Effect of Tillage and Nutrient Management on Yield of Pearl Millet and Soil Health in Semi Arid Tropics

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ABSTRACT

A field experiment was conducted to study the impact of tillage and nutrient management practices on yield of pearl millet and soil health at Research Farm, Raja Balwant Singh College, Bichpuri, Agra (U.P.), India during the rainy season (kharif). Pearl millet yield varied significantly due to tillage practices and nutrient management practices during both the years. The highest average grain yield (2124 kg ha⁻¹) was obtained with deep tillage + two interculture and lowest (1601 kg ha⁻¹) with minimum tillage + one interculture. Seasonal water use was highest with minimum tillage + one interculture in both the years. Water-use efficiency was also highest with deep tillage + two interculture. Deep tillage (with one disc ploughing) was superior to minimum tillage treatments (without disc ploughing) in improving of physical conditions of soil along with chemical parameters. Nutrient management practices showed beneficial effect on yield. The highest grain yield (1994 kg ha⁻¹) was obtained with application of 100% nitrogen through inorganic source, followed by application 50% nitrogen through organic source + 50% nitrogen through inorganic source (1780 kg ha⁻¹). Application 100% nitrogen through inorganic source caused considerable increase in water use. Application of nitrogen through different sources did not influenced the water use efficiency during both the seasons. However, water use efficiency of grain and stover under application 100% nitrogen through inorganic source was higher. Source of nitrogen had not much more effects on physical parameters of soil.

Key words:
pearl millet, tillage practice, nutrient management

INTRODUCTION

Pearl millet (Pennisetum glaucum L.) is the fifth most important cereal crop, and the most important millet, accounting for more than 55% of global millet production. It is grown in over 40 countries, predominantly in Africa and Asia, as a staple food grain and source of feed, fodder, fuel and construction material in the hottest, driest, semi-arid and arid regions where rainfed agriculture is practiced. The crop is most important to national food security in Namibia and Niger; the major producing countries are Senegal, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, and India. Pearl millet is also grown in Oceania and the Americas, predominantly as a forage and/or mulch component of minimum tillage-based cropping systems. It is usually grown in the soil with depleted fertility, which receives annual rain fall of 150 mm -750 mm. Pearl millet is a short day C3 plant adapted to hot climate and is more resistance to drought than sorghum. No other cereals grown, so well in hot dry region. It yields reasonably well in poor sandy soil on which most crops fail. It provides staple food for the poor in a short period in the relatively dry tracks of the country. It is the most drought tolerant crop among cereals and millets. The grain of pearl millet is superior in nutritive value than sorghum grain, but inferior in feeding value. Pearl millet grain contains about 12.4% moisture, 12.6% protein, 5.0% fat, 67.3% carbohydrates and about 2.7%. Pearl millet grains are eaten cooked like rice or “chapaties” are prepared out of flour like maize or sorghum flour. Proper tillage operation coupled with organic manure has positive impact on dry land crops. There has been no sustainable rise in productivity of rainfed pearl millet mainly because of soil-moisture deficiency, usually at critical stages of growth. The soils of the pearl millet growing regions being mostly light in texture embody low moisture holding capacity. Efforts have been made to augment the soil-moisture retentivity by adopting various tillage practices and addition of organic matter. Use of organic sources along with chemical fertilizers not only conserves moisture and reduces erosion but also increases the use efficiency of fertilizers, thereby improving the overall productivity of soil (Patil and Sheelavant, 2001). Kumar et al (1984) reported that application of farm manure in sandy soils resulted in progressive increase in the volume of water retained at a given suction, together with a small increase in available water and decrease in hydraulic conductivity and infiltration rate. However, the water so retained in the root zone has very little significance unless conserved properly. Singh et al (1997) and Nema et al (2008) reported beneficial effect of various tillage practices on the moisture conservation and crop yields under dryland condition. Hence an experiment was conducted to determine an effective practice of tillage and nutrient management to increase the productivity and water-use efficiency of pearl millet and to improve soil health.
MATERIALS AND METHOD

