

Innovative ridge furrow technology

impact on area, productivity and economics of pearl millet: A case study

Y P Singh*, Sandeep S Tomar, Ravi Yadav, Ravi Gurjar and Sudhir Singh

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh 474 002

In arid and semi-arid tropics, dual-purpose pearl millet was grown as a rainfed crop, resulting in low yield of grain and fodder in shrinking sources, particularly irrigation water. The objective of the present study was to improve productivity, economic profitability, water productivity (WP) and the impact of adoption on area, production, and additional net benefits in the Chambal division. The ridge furrow (RF) at 40 cm increased the grain yield by 18.0%, additional net returns (NRs) from ₹13,095/ha, saving Total Water Use (TWU) 37 mm and enhanced WP (33.1%) as compared to farmers' practice (FP). The overall results conclude that RF with 40 cm spacing (25 DAS) in pearl millet during the rainy season produces higher yield, NRs and WP of Chambal division of Madhya Pradesh..

Keywords: Impact on adoption, Pearl millet, Productivity, Ridge furrow, Water-use efficiency

INDIA is the largest producer of millets in the world, and pearl millet accounts for about two-thirds of millet production in the country. Dual-purpose crop pearl millet (*Pennisetum glaucum* L.) is grown in light to medium textured soils of dry regions of arid and semi-arid areas for food grain and green/dry fodder in India. Pearl millet has now been emphasized as nutri-cereal food for resource-poor villagers. Fortunately, the farmers in these areas practice livestock-based farming systems wherein they feed pearl millet straw to the livestock. It was grown with traditional practices in rainfed areas with need-based irrigation at the reproductive stage. Low yields and income from rainy season pearl millet were obtained due to dry spells at the reproductive stage, causing a decline in productivity and profitability due to shrinking rainy days.

The pearl millet crop is mainly grown during the rainy (*kharif*) season on marginal lands with low inputs, and efficient weed management is a significant challenge. There is a need to acquire an energy-efficient and eco-friendly methodology for weed management, including rainwater conservation. Herbicides are also effective for weed control in pearl millet. But the direct and residual effect of herbicide in soil has degraded the quality of grain, fodder, soil and environment. As this crop is also a significant fodder source for animals, farmers fear that using herbicides may deteriorate the fodder quality and animal health. Improving the biophysical and economic sustainability of pearl millet requires promoting conservation and efficient use of

precious rainwater through conservation practices and cutting back the cultivation costs and energy-intensive operations. Hence, there is a need to explore potential technology for safe and efficient weed control methodology along with efficient rainwater utilization for pearl millet production. The present study was conducted on innovative weed management along with rainwater conservation technique in rainy season crop pearl millet on productivity, economics, water use, and impact of technology in the Chambal division of Madhya Pradesh state of India.

Techniques adoption

A case study was organized on selected farmer fields at Santa and Hadwansi adopted villages under the Farmer FIRST Programme (FFP) project at the lower Chambal canal command of Morena district of Madhya Pradesh during the period from 2017–2021. The climate of the research study area was characterized as semi-arid and extremely cold during December–January (-1.0°C minimum temperature), and hot during May–June (49°C maximum temperature). The average annual rainfall was 650 mm, primarily concentrated in the months of July and August. During the 5-year study period, the minimum and maximum temperature was 0°C and 48°C . In general, the selected locations were sandy loam in texture and neutral to alkaline in nature, low in organic carbon content, available nitrogen, phosphorus, sulphur, and zinc, while the medium in potassium.

The impact study is based on two interventions for weed management in pearl millet crops, viz. chemical weed method (use of 2, 4-D @1.0 kg/ha application at 20 days after sowing or 10–30 cm tall plant) of weed control (FP- farmers' practice) compared with tractor operated ridge furrow (RF) at 40 cm spacing- 40 cm at 25 days after sowing (DAS) for weed management (IP- improved practice). The pearl millet (var. hybrid) was sown in the first to the second week of July after the first monsoonal rains. The seed rate was 4–5 kg/ha for pearl millet. The Vishwa Vidyalaya recommended agronomical packages of practices were followed. The crop was matured with rain water due to timely rains at critical stages of pearl millet in 2017 and 2019, while one irrigation at the reproductive stage was applied during 2018, 2020 and 2021, respectively. As per the FFP project general standards, demonstration plots were 4,000 m² in size. Parameters of yield attributing characters of crops were recorded at the maturity stage, and at maturity, grain and straw yields were recorded. Weed density and biomass in each plot were determined from 2.0m × 2.0m at maturity stage, dried at 70°C for 3 days, and weighed.

