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# Growth, yield, economics and stress indicators in response to tillage practices of pearl millet (*Pennisetum glaucum* (L.) R. Br.) cultivars under rainfed conditions

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**ABSTRACT**

A field experiment was conducted at Agriculture Research station, SKRAU, Bikaner, India during two consecutive *kharif* seasons to study the effect of tillage practices on growth, yield, economics and stress indicators of pearl millet [*Pennisetum glaucum* (L.) R. Br.] cultivars under rainfed conditions. The experiment was laid out in split plot design with four tillage practices in main plots (conventional tillage, zero tillage, conventional tillage + ridging and zero tillage + ridging) and four cultivars of pearl millet in sub plots (Pusa composite 443, CZP 9802, MPMH 17 and RHB 177) and replicated four times. Results, pooled over two years, indicated that the tillage practices significantly improved the performance of pearl millet crop. Conventional tillage and zero tillage along with ridging significantly increased the relative leaf water content, proline content and membrane stability index which resulted in higher grain yield, net returns and B:C ratio. Pearl millet cultivars also showed significant variations among the observed parameters. Pusa Composite 443 recorded maximum plant height (138.2 cm) and dry matter accumulation (19.9 g/plant) and remained significantly higher in comparison to pearl millet hybrids (MPMH 17 and RHB 177). Contrary to this, pearl millet hybrids (MPMH 17 and RHB 177) recorded significantly higher grain yield, net return, B:C ratio, relative leaf water content, proline content and membrane stability index in comparison to composite cultivars. Hybrid MPMH 17 gave the highest net return of ₹ 21682 under conventional tillage + ridging treatment and remained at par where cv. MPMH 17 or RHB 177 when grown under zero tillage + ridging.

***Keywords:*** Conventional tillage, zero tillage, ridging, relative leaf water content, proline content, membrane stability index.

## INTRODUCTION

Indian agriculture virtually depends on the arrival of the monsoon and small farmers rely on rains to irrigate their fields. Today, it is getting more attention due to increasing evidence of less seasonal rainfall, terminal heat, frequent occurrence of extreme weather events coupled with scanty water resources (Singh *et al.,* 2010). Despite considerable progress in irrigation development over the five year plans, 85% of coarse cereals, 83% in pulses, 42% in rice, 70% in oilseeds and 65% in cotton are still cultivated as rainfed (CRIDA, 2011). These areas contribute 42% to the national food grain production where more than 90% of sorghum and millets as well as 75% of pulses are grown. Uncertain onset of monsoon, its uneven temporal and spatial distribution etc. in *kharif* season affects area, production and productivity of crops particularly in dry lands. Pearl millet [*Pennisetum glaucum* (L.) R. Br.] being drought tolerant crop, is the only edible cereal crop particularly in the arid tracts of western Rajasthan.

Among all cereals, pearl millet is the cheapest source of energy, protein, iron, and zinc. Its grain contains 5-6% oil and is also rich in important micronutrients such as iron and zinc. It is also used as feed for poultry and green fodder or dry *karbi* for cattle. Tillage is very ancient agriculture practice as the agriculture in the world. Besides, helping in loosening the soil, improving the aeration, creating optimum tilth for sowing particularly for small grain crops as pearl millet, it also helps in maintaining optimum moisture level in the root zone. In rainfed areas, selection of cultivars plays an important role in production because yield is directly influenced by crop variety. Development of new cultivars with short maturity period and high yield potential are helping the farmers for getting higher production even under the aberrant weather conditions. Adoption of proper tillage practices and cultivars helps in sustaining the production level against the vagaries of weather.

Therefore, the present investigation was carried out to study the performance of tillage practices and various pearl millet cultivars in rainfed area of arid tract of Rajasthan.

## MATERIALS AND METHODS

### Treatments and agronomic practices

The experiment was conducted at Agriculture Research station (28°10' N and 73°35' E), SKRAU, Bikaner, India during two consecutive *kharif* seasons. The soil of the experimental field was loamy sand in texture and alkaline in reaction and poor in organic carbon, low in available nitrogen and phosphorus but medium in available potassium. The experiment was framed in split plot design with four replications. Experiment comprising of four tillage practices in main plots [conventional tillage (CT), zero tillage (ZT), conventional tillage + ridging (CT+R) and zero tillage + ridging (ZT+R)] and four cultivars of pearl millet in sub plots (Pusa composite 443, CZP 9802, MPMH 17 and RHB 177). For conventional tillage, earmarked blocks were ploughed soon after receiving the pre monsoon showers and these were later prepared for sowing by a harrowing followed by planking at the onset of rains. Sowing was done by *kera* method. For zero tillage, the seed was sown by *kera* method without any field preparation in the blocks kept reserved for these treatments. In the earmarked blocks, ridging was done by running hand plough between two rows of crop at 30 days after sowing. In subplots, four cultivars comprising of two composites (Pusa composite 443 and CZP 9802) and two hybrids (MPMH 17 and RHB 177) were allocated. Seed treatment, sowing, fertilizer application and other operation were followed as mentioned in the package of practices recommended and adopted in the agroclimatic zone 1c (Hyper Arid Partially Irrigated Western Plain). A life saving irrigation was given to the experimental crop during both the seasons when crop faced prolonged break between two consecutive rains.

