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Moisture Conservations Options for Boosting System Productivity under Pearl Millet: Cluster Bean Strip Intercropping

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out to study the Moisture conservations options for boosting system productivity under Pearl millet: Cluster bean strip intercropping under aberrant weather situations of south-western Haryana. The experiment was laid out in randomized block design comprising nine treatments replicated thrice. Pearl millet: Cluster bean strip cropping (6:3) under deep summer ploughing recorded maximum land equivalent ratio (1.37) and pearl millet equivalent yield (29.30 q/ha) over conventional and straw mulching practices. While, the highest gross return Rs. 50134, net return Rs. 21749 and B:C (1.77) also recorded under Pearl millet: Cluster bean strip cropping (6:3) under deep summer ploughing (30 cm depth) over other treatments. Pearl millet:

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Cluster bean strip cropping (with raw ratio 6:3) under deep summer ploughing (30 cm depth) moisture conservation practice significantly improvement of system productivity, land equivalent ratio and pearl millet equivalent yield of pearl millet + Cluster bean strip cropping system.

Keywords: Moisture conservation practices; land equivalent ratio; pearl millet equivalent yield; system productivity.

1. INTRODUCTION

To maximize the production per unit area per unit time, the strip-cropping pearl millet (*Pennisetunz glauclun* L.) with legumes augments the utilization of available light, moisture and nutritional factors with reference to space and time. This practice assumes a great importance and is an important economic support system of crop production for the farmers of rainfed regions. It is one of the most recognized systems of cropping to increase the cropping intensity and production per unit area, time and inputs by growing two or more crop component crops in appropriate geometry. Keeping the above facts in view, the present investigation was undertaken to study the performance of sole, as well as intercropping/strip-cropping systems of pearl millet legume association with cluster bean under different moisture conservation practices.

The productivity of grains already showed a plateau in irrigated agriculture due to problems related to nutrient exhaustion, salinity build up and raising water table. Therefore, the challenges of the present millennium would be to produce more from rainfed agriculture while ensuring conservation of resources, the soil and water. Hence, new strategies would have to be used which would conserve the water and the fragile soil of rainfed ecosystems. There are a variety of methods that can be used to conserve soil moisture. A large number of the methods rely on providing some kind of cover for the soil to minimize evapotranspiration and direct soil exposure to heat and sun. Generally, most methods used for soil quality improvement and conservation, will also yield benefits to soil moisture conservation.

“It was observed that the drought situation may arise during crop growth period which may result in partial failure of crops. Drought situations caused due to aberrant weather and erratic rainfall has been routine crises in rainfed agriculture. To cope up with such crunch, it is necessary to find out the possibilities to survive the crop under contingent conditions by using some of the simple methods of in-situ moisture conservation” [1]. “It was therefore, felt worthwhile to adopt the proper methods of in-situ moisture conservation so as to partially meet out the adverse effect of water stress in standing crops. The positive effects of moisture conservation practices like mulching, deep summer ploughing etc. in crops like pearl millet, cluster bean, sorghum, cowpea, Bengal gram and sunflower have been observed” [2]. “In-situ moisture conservation practices *viz*., ridges and furrows + mulch, imparted beneficial effect on cluster bean for getting good growth and higher yields; which subsequently led to higher net returns and B: C ratio” [3].

“Intercropping/strip cropping is referred to the cultivation method of two or more crop species simultaneously in the same land” [4]. “According to the statistics, intercropping covers the 3% of the land in the world, not only in the irrigated areas” [5], “but also in the rainfed regions” [6]. “Intercropping could greatly improve the crop yield under full irrigation” [5,7]. “For example, wheat yield in intercropping was increased by 40-70% in wheat/maize intercropping under well-watered environment” [5]. “Previous studies have also showed that the intercropping requires a large amount of water” [8]. Water is the main limiting factor for agricultural productivity under rainfed conditions. However, apart from the studies, there is few information on the yield performance of strip-cropping under rainfed conditions, especially in cereal/cereal intercropping.