Grain, straw yield, gross return, net returns, and cost-benefit ratio were calculated on hectare (ha) basis. Different economic indicators of inputs were calculated based on the minimum support price and existing market price. The total water use (TWU) was computed by the sum of irrigation water used, adequate rainfall, and changes in soil moisture storage between the sowing and harvest of crops (increased after harvest of rainy season crops). The final data of TWU was calculated after deducting runoff. The water productivity (WP) was calculated by seed yield (kg/ha) divided by TWU (mm/ha water).

Measurement on adoption

Assessment of the area and net revenue generated was through innovative technology in terms of area acreages and revenue generated after five years of Chambal division (Bhind, Morena and Sheopur). The change in area and income was calculated through questionnaires and interviews of 100 random pearl millet growers

in each district. The economics was worked out by calculating the cost of inputs used for crop production. The gross returns (GRs) were calculated by multiplying the yield of the crop by the minimum support price and fodder rate as per the local market. Net returns (NRs) were calculated as the difference between gross returns and the total cost of cultivation (NRs = GR – TCC).

Yield and its attributes of pearl millet

Findings on growth characters (plant height, tillers, ear length, and 1000 grain wt.), grain and straw yield of pearl millet was recorded significantly higher with the intervention of plant height, tillers, ear length, and 1000 grain wt. were substantially higher with RF-40 cm intervention as compared with farmers practice (FP). The density and biomass of weeds were statistically at par as compared with FP and RF- 40 cm intervention (Table 1).

The weed density and biomass were suppressed with RF- 40 cm due to making RF operation at 25 DAS. Additionally, 25 days old, pearl millet crop suppresses the weed growth due to foliage coverage of the crop. The innovative RF- 40 cm intervention was found to be most effective in controlling broad and narrow-leaved weeds in pearl millet crops. The average response on grain and straw yield was increased by 18.0% and 10.9% with RF-40 cm as compared with FP, respectively. The *in-situ* rainwater conservation practice in pearl millet increases uniform more extended time availability of soil moisture and nutrition, resulting in higher growth parameters and yield of the crop.

Economics

Adoption of RF-40 cm practice additional net savings of production cost was ₹992/ha compared with total cultivation cost under FP (₹22,482/ha) of pearl millet crop (Table 1). The NRs were significantly higher with RF-40 cm as compared with FP. The additional NRs obtained ₹13,095/ha with innovative technology RF-40 cm as compared with FP in pearl millet. This shows that the higher net income of the system resulted in higher yield, and saving production cost of pearl millet with RF-40 cm intervention.



Ridge furrow at 40 cm spacing



Crop at flowering stage

Table 1. Impact of ridge furrow in standing pearl millet crop on growth parameters, yield and economics (mean values of 58 farmers' field of 5 years)

Intervention	Weed* density (plant/m ²)	Weed dry wt. (g/m ²)	Plant height (cm)	Tillers/plant (no.)	Ear length (cm)	1000 grain wt.	Grain yield (t/ha)		Straw yield (t/ha)	CC (₹/ha)	Net returns (₹/ha)
							Range	Mean			
FP	11a	34.4a	206a	2.2a	21.8a	8.37a	2.08–2.62	2.34a	6.32a	22,482a	36,070a
IP	14b	35.4a	228b	2.8b	23.9b	9.09b	2.45–3.35	2.76b	7.01b	21,560a	49,165b

FP- Farmers' practice, IP- Ridge furrow at 40 cm spacing, C.C.- Cost of cultivation, **Commelina benghalensis*, *Celosia argentea*, *Trianthema portulacastrum*, *Echinochloa colonum*, *Sorghum halepense*, *Cyperus rotundus*, Minimum seed support pearl millet price in ₹/t for the year 2017, 2018, 2019, 2020 and 2021 @14,250, 19,500, 20,000, 21,500 and 22,500 for grain and for stover in local market @1750, 2000, 2500, 3000 and 3250. Different letter within treatments indicates a significant difference, while the same letter is not significant.