### Meteorological observations

During the crop growing period, crop received 417.4 mm of rainfall in 11 rainy days in first year and 311.5 in 13 rainy days during second year. The lowest and highest maximum temperature ($T_{max}$) of 32.2°C and 38.7°C and 31.0°C and 40.2°C were recorded during first and second year, respectively. The details of mean weekly weather parameters recorded during crop season are depicted in Figure 1.

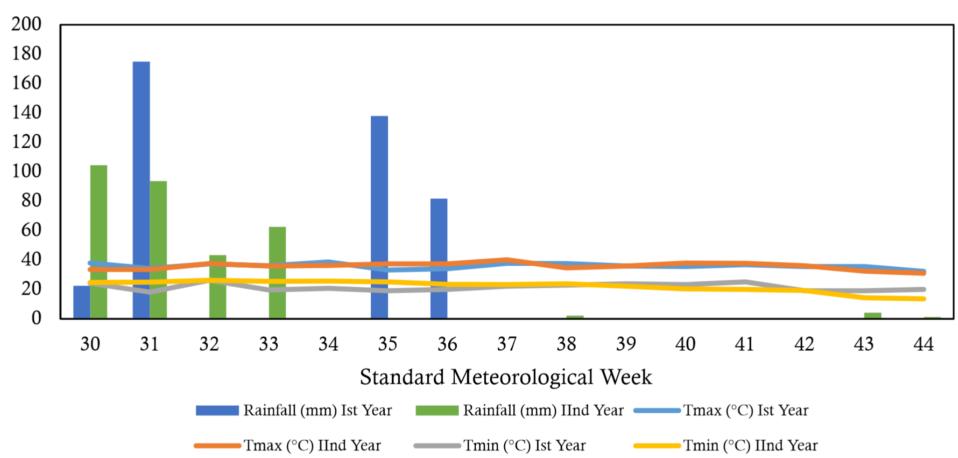


**Fig. 1.** Mean weekly meteorological data of Bikaner

### Agronomic observations and computation

Five randomly selected plants were marked to record plant height and dry matter accumulation (g plant$^{-1}$). Grain yield was recorded from net plot and after cleaning the threshed produce, converted to express in kg ha$^{-1}$. On the basis of prevailing market price of input and output, economics of different treatments was worked out in terms of net returns (ha$^{-1}$) and B: C ratio to compare the profitability of different treatments so as to arrive on an economically viable recommendation.

### Plant analysis

Stress indicators like Relative leaf water content (Turner, 1981), Proline content (Bates *et al.,* 1973) and Membrane stability index (Sairam, 1994) were estimated from the leaf sample collected randomly from each plot at flowering stage of crop by following the standard methods.

### Statistical analysis

The data obtained during the investigation was pooled, statistically analyzed and the differences among the treatment means were tested for their significance ($P<0.05$) as per the methodology described by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### Growth, yield and economics

Conventional tillage (CT) + ridging (R) treatment recorded the highest plant height (138.7 cm), dry matter accumulation (21.4 g plant$^{-1}$) and grain yield (1086 kg ha$^{-1}$), however it was at par with zero tillage (ZT) + ridging (R) except dry matter accumulation. Conventional tillage + ridging and zero tillage + ridging significantly increased the grain yield by a margin of 10.18 and 8.53 per cent over conventional tillage, respectively. Significant improvement under CT+R treatment in present investigation might be due to loosening of the soil more effectively which facilitated percolation and storage of water in the root zone and also reduce bulk density which increase the proliferation of roots for uptake of nutrient as well as moisture (Reddy and Reddy, 2010), Further, The practice of ridging in zero tillage increased the yield could be attributed to improvement in growth attributes under the influence of different tillage treatments, through increased availability of soil moisture and nutrients, which favourably influenced number of physiological processes like transpiration, photosynthesis and build up of food material. Positive effect of ridging on grain yield either in conventional tillage or in zero tillage plots should also be viewed in the light of dry spell that crop experienced during its growth period. Our findings corroborate results of Usman *et al.,* 2014, Sinha, 2015 and Pareek *et al.,* 2018. Table 1 also shows that the different tillage practices had significant influence on net return and B:C ratio. The highest net return of 19250 ha$^{-1}$ and B:C ratio of 3.03 were realized with zero tillage + ridging, which were significantly higher by 1527, 2586 &3750 and 0.58, 0.14 and 0.69, respectively over conventional tillage + ridging, zero tillage and conventional tillage. The treatment zero tillage + ridging accrued more net return and B:C ratio as compared to conventional tillage + ridging

