due to that moderation in soil hydrothermal regime might have favoured a better root development resulted in better nutrients uptake[11].

Enriched compost application has registered significantly higher nutrient uptake of 52.0, 9.4 and 25.8 kg/ha NPK respectively over other treatments, possibly due to application enriched compost might have increased the nutrients availability by increased nitrogen fixation in root nodules, reduced phosphorus fixation and supply of K were collectively resulted in more nutrients uptake. Further, releasing of organic acids from organic manures might have also increased the solubility of native soil nutrients and subsequently increased the uptake[7].

Soil fertility: Efficient management of natural resources in rainfed agro-ecosystem would not only increase the crop production but also improve the soil health. Soil sustainability in rainfed areas is a big question because of inherent poor fertility status of soil and farmers hesitation to apply fertilizers due to risk of crop failures. But the crop sustainability stems from soil sustainability, soil health maintenance should be given primary concern in crop production. In the present investigation, the post harvest available NPK were significantly improved by moisture conservation through mulching mainly due to higher soil moisture availability, decomposition of mulching materials which would have increased the biological activity and nitrogen fixation by pigeonpea[6].

Enriched compost application (221.1, 27.6 and 87.8 kg/ha NPK) and application of 50% inorganic fertilizers and 50% enriched compost (207.1, 24.2 and 73.8 kg/ha NPK) were found to increase the soil available NPK status over farmers practice of no nutrient application possibly due to slow release of nutrients from compost, increased nodulation[12] and reduced phosphorus fixation (Table 2).

Thus, management of rainwater through formation of tied ridges followed by mulching through locally available crop residues at the rate of 2.5 t/ha and soil fertility management by application of enriched compost at the rate of 2.5 t/ha could be viable technique for higher productivity of pigeonpea in rainfed *alfisol* ecosystem.

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