“The increased crop productivity with intercropping is mainly due to increased light interception [9], improved crop rooting systems [10] to facilitate soil nutrient sharing between the intercrops [11], and improved conservation of soil moisture” [12]. “However, other studies showed that the yield increment of intercropping was mainly attained from the amounts of water applied through irrigation to satisfy the biological process” [10]. “The main reason put forth for higher yields in Pearl millet: Cluster bean intercropping is that component crops complement each other and make better overall use of resources over time. Many studies have

indicated that the yield advantage of this system was largely affected by nutrient application levels. Interspecific competition can be alleviated by increasing the rate of phosphorus and nitrogen application" [5].

To our knowledge, little information on strip-cropping with moisture conservation practices. In this study, we focused on a sole pearl millet, cluster bean and their strip cropping system under different moisture conservation practices with following objectives: (1) To study the effect of moisture conservation practices on yield of pearl millet, cluster bean and their strip cropping systems for realizing maximum yield. (2) To work out the economics of different treatments.

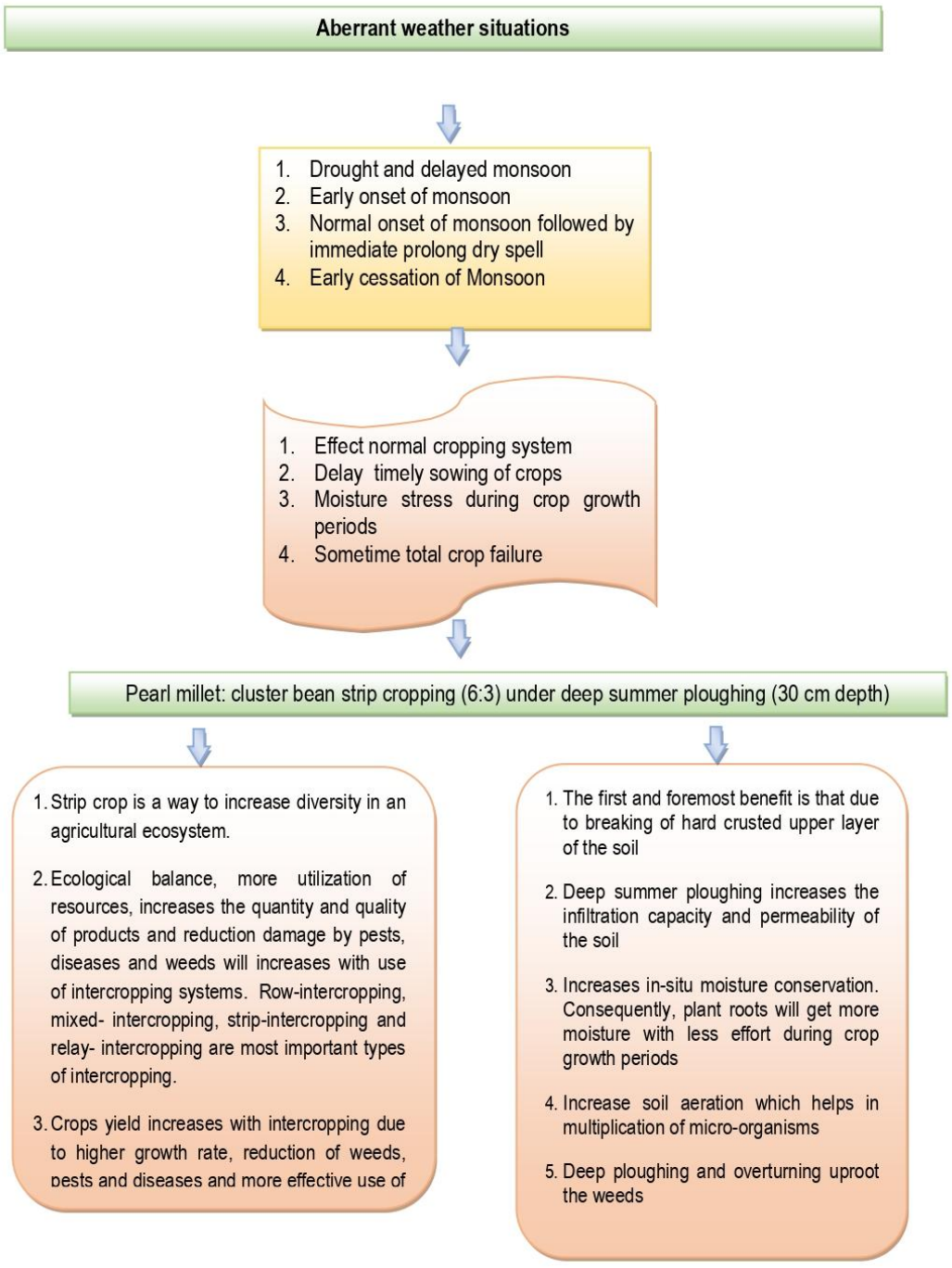

Fig. 1. Benefits of moisture conservation practices

2. MATERIALS AND METHODS

2.1 Study Area

Field experiments were conducted at the CCS Haryana Agricultural University, Regional Research Station ($25^0$27' Latitude, 78^0 75 E, 271 m above mean sea- level), located in Haryana state of India. This area belongs to semi-arid region. The annual mean temperature is 13.4 °C. The mean annual precipitation was 585 mm (55 years), and 60–70% of the precipitation falls from July to September.

2.2 Experimental Design and Treatments

The experiment was laid out in randomized block design comprising 9 treatments replicated thrice. The detail of the treatments is given in Table 1.

The recommended dose of fertilizers in the sole stands of pearl millet and pearl millet: cluster bean was applied at 157 N+60 P_20_5 and 20 N+ 40 P_20S kg/ha, respectively. The pearl millet var. HHB-67 (Improve) and cluster bean var. HG 2-20 were grown in *kharif* session.

2.3 Estimation of Yield and Land Equivalent Ratio