**Table 1.** Effect of tillage practices on plant height, dry matter accumulation grain yield and economics at harvest of pearl millet cultivars (Pooled of two *kharif* seasons)

| Treatments | Plant height (cm) | Dry matter accumulation (g/plant) | Grain yield (kg/ha) | Net returns (₹/ha) | B:C ratio |
|---|---|---|---|---|---|
| CT | 128.9 | 17.9 | 985 | 15500 | 2.34 |
| ZT | 127.5 | 17.3 | 949 | 16664 | 2.89 |
| CT+R | 138.7 | 21.4 | 1086 | 17723 | 2.45 |
| ZT+R | 134.8 | 19.0 | 1069 | 19250 | 3.03 |
| S. Em.± | 2.0 | 0.6 | 24 | 368 | 0.04 |
| C.D. (p=0.05) | 5.9 | 1.7 | 71 | 1095 | 0.11 |
| PC 443 | 138.2 | 19.9 | 888 | 15374 | 2.51 |
| CZP 9802 | 134.7 | 19.3 | 904 | 15528 | 2.50 |
| MPMH-17 | 128.7 | 18.3 | 1176 | 19413 | 2.86 |
| RHB-177 | 128.3 | 18.0 | 1133 | 18822 | 2.83 |
| S. Em.± | 1.6 | 0.4 | 19 | 341 | 0.03 |
| C.D. (p=0.05) | 4.5 | 1.3 | 53 | 961 | 0.09 |

because higher cost of tillage operations is involved in field preparation in conventional tillage system, but no cost of field preparation was involved in case of zero tillage practice. These findings are in confirmation with that reported by Dixit *et al.* (2014) and Mishra *et al.* (2014).

Data (Table 1) further reveal that variety 'Pusa composite 443' was found significantly superior to both the hybrids and recorded higher values of plant height and dry matter accumulation in comparison to the MPMH 17 and RHB 177, respectively. The variation in plant height and dry matter accumulation values of different pearl millet cultivars is obviously due to their genetic makeup as a result of breeding method adopted for their development. Saifullah *et al.* (2011) also observed more plant height in composites as compared to others. Among the cultivars, hybrid cultivars gave more grain yield as compared to composite cultivars. The hybrid MPMH 17 recorded the highest grain yield of 1176 kg ha$^{-1}$ and registered significant increment of 31.21 and 27.65 per cent over Pusa composite 443 and CZP 9802, respectively. The marked increase in grain yield so obtained with hybrids might be due to difference in their genetic potentials, which led to varied assimilation of photosynthates and its translocation to sink for grain yield formation. This subscribes the view that hybrid (MPMH 17) had genetic ability to translocate dry matter more effectively to reproductive structures than that of composites. This opinion was supported by Sharma (2014). Both of the composite and hybrid cultivars did not differ significantly from each other in their respective group. As far as net return is concerned the hybrid MPMH 17 recorded the highest net return (19413) and registered significant increase of 26.3 and 25.0 per cent over Pusa composite 443 and CZP 9802, respectively (Table 2). It did not differ significantly from RHB177 in this respect. The B:C ratio was also highest with hybrid MPMH 17 and significantly superior over composites (Pusa composite 443 and CZP 9802).

Data in table 2 pertains to combined effect of tillage treatments and pearl millet cultivars on net reruns per hectare. It is clear from the data that cultivar MPMH 17 gave the highest net return of 21682 under conventional tillage + ridging treatment. This combination of treatments (i.e. cultivar MPMH 17 under conventional tillage + ridging) proved significantly superior to other treatment combinations except, where Cv. MPMH 17 and RHB 177 were grown under zero tillage + ridging.