Table 2. Impact of ridge furrow in standing pearl millet crop on the water balance (Mean values of 10 farmers' fields for 5 years)

Intervention	SWS at seeding* (mm)	SWS at harvest* (mm)	SWA* (mm)	Rainfall (mm)	Runoff (mm)	Irrigation applied (mm)	TWU (mm/ha)	WP (kg grain/mm)
FP	96a	141a	45a	401	61b	65b	360b	6.35a
IP	102b	195b	93b	401	29a	44a	323a	8.45b

FP- Farmers' practice, IP- Ridge furrow at 40 cm spacing, SWS- Soil water storage, SWA- Soil water addition, TWU- Total water use, WP- Water productivity, *0–120 cm soil depth. Different letter within treatments indicates a significant difference at 5%.

Table 3. Estimated impact of ridge furrow in standing pearl millet crop on area coverage, total yield and net benefits of Chambal division

Intervention	Coverage area (ha)	Total production (tonnes)		Additional production (tonnes)	Total cultivation cost (crore)		Net savings (crore ₹)	Net income (crore ₹/year)		Additional net income over FP (Crore ₹/ year)
		FP	IP		FP	IP		FP	IP	
FP	0.547	1.28			123.0			197.3		
IP	1.953	4.57	5.429	0.859	439.1	421.1	18.0	704.4	960.2	255.80

FP- Farmers' practice, IP- Ridge furrow at 40 cm spacing, total 2.75 lakh ha area of pearl millet in Chambal division of MP, technology impact based on 100 samples surveyed during 2021 in each district of Chambal division.

Water balance

The soil water addition (SWA) is essential for sustaining production, particularly in low irrigation areas of dry land. As compared with FP, the 54 mm additional SWA at harvest of pearl millet was recorded with RF- 40 cm (Table 2). Moreover, rainwater runoff was also reduced by 32 mm as compared with the value of FP (61 mm). The significantly higher TWU was recorded with FP, as compared with RF-40 cm treatment. The ridge furrow making for conservation of rainwater and more excellent water application uniformity in furrows resulted in saving irrigation water (11.5%) with RF-40 cm as compared with FP. As compared with FP, the significantly higher WP with RF-40 cm was recorded due to a higher yield with the lower amount of irrigation water application in localized furrow irrigation and higher SWS additions between seeding to harvesting. The WP under RF- 40 cm was more excellent by 33.1% as compared with FP.

Impact on technology adoption

The impact of innovative technology on area coverage, productivity, change in cultivation cost, and net income was collected through pre-tested questionnaires and interviews. The total net savings of cultivation cost with RF at 40 cm was ₹18.0 crores as compared with FP from total acreages of pearl millet grown in the division

(Table 3). The minimum production cost with RF - 40 cm was due to mechanized operation. The beneficial impact on the total adopted area, additional total production and net returns were 1.95 lakh ha, 0.859 lakh tonnes, and ₹255.8 crores with innovative RF- 40 cm techniques as compared with total acreage (2.75 lakh ha), total production and net profit of Chambal division (2.75 lakh ha) with FP.

SUMMARY

Pearl millet is also nutritionally superior and rich in micronutrients and can mitigate malnutrition and hidden hunger. The ridge furrow making in standing crop of pearl millet at 40 cm spacing by ridge furrow maker at 25 DAS gave significantly higher yield, net income, and WP. Impact of weed and rainwater conservation with ridge furrow at 40 cm spacing in standing pearl millet crop was adopted in 1.953 lakh ha area and additionally gave ₹255.8 crores, while saving ₹18 crores of pearl millet growers of the Chambal division. This technology sustainably enhanced productivity for nutritional security and , economic profitability, saving cultivation costs.

*Corresponding author's e-mail: ypsinghkvk@gmail.com