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Resource Conservation Practices in Rainfed Pearl Millet-Energy Input-Output Analysis

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ABSTRACT: A field experiment with conservation agricultural practices in pearl millet was conducted at Hisar in 2005-09 with a set of five tillage treatments. Rainfall for the cropping season showed significant role in production and no tillage treatment resulted in lowest grain yields in all the years. Conventional tillage and low tillage treatments yielded at par proving that a preparatory tillage could be saved without compromising the yield. Lowest energy output/input ratio was observed for "No tillage" treatment obviously due to lowest grain yield. Highest ratio was for low tillage followed by two intercultures which was also accompanied by highest B:C values. Estimation of net energy additions over "no tillage" treatment revealed that for every additional one unit energy input in low tillage plus two interculture gave additionally highest output of 39.6 MJ closely followed by low tillage + one interculture + Atrazine spray. Energy input was around 7000MJ/ha for producing rainfed pearl millet and values were close to literature values. Two intercultural operations seemed to be necessary for optimum harvests through moisture conservation as well as weed management. Results indicated that 'no tillage or low tillage' concept needs a relook for rainfed areas as weed control is a vital aspect.

Key words: Tillage, energy, pearl millet

Resource conservation is now emphasized for minimizing the cost of cultivation as the yields are stagnating. Being agrarian economy, the progress of Haryana State is directly linked with agriculture. In rainfed areas of India, the economic returns from agriculture are highly vulnerable as yields harvested in rainfed areas are one third of that in irrigated agriculture. Moreover, with threat of drought always looming large, farmers are apprehensive of using full recommendations of crops. As apparent, new technologies are highly energy intensive and any further upward trends in demands will lead it to going further up in the near future. Energy inputs are costly which rainfed farmers can hardly afford. Field experiment on combination of conventional tillage with intercultural operations by machines as well as chemicals was conducted under rainfed conditions for pearl millet in 2005-2009 at Hisar. Energy analysis of input and output was made to bring out the most energy efficient combination and its relationship with yields.

Materials and Methods

A field experiment was conducted at the Research Farm of Dept. of Dryland Agriculture, CCS Haryana Agricultural University, Hisar during 2005-2009 at a fixed site. The field had sandy loam texture, water holding capacity at 40%, alkaline in reaction (pH 7.8), non saline (EC 0.45 dS/m), low in organic C (0.31%) and consequently moderate in fertility with respect to N (232 kg/ha), medium in P_2O_5 (17.4) and high in available K (232 kg/ha). The climate of the region can be classified as tropical steppe, semi- arid and hot, mainly dry with prolonged hot period from March to October and fairly cool winters. There are mainly two cropping seasons, *kharif* (July-October) and *rabi* (November-April). Under rainfed situation, only one crop either in *kharif* with monsoonal rains (Pearl millet/mungbean/clusterbean) or *rabi* under conserved moisture (mustard/chickpea) is feasible. The normal annual rainfall is 380 mm (only ~ 60 mm falling in *rabi* season).

A field experiment with conservation agricultural practices in pearl millet was started at Hisar in randomized block design with three replications. Tillage practices tested were: no tillage, conventional tillage with 2 intercultural operations, 50% conventional tillage with 1 intercultural operation, 50% conventional tillage with 2 intercultural operations and 50% conventional tillage with 1 intercultural operation plus use of Atrazine at pre-emergence. Detailed description of treatments is as follows:

Treatment	Description
No tillage	No tillage operation at sowing
Conventional tillage	One harrowing + 1 cultivator and planking + two interculture with wheel hand hoe (15 and 30 DAS)
Low tillage with one interculture	One cultivator and planking + 1 interculture with WHH at 20 DAS
Low tillage with two interculture	One cultivator and planking + 2 interculture with WHH at 15 and 30 DAS
Low tillage + one interculture + weedicide	One cultivator and planking + 1 interculture with WHH at 20 DAS + Atrazine at pre emergence

Consequent upon receipt of significant (> 25 mm) rain, pearl millet was sown in all the seasons in the first fortnight of July using HHB-67 (Improved) variety. Recommended fertilizer dose of 40, 20 kg/ha of N and P_2O_5 was drilled at sowing. At maturity, crop was harvested, air dried and ear heads were separated to recover grains and yield recorded. Energy equivalent values for field operation and other inputs/outputs were worked out as per Mittal *et al*. (1985).