**Stress Indicators**

Data (Table 3) indicated that different tillage practices recorded significant difference in physiological stress indicators *viz.* relative leaf water content (%), membrane stability index (%) and proline content (mg/g fresh weight). The highest values of relative leaf water content and membrane stability index of plant was observed in the plots of conventional tillage + ridging treatment though in comparison to zero tillage + ridging, the difference was significant in case of RLWC only. Relative leaf water content and membrane stability index are physiological parameter to assess the drought tolerant capacity and photosynthetic efficiency of plants. The tillage practice provides more infiltration opportunity time to rain water to percolate up to deeper layers in root zone and ridging practice further conserve more rain water and increase the relative water content and membrane stability index as compare to no tilled treatments. Higher plant water status under ridging has been reported by Ramesh and Devasenapathy (2006) in cowpea and highest membrane stability index and highest relative water content was recorded under 60 cm row spacing along with earthing by hand plough at 25 & 35 DAS in cluster bean by Pareek *et al* (2021).

Data (Table 3) further showed that the higher proline content (0.70 mg/g fresh weight) was observed under zero tillage. Proline content of plants is a reliable biomarker of the plant growing

**Table 2.** Combined effects of tillage practices and pearl millet cultivars on net returns (₹/ha)

| Treatments | CT | ZT | CT + R | ZT + R |
|---|---|---|---|---|
| PC -443 | 13020 | 15102 | 14015 | 19358 |
| CZP 9802 | 14182 | 15913 | 16185 | 15832 |
| MPMH-17 | 18251 | 16757 | 21682 | 20960 |
| RHB-177 | 16546 | 18882 | 19008 | 20850 |
| | S. Em.± | 681 | CD (p=0.05) | 1922 |

**Table 3.** Effect of tillage practices on physiological stress indicators of pearl millet cultivars (Pooled of two *kharif* seasons)

| Treatments | Relative leaf water content (%) | Membrane stability index (%) | Proline content (mg /g fresh weight) |
|---|---|---|---|
| CT | 62.00 | 45.68 | 0.67 |
| ZT | 60.27 | 44.61 | 0.70 |
| CT+R | 66.99 | 48.90 | 0.64 |
| ZT+R | 63.89 | 46.71 | 0.66 |
| S. Em.± | 0.95 | 1.13 | 0.02 |
| C.D. (p=0.05) | 3.05 | 3.63 | 0.05 |
| PC 443 | 62.56 | 45.94 | 0.65 |
| CZP 9802 | 61.99 | 45.84 | 0.64 |
| MPMH 17 | 64.11 | 47.59 | 0.70 |
| RHB 177 | 64.50 | 46.52 | 0.68 |
| S. Em.± | 0.89 | 0.60 | 0.01 |
| C.D. (p=0.05) | NS | 1.72 | 0.03 |

environment. It accumulates in the leaves whenever the plants are exposed to any kind of stress. Soil moisture conservation practice (as in the present study), have an impact on the soil moisture stress there by influencing the crop physiological behaviour. Under stress condition, the amino acid metabolism is largely altered, protein synthesis impaired and proteolysis increased. As a consequence, proline synthesis might be promoted due to increased concentrations of related metabolites such as polyamines, ammonia, arginine, ornithine, glutamine and glutamate. The increase in the concentrations of metabolites involved in the production of proline precursors might be the main cause for proline accumulation in plant tissues exposed to environmental stress (Silveira *et al.,* 2001). The lowest proline content recorded in the plots of conventional tillage + ridging in present study also confirms these findings. Similarly, results of Zhao *et al.,* 2012 and Kumar *et al.,* 2015 also corroborate the present findings.

Membrane stability index and proline content were significantly higher in case of hybrids than composite varieties. Relative leaf water content (Table 3) was not influenced significantly by different cultivars but hybrids had more values as compare to composite cultivars. From the data mentioned in Table 3, it is ascertained that hybrids are more drought tolerant varieties of pearl millet. Vijayalakshmi *et al.* (2012) worked on pearl millet and stated that the hybrid maintains higher relative water content and membrane stability index suggesting its better ability to avoid tissue dehydration than the parents. Proline content had positive correlation with the grain yield of pearl millet cultivars, the proline content increases with increase in the grain yield. Pareek *et al.* (2018) observed higher field water use efficiency in pearl millet hybrid cultivars than composite cultivars under rainfed conditions.

## CONCLUSION

From this study, it can be concluded that MPMH 17 in combination with conventional tillage + ridging resulted in higher grain yield, and net returns over other treatment combinations. Hybrid MPMH 17 gave the highest net return of 21682 under conventional tillage + ridging treatment and remained at par where cv. RHB 177 or MPMH 17 was grown under zero tillage + ridging.

## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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