The experiment was carried out at Research Farm of All India Coordinated Research Project for Dryland Agriculture, Raja Balwant Singh College, Bichpuri, Agra during the two consecutive kharif seasons of 2005 and 2006. The soil of the experimental plot was sandy loam having pH 7.9, organic carbon 0.30%, available nitrogen, phosphorus and potash 191.50, 21.50 and 304.56 kg/ha respectively. Moisture content at field capacity and permanent wilting point was 17.75 and 6.60 percent respectively. The experiment was laid out in split plot design replicated four times. The main plot treatments were consisted of four tillage practices viz. (i) deep tillage (CT) + two interculture; T<sub>1</sub> (ii) minimum tillage (50% of CT) + one interculture; T<sub>2</sub> (iii) minimum tillage (50% of CT) + two interculture; T<sub>3</sub> and (iv) minimum tillage (50% of CT) + one interculture + weedicide application; T<sub>4</sub>. Sub-plot treatments were comprised of three sources of nitrogen supply viz. (i) application 100% nitrogen through organic source; N<sub>1</sub> (ii) application 50% nitrogen through organic source + 50% nitrogen through inorganic source; N<sub>2</sub> and (iii) application of 100% nitrogen through inorganic source; N<sub>3</sub>. The details of layout and allocation of the treatments are given in Fig.1.

For the purpose of study, deep tillage operation was performed by one ploughing the field with disc plough followed by one ploughing with disc harrow + one ploughing with cultivator to develop seed bed for sowing. Low-tillage (minimum tillage) operation was done by one ploughing the field with disc harrow + one ploughing with cultivator. Interculture operation was done manually as per treatment. The pearl millet variety “Pro Agro-9330” was sown on 3<sup>rd</sup> August, in 2005 and 15<sup>th</sup> July in 2006, respectively at a spacing of 45cm x 15 cm. Uniform dose of 40 kg P<sub>2</sub>O<sub>5</sub> was applied at sowing. As per treatment requirement full quantity of farmyard manure and half of the N were applied as basal and the remaining half was broadcasted in two equal split doses. During kharif (July - September) of 2005 a total 628.2 mm rains were received, while it was 330 mm rains during 2006. During first season (2005) well distributed rains were received but in the second season (2006), there was early withdrawal of monsoon and highly erratic and below the normal. Relative humidity was higher during both the seasons and ambient temperature as well as atmospheric evaporation was higher during second season as compared to first season (Fig 2 and Fig 3). In general, weather conditions were more favourable for growth and development of crop during 2005 which have been reflected very clearly on growth and yield of crop.

Soil moisture content up to depth of 90 cm was determined with gravimetric method with soil layers of 0-
Soil moisture measurements were taken prior to sowing and thereafter 20 DAS interval throughout the growing season. After drying, the moisture percentage was expressed on dry weight basis and the data so obtained were utilized for the determination of consumptive use of water and water use efficiency.
RESULTS AND DISCUSSION

Grain and Stover Yield

Effect of tillage

The grain and stover yield of pearl millet (Table 1) was influenced by tillage practices. The maximum grain and stover yield was obtained under deep tillage treatment whereas the minimum was under minimum tillage. The deep tillage gave 33.29 and 31.93 percent increase in yield during 2005 and 2006 respectively over minimum tillage with one interculture. Due to the deep tillage performed by deep ploughing with disc plough, root of the plants penetrated to deeper layer and this resulted in greater moisture extraction from deeper layers and ultimately increased the yield of crops. Similar trend was also noticed in respect of stover yield. The similar results were observed by Singh and Verma (2002) and reported that deep tillage improved the efficiency of moisture extraction from deeper soil profiles and making it available to the plant roots thereby increasing the availability to the plant which resulted in higher crop yield.

Effect of nutrient management

Grain and stover yield during both the seasons as influenced by varying nitrogen application from different sources also presented in Table 1 reveals that the grain yield of pearl millet was 1791, 1839 and 1959 (kg ha\(^{-1}\)) in 2005 and 1644, 1721 and 1850 (kg ha\(^{-1}\)) in 2006 under application of 100% nitrogen through organic source, 50% of nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through inorganic source respectively. This shows that application of 100% N through inorganic source resulted in higher yield in both the seasons. Stover yield was also higher in application of 100% N through inorganic source. The variation in yield is attributed to improved growth and ear characters increased availability and absorption of nitrogen from soil which enhanced metabolic activities, translocation and synthesis of nutrients resulted in higher grain yield. The beneficial effect of nitrogen application through various sources on grain yield of pearl millet have also, been reported Meena et al. (2003) and Hadda et al. (2005).