All the other recommended package of practices of CCS Haryana Agricultural University was followed for successful raising of zero till wheat. Harvested crop produce from net plot was threshed manually by beating on hard surface. The grain^{-1} yield was recorded in kg per plot and expressed in quintal ha. Bundle weight was taken before threshing and straw weight (kg) was recorded after deducting grain weight (kg) from the bundle -1 weight (kg), which was straw yield, expressed in quintals ha. Land Equivalent Ratio (LER) the ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level. It is the sum of the fractions of the intercropped yields divided by the sole-crop yields.

Table 1. Physicochemical properties of the soil (0-30 cm) of experimental area

Property	Value
Soil texture	Loam
WHC@FC (%)	24
pH	8.13
Organic matter (g kg^{-1})	11.82
Total N (g kg^{-1})	0.87
Available N (mg kg^{-1})	51.02
Available P (mg kg^{-1})	13.57
Available K (mg kg^{-1})	95.32

WHC@FC- Water holding capacity at field capacity

Table 2. Treatment details

Sr. No.	Treatment
T1	Sole pearl millet sowing under conventional tillage,
T2	Sole pearl millet sowing under deep summer ploughing (30 cm depth),
T3	Sole pearl millet sowing under straw mulching with residual wheat stubbles using roller followed by zero tilled sowing,
T4	Sole cluster bean sowing under conventional tillage,
T5	Sole cluster bean sowing under deep summer ploughing (30 cm depth),
T6	Sole cluster bean sowing under straw mulching with residual wheat stubbles using roller followed by zero tilled sowing,
T7	Pearl millet: Cluster bean (Strip cropping 6:3) under conventional tillage,
T8	Pearl millet: Cluster bean (Strip cropping 6:3) under deep summer ploughing (30 cm depth),
T9	Pearl millet: Cluster bean (Strip cropping 6:3) under straw mulching with residual wheat stubbles using roller followed by zero tilled sowing.

Table 3. Moisture conservation practices adopted in pearl millet: Cluster bean strip cropping systems

Crop	Month	Field Operations	CT	DSP	ZT+ SM with roller
Pearl millet: Cluster bean	May	Land preparation	Harrow once	Disk ploughing once (30 cm deep)	
	June		Harrow once		Roller once (30 kg weight + 2.9 M width) for spreading wheat stubbles on soil surface straw mulching with residual wheat stubbles using roller
	July (first fortnight		Cultivator once Levelling once	Cultivator once Levelling once	
	July (second fortnight depending on rainfall)		Sowing through cultivator	Sowing through cultivator	Sowing through zero tillage machine

CT- Conventional tillage, DSP-Deep summer ploughing, ZT- zero tillage and SM- Straw mulch

Table 4. Effect of different treatments on yield, LER and PMEY of pearl millet, cluster bean and their strip cropping system (pooled data)