Results and Discussion

Pearl millet grain yield

Data presented in Table 1 revealed that there was wide variation in yields which was attributed to the quantum and spread of rainfall. Highest mean yields were obtained in 2007 and 2008 while lowest values were in the year 2005. With the duration of crop limiting to only 65-70 days, rainfall for the cropping season has a significant role in production. Comparing the treatments, no tillage treatment (T_0) resulted in lowest yields in all the years due to infestation of weeds and consequently depletion of stored profile moisture due to higher stress on resources. Use of Wheel Hand Hoe (WHH) helped in two ways; firstly in removal of weeds and secondly, by slicing a thin layer of top soil which acted as soil mulch in moisture conservation. Overall mean yield values in different years indicated that conventional tillage treatment (T_1) and low tillage (T_4) were yielding at par thus proving that a preparatory tillage could be saved without compromising the yield. Two intercultural operations seemed to be necessary for optimum harvests through moisture conservation as well as weed management. As already stated, the duration of this crop is short (65-70 days) progressing along with advancing rainfall, weed infestation is relatively higher and need to be managed either by manual means or through use of chemicals. Combined use of Atrazine with one interculture though controlled weeds at par with two manual controls, but still the yields were slightly lower in this treatment. This brings to the fore the role of WHH in moisture conservation. Except no tillage treatment, B:C values in all other treatments failed to exhibit much variance due to the fact that slightly lower yields were associated with corresponding lower monetary inputs as labour or fuel.

Table 2 enumerates the actual rainfall in the experimental phase of July-September. Considering the pearl millet grain yield with rainfall, lowest yields can be attributed to poor rains in August (average for 40 years: 85 mm) and total absence of rains in September for the full study period.

Table 2 : Rainfall in 2005-2009

Year	July	August	September
2005	116.9 (2)	53.4 (1)	-
2006	84.4 (3)	114.3 (3)	80.0 (10)
2007	99.6 (3)	170.0 (3)	70.9 (1)
2008	61.1 (3)	65.9 (1)	150.1 (2)
2009	38.3 (2)	36.1 (3)	21.1 (3)

*values in parentheses are number of events

In 2007 and 2008, rains were well distributed as well as adequate in quantity to sustain crop production. In September 2008, there were two extreme events of >70 mm which lead to high rainfall values for this season.

Prior to sowing, pre monsoon showers are generally received in the 2nd half of June. After a good event of rains, field was ploughed using disc harrow followed by cultivator and planking. On receipt of next good (>20mm) rain in early July, sowing was done without any tillage operation in "No tillage" plots while all listed operation were carried out in other treatment plots.

Table 1 : Strategies for resource conservation and productivity of rainfed pearl millet

Treatment	Grain yield (kg/ha)						B:C
	2005	2006	2007	2008	2009	Mean	
No tillage (T_0)	1171	1071	1554	1406	1313	1303	0.99
Conv. Tillage + interculture (2) (T_1)	1416	1842	1970	2007	1635	1774	1.19
Low tillage (50% conv. tillage) + 1 interculture (T_3)	1265	1644	1808	1841	1555	1622	1.19
Low tillage (50% conv. tillage) + 2 interculture (T_4)	1367	1776	2063	2100	1685	1798	1.23
Low tillage (50% conv. tillage) + 1 interculture + Atrazine (T_5)	1260	1639	1987	2034	1372	1718	1.21
Mean	1296	1594	1876	1878	1572	1643	-
CD (P=0.05)	71	111	152	163	101	-	-