Water Use and Water Use Efficiency

Effect of tillage

It is evident from the data (Table 1) that during both the seasons of investigation, minimum tillage recorded maximum consumptive use of water whereas the minimum was observed under deep tillage with deep ploughing. Because deep tillage checked weed growth and reduced moisture losses from soil surface. During early stages of crop growth, the rate of water use was very low in both the years. It may be due to incomplete coverage by the crop plants resulting in lesser transpiration losses. With advance in age and crop growth, the rate of water use progressively increased and it was more during 40 – 60 DAS. Thereafter, the rate of water use decreased during both the years Significant difference in consumptive water use between deep tillage and minimum tillage plots can be reasonably attributed to suppression of weeds (weed control) during early period of crop growth, by deep tilling of the soil (Dogra et al., 2002). Water use efficiency (Table 1) was in reverse order to that of consumptive use. Maximum water use efficiency was observed in deep tillage which may be attributed to the greater yield advantage through deep tillage. These results were in close agreement with the findings of Singh and Verma (2002) and Sinha et al. (2006).

Effect of nutrient management

Application of 100% nitrogen through inorganic source showed higher consumptive use than all other nitrogen source treatments. This can be attributed to the better root development and crop growth with application of nitrogen through inorganic source. Application of 100% nitrogen through organic source recorded minimum consumptive use at all the growth stages during both the seasons. Values of consumptive use increased with application of 100% nitrogen through inorganic source. The water use efficiency was higher under application of 100% nitrogen through inorganic source and lowest under application of 100% nitrogen through organic source. Similar results for grain, stover and total produce were obtained except for grain in 2005 during both the seasons. This may be attributed to increased dry matter production due to the better nutrients uptake and enhanced growth of the crop. These results are conformity with the findings of Patel et al (2001) and Hadda et al (2005).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain (kg ha(^{-1}))</th>
<th>Stover (kg ha(^{-1}))</th>
<th>Water use (mm)</th>
<th>Water use efficiency (kg ha(^{-1}) mm(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y(_1)</td>
<td>Y(_2)</td>
<td>P</td>
<td>Y(_1)</td>
</tr>
<tr>
<td>T(_1)</td>
<td>2202</td>
<td>2045</td>
<td>2124</td>
<td>5306</td>
</tr>
<tr>
<td>T(_2)</td>
<td>1652</td>
<td>1550</td>
<td>1601</td>
<td>4181</td>
</tr>
<tr>
<td>T(_3)</td>
<td>1777</td>
<td>1685</td>
<td>1731</td>
<td>4408</td>
</tr>
</tbody>
</table>

Table 1: Grain yield, stover yield, water use and water use efficiency as influenced by different tillage practices and source of nutrient
Nutrient management

Sub treatment (Nutrient management: N)

CD (0.05)

| N₁ | 1791 | 1644 | 1639 | 4291 | 3898 | 4095 | 283.9 | 273.4 | 6.30 | 6.01 | 15.1 | 14.2 |
| N₂ | 1839 | 1721 | 1780 | 4522 | 4269 | 4396 | 302.3 | 291.2 | 6.0 | 5.9 | 14.5 | 14.7 |
| N₃ | 1959 | 1850 | 1994 | 4980 | 4747 | 4864 | 322.4 | 302.5 | 6.38 | 6.11 | 15.4 | 15.6 |
| CD (0.05) | 132.20 | 127.46 | 145.70 | 304.60 | 281.40 | 342.40 | 3.86 | 3.47 | 0.49 | 0.43 | 1.40 | 1.31 |

Field capacity was high under deep tillage (Table 2) as compared to minimum tillage treatment. There was not much difference in wilting point due to different tillage treatments. However, the wilting point was in higher order under deep tillage treatment as compared to minimum tillage in all the soil layers. This is attributed to the favourable tilled surface conditions for rapid movement of moisture to the deeper layers. The increased field capacity in deep tillage is also attributed to improved porosity. Similar trend has also been reported by Singh and Verma (2002) that deep ploughing seems to be an essential practice in rainfed soils for improvement of structure better field capacity and increased availability of nutrient for obtaining higher grain yield. Lower field capacity observed under minimum tillage practices was due to presence of hard plough pan compact layer in the soil which could not be touched with this type of tillage.