Sr. No.	Treatments	Yield (q/ha)				LER	PMEY q/ha
		Grain/Seed		Straw			
		PM	CB	PM	CB		
T_1	Sole PM + CT	18.40	-	49.69	-	1.0	18.40
T_2	Sole PM + deep summer ploughing	19.54	-	51.83	-	1.0	19.54
T_3	Sole PM + SM + ZT	17.46	-	48.63	-	1.0	17.46
T_4	Sole CB + CT	-	9.09	-	22.87	1.0	21.95
T_5	Sole CB + deep summer ploughing	-	10.15	-	24.86	1.0	23.74
T_6	Sole CB + SM + ZT	-	8.75	-	22.66	1.0	21.13
T_7	PM : CB + CT	15.07	4.55	41.35	10.81	1.32	26.07
T_8	PM : CB + deep summer ploughing	16.18	5.43	44.52	13.19	1.37	29.30
T_9	PM : CB + SM + ZT	14.23	4.30	40.31	9.82	1.31	25.06
	CD (P=0.05)	1.06	0.76	2.09	1.98	0.03	1.13

PM- Pearl millet, CB- Cluster bean, CT- Conventional tillage, SM- Straw mulch, LER- Land equivalent ratio, PMEY- Pearl millet equivalent yield

Table 5. Effect of different treatments on economics of pearl millet, cluster bean and their strip cropping system

S/No.	Treatments	Gross Return (Rs./ha)	Cost of Cultivation (Rs./ha)	Net Return (Rs./ha)	B:C
T_1	Sole PM + CT	34503	27515	6988	1.25
T_2	Sole PM + deep summer ploughing	36406	28275	8131	1.29
T_3	Sole PM + SM + ZT	33110	26650	6460	1.24
T_4	Sole CB + CT	32988	27850	5138	1.18
T_5	Sole CB + deep summer ploughing	36665	28600	8065	1.28
T_6	Sole CB + SM + ZT	31915	26975	4940	1.18
T_7	PM : CB + CT	44774	27635	17139	1.62
T_8	PM : CB + deep summer ploughing	50134	28385	21749	1.77
T_9	PM : CB + SM + ZT	42509	26760	15749	1.59

PM- Pearl millet, CB- Cluster bean, CT- Conventional tillage, SM- Straw mulch

2.4 Statistical Analysis

The data obtained from two-year study was statistically analysed by the methods of analysis of variance (ANOVA) as described by Panse and Sukhatme [13]. The significance of treatment effects was computed with the help of 'F' (variance ratio) test and to judge the significance of differences between means of two treatment, critical differences (CD) was worked out as described by Gomez and Gomez [14].

3. RESULTS AND DISCUSSION

On the mean basis of three year (Tables 4 and 5) sole pearl millet (19.54 q/ha) and sole cluster bean (10.15 q/ha) yielded significantly higher in deep summer ploughing then sole pearl millet (18.40 q/ha), sole cluster bean (9.09 q/ha) under conventional tillage system by the margins 6.20 and 11.66, respectively. Increase in the yield of field crops with adoption of moisture conservation practices is also reported by Somasundaram et al. [2] and Allolli et al. [3]. The LER and PMEY were found to be influence by different moisture conservation practices. The pooled data of three years mean showed the PM: CB (6:3) strip cropping under deep summer ploughing recorded maximum LER (1.37) and PMEY (29.30 q/ha) over conventional and straw mulching practices. Incorporation of strip crops have increased the LER and PMEY, these results are in line with those obtained by Gao et al. [8] Li et al. [5] and Vandermeer [4].

While, the highest gross return Rs. 50134, net return Rs. 21749 and B:C (1.77) under PM: CB strip cropping (6:3) sowing with deep summer ploughing (30 cm depth) over other treatments. The increased productivity and profitability by adoption of moisture conservation practices have been also attested by Li et al. [11] Zhang et al. [9] Yang et al. [10] and Ahmad et al. [12].

4. CONCLUSION

Pearl millet: Cluster bean strip cropping under deep summer ploughing recorded maximum land equivalent ratio and pearl millet equivalent yield over conventional and straw mulching practices. It also yields to highest gross and net return over other treatments. Pearl millet: Cluster bean strip cropping significantly improved system productivity, land equivalent ratio and pearl millet equivalent yield of pearl millet + Cluster bean strip cropping system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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