Energy balance

Data presented in Table 3 revealed that lowest energy output/input ratio was observed for "No tillage" treatment obviously due to lowest grain yield. Highest ratio was for low tillage followed by two intercultures which was also accompanied by highest B: C values. It may be noted that for energy inputs, the value of seed, fertilizers, harvesting, manual sowing and threshing were common to all combination of treatments and only variable factor was tillage plus intercultural operations. So a major part of energy input was constant and it was 89-93 per cent of the total energy inputs. It meant that by variation in less than 10 per cent of the total energy input for rainfed pearl millet, the gain in energy output were 30-40 per cent over no tillage treatment. It clearly indicated that 'no tillage or zero tillage' concept needs a relook for rainfed areas especially in low and medium rainfall zones since weed control is a vital aspect. It is well known that weeds compete with main crop for moisture and nutrition and as moisture is most limiting factor under such conditions, any stress could severely hamper the ultimate yields. Low yields and poor energy efficiency in this particular treatment brings to fore the importance of weed management under dryland conditions. Higher additional energy output per unit of energy input in low tillage plus two intercultural operations at 15 and 30 DAS are important. Estimation of net energy additions over "no tillage" treatment revealed that for every additional one unit energy input in T_3 gave additionally highest output of 39.6 MJ closely followed by T_4 with only difference of one interculture being replaced by Atrazine spray for weed control. Treatment with highest energy input gave lowest gain in output (T_1) indicating that necessarily all inputs were not transformed into meaningful output. Energy inputs in different treatments revealed that around 7000MJ/ha energy was consumed for producing rainfed pearl millet. These values are in agreement with those reported by Jain (1988) at 1623 x 10^3 Kcal or 6790.6 MJ/ha in Haryana for pearl millet production. Since this set of experimentation was conducted adopting full other recommendations except tillage, so values at farmer's fields could be still lower as full adoption of recommended practices is slow and limited. It meant that by enhancing the energy inputs through adoption of recommendations, there is good scope to enhance production of pearl millet grain from a unit area. Singh *et al.* (2002) from the study on energy use pattern for pearl millet production in "Chokha" village of Jodhpur, India reported that total energy use for cultivating pearl millet was 3807.4 MJ/ha with average output-input ratio of 4.8. Abubakar and Ahmad (2010) evaluated energy use pattern for pearl millet production in some selected farms in north eastern Jigawa, Nigeria. They observed that farms with <1 ha size consumed highest total energy at 6078 MJ/ha while relatively bigger farms, >5 ha, utilized the minimum energy at 1705 MJ/ha along with total energy values also being higher for such farms. A significant linear relationship between energy input-output was observed. Energy use ratio values indicated low values at bigger farms and values hovering around 1.3. Energy input-output analysis for millet production in semi arid zone of Nigeria, Abubakar (2012) reported that in all farm sizes, tillage and weeding consumed the highest energy as a result of low chemical usage. Their results further indicated that farms with 2-4 ha size were using energy more efficiently while small farms showed lowest efficiency (ratio of 0.8) due to higher human and or animal energy component. Jain (1988) concluded that in Haryana, energy consumption for pearl millet production had stagnated due to risk, large variations in yields over the years and susceptibility of the existing varieties to insect pest or diseases. Rainfed farming being low input energy farming system, the inputs are lower than 1 GJ/ha as compared to modern high input farming systems in west Europe where it may exceed 3 GJ/ha (Pimental, 2009; Reed *et al.*, 1986).

Table 3 : Energy input and output (MJ/ha) in various treatments

Treatment	Energy		Overall output/ input	Net energy additions	Gain in output energy	Change in output/ input
	Input	Output				
No tillage (T_0)	6723	54987	8.18	-	-	-
Conv. Tillage + interculture (2) (T_1)	7497	74863	9.99	774	19876	25.67
Low tillage (50% conv. tillage) + 1 interculture (T_3)	7180	68124	9.49	457	13137	28.70
Low tillage (50% conv. tillage) + 2 interculture (T_4)	7251	75876	10.46	528	20889	39.55
Low tillage (50% conv. tillage) + 1 interculture + Atrazine (T_5)	7229	72499	10.03	506	17512	34.63

Conclusion

Based on field experiment with conservation agricultural practices in pearl millet conducted at Hisar, it may be concluded that the mean yield values in different years were at par under conventional tillage and low tillage indicating that a preparatory tillage could be saved without compromising the yield levels. The necessity of two intercultural operations seemed to be important for optimum harvest through moisture conservation as well as weed management which was indicated by higher additional energy output per unit of energy input in low tillage plus two intercultural operations at 15 and 30 DAS. Around 7000MJ/ha energy consumption was reflected through energy inputs in different treatments for producing rainfed pearl millet.

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