Chemical properties

It is evident from the data (Table 2) that the different tillage treatments though did not influence the pH, electrical conductivity and available K status but have altered organic carbon and available nitrogen. The organic carbon and available nitrogen were not influenced much by tillage treatments. However, a little increase in both organic carbon and available nitrogen was observed under

<table>
<thead>
<tr>
<th>Treatment</th>
<th>F.C. (%)</th>
<th>W.P. (%)</th>
<th>B.D (g cm⁻³)</th>
<th>C %</th>
<th>EC (mmhos cm⁻¹)</th>
<th>pH</th>
<th>Available nutrient (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original value</td>
<td>17.75</td>
<td>6.60</td>
<td>1.45</td>
<td>0.30</td>
<td>1.42</td>
<td>7.90</td>
<td>191.5</td>
</tr>
<tr>
<td>Main treatment (Tillage: T)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₁</td>
<td>17.89</td>
<td>6.64</td>
<td>1.40</td>
<td>0.34</td>
<td>1.43</td>
<td>7.91</td>
<td>194.4</td>
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<tr>
<td>T₂</td>
<td>17.80</td>
<td>6.61</td>
<td>1.43</td>
<td>0.31</td>
<td>1.42</td>
<td>7.91</td>
<td>192.2</td>
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<tr>
<td>T₃</td>
<td>17.81</td>
<td>6.61</td>
<td>1.42</td>
<td>0.31</td>
<td>1.42</td>
<td>7.91</td>
<td>192.1</td>
</tr>
<tr>
<td>T₄</td>
<td>17.80</td>
<td>6.61</td>
<td>1.43</td>
<td>0.31</td>
<td>1.42</td>
<td>7.91</td>
<td>191.9</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>0.05</td>
<td>NS</td>
<td>0.02</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Sub treatment (Nutrient management: N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N₁</td>
<td>17.88</td>
<td>6.62</td>
<td>1.42</td>
<td>0.34</td>
<td>1.42</td>
<td>7.91</td>
<td>195.8</td>
</tr>
<tr>
<td>N₂</td>
<td>17.84</td>
<td>6.61</td>
<td>1.43</td>
<td>0.32</td>
<td>1.42</td>
<td>7.91</td>
<td>194.9</td>
</tr>
<tr>
<td>N₃</td>
<td>17.74</td>
<td>6.59</td>
<td>1.46</td>
<td>0.32</td>
<td>1.43</td>
<td>7.92</td>
<td>194.3</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>0.03</td>
<td>NS</td>
<td>0.01</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
deep tillage as compared to minimum tillage treatments. This may be attributed to the decomposition of higher quantity of dry matter added in the soil through increased root biomass and dried leaves under these treatments. It was also observed that the available phosphorous was also not much influenced by tillage treatments. However the soil available phosphorous was higher from the plot receiving disc ploughing treatment (deep tillage treatment). An improvement in the level of available phosphorous in soil under deep ploughing has also been reported by Sharma et al (2003).

Effect of nutrient management

Physical properties
It is clear from the Table 2 that source of nitrogen had not much more effects on physical parameters of soil. However decreasing in bulk density was observed due to application of 100 % nitrogen through organic source when compared to application of 100% nitrogen through inorganic source and 50% of nitrogen through organic source + 50% nitrogen through inorganic source.

Further application of 100 % nitrogen through organic source (FYM) improved the field capacity of soil over application of 50% of nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through inorganic source. Application of 100% nitrogen through inorganic source did not affect this physical parameter. Laddha and Totawat (1998) has found similar results.

Chemical properties
Application of nitrogen through different source affected slightly to the chemical properties of soil. Application of 100 % nitrogen through organic source (FYM) has slightly improved the organic carbon and available phosphorous and available potash of status of soil. The favourable effect of application of nitrogen through organic source is an outcome of increased proliferation of roots and microbial activity, which in turn have released the organic acids lowering down the pH of the soil and releasing the native phosphorous and potash from the soil, apart from reduction in fixation of applied phosphorous. Similar results have been incorporated by Patil et al. (2001), Anonymous (2001-02 & 2005-06).

CONCLUSION

Based on this study it can be concluded that deep tillage (deep ploughing by disc plough) with one interculture, was very effective in conserving profile moisture throughout season of crop and increased yield attributes and grain yield of pearl millet and gave 32.66, 22.70 and 21.72 per cent higher grain yield than minimum tillage treatments. Deep tillage (with one disc ploughing) were superior to minimum tillage treatments (without disc ploughing) in improving of physical conditions of soil along with chemical parameters and greater profile water storage, which in turn resulted in deeper root system for efficient use of water from lower soil depth during dry spell and better supply of nutrients to crop. Appreciable higher grain yield of pearl millet with application of 100% nitrogen through inorganic source was because of fertilizer increased water use by improving root development and better crop growth, which ultimately led to higher grain yield. Source of nitrogen had not much more effects on physical parameters of soil, it requires more time.

REFERENCES


