EFFECT OF VERTICAL MULCH ON MOISTURE CONSERVATION AND YIELD OF SORGHUM IN VERTISOLS

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ABSTRACT


The intake rate of the local Vertisol is very low (0.08 cm/h). Vertical mulch was used from 1971 to 1976 in order to improve infiltration. Higher moisture contents were recorded near the mulch. The favourable effects of mulch extended to 1.5 m on either side of the mulch row. Vertical mulching exerted a greater influence on crop yields under dry conditions than in normal and above normal seasons. Compared with low yields in control plots (grain: 0.2 q/ha (20 kg/ha); straw: 9.5 q/ha (950 kg/ha)) mulches spaced at 2, 4 and 8 m produced 3.9 q/ha of grain and 19.0 q/ha of straw under the extremely dry conditions of 1972–1973. However, the increase in grain and straw yields under wet conditions in 1973–1974 was only 47.2 and 15.0%, respectively. Averaged over dry and wet years, vertical mulching resulted in 45.1 and 37.9% higher grain and straw yields. The favourable effects of vertical mulching were found to last for 4 years. Considering dry and wet years, a spacing of 4 m was found to be ideal. Placing sorghum stubble as a vertical mulch to the top of the salt zone (30 cm) was found to be as good as placing it to a depth of 90 cm.

INTRODUCTION

Moisture is the main limiting factor for successful crop production in rainfed agriculture with inadequate rainfall and/or poor distribution. The problem becomes much more severe when the soils are also problematic. The primary aim for improving production is to increase the proportion of the rainfall available for crop production. The Vertisols of the Deccan tract are heavy, with a tendency to become sodic (E.S.P. 8–30), and are characterized by low infiltration rates (0.08 cm/h). Various moisture conservation practices turned out to be ineffective as there was no increase in the water intake per se (Rama Mohan Rao and Seshachalam, 1976). There is a considerable run-off accounting for 25–40% of the rainfall during the crop growth period. This run-off is accentuated by the presence of long gentle slopes. Therefore studies were initiated to find out the effect of vertical mulching
at different depths and spacings on moisture conservation and crop performance. The results are presented in this paper.

EXPERIMENTAL

The experiments were conducted at the Soil Conservation Research Centre, Bellary, India, during the period 1971–1976. The soils where the experiments were conducted are Vertisols with a depth of 1 m, and a slope of 0.5 to 1.5%. Some physical and chemical characteristics of the soils are presented in Table I. Sub-soil salinity is common in these areas and the depth at which it occurs varies from 15 to 45 cm.

Trenches of 15 cm width were made at specified intervals and depths as outlined below, across the slope for different trials. Sorghum stubble was packed in the trenches during the summer in such a way as to protrude 10 cm above the surface. In all trials independent drainage was provided through channels all around the plots (Fig.1).

A preliminary trial with two 30 x 10 m plots was made with trenches at 5 and 10 m intervals to 50 cm depth with an adjacent control plot of similar size. The trial was initiated in 1971–1972 and was continued until 1973–1974 (Fig.1a).

A regular trial was laid out in 1972–1973 and was continued till 1975–1976 with vertical mulches of 40 cm depth spaced at intervals of 2, 4 and 8 m with three replications. Sorghum stubble inserted into cracks was also included (Fig.1b).

Vertical mulches at 4 m intervals and extending down to the salt zone (30 cm), to the middle of the salt zone (60 cm) and to the bottom of salt zone (90 cm) were laid out in addition to mulches with 50 cm depth in the year 1973–1974 (Fig.1c).

The net plot sizes for regular spacing and depth studies were 16 x 8 m and 20 x 8 m respectively. The sorghum variety M 35-1 was used in the observational trial while an improved variety, CSV-7R was used in the other trials. The spacing was adjusted to 45 cm between rows with 17.5 cm between plants. Fertilizers were drilled by the side of seed rows at sowing at the rate of 40 kg N and 40 kg P₂O₅/ha. Soil samples for moisture observations were collected at specified distances from the mulch rows at 15 cm intervals down to a depth of 90 cm twice during crop growth. Individual rows were harvested for recording yields and pooled plot-wise for the presentation of the data.

RESULTS AND DISCUSSION

Moisture conditions

The year 1971–1972 was relatively dry (356.3 mm) due to insufficient rainfall during pre-sowing and poor distribution in the post-sowing period. Crops totally failed in the region during 1972–1973 due to extreme drought
<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH (1:2.5 soil:water ratio)</th>
<th>Electrical conductivity (mmho/cm) (1:5 soil:water ratio)</th>
<th>Available nutrients (kg/ha)</th>
<th>Organic carbon (%)</th>
<th>Mechanical separates (%)</th>
<th>Moisture retention (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–15</td>
<td>9.0</td>
<td>0.25</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–30</td>
<td>9.1</td>
<td>0.25</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30–45</td>
<td>9.1</td>
<td>0.10</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45–60</td>
<td>9.2</td>
<td>0.30</td>
<td>0.39</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>60–75</td>
<td>9.0</td>
<td>0.40</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75–90</td>
<td>8.3</td>
<td>0.65</td>
<td>0.52</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.R. = Not recorded.
conditions primarily caused by ill-distributed rainfall (Fig. 2). The period from 1973 to 1976 was unusually wet, with annual rainfall varying from 637.2 mm in 1974—1975 to 730.0 mm in 1975—1976.

Fig. 1. Field plan of different trials.

Fig. 2. Distribution of rainfall at Bellary (1971—1976).
The available moisture in the preliminary trial near the mulch row was higher and decreased with distance from the mulch row during 1972–1973 (Fig. 3a). The moisture content at a distance of 50 cm from the mulch row was 2.3 cm at 18 days after seeding and 2.8 cm at 42 days after seeding as against corresponding values of 1.0 and 0.2 cm in the control for the 1971–1972 season. The available moisture in 10 m spacing closely approached that of the control beyond 1.5 m on either side of the mulches. Although with vertical mulching higher moisture values were recorded near mulch rows in wet years, the differences between mulches and control were smaller than in dry years (Fig. 3b).

Moisture distribution in the replicated spacing trial showed a parabolic trend, particularly in dry seasons, as observed earlier at both the sampling dates (Fig. 4). On the whole higher moisture values were recorded with vertical mulches during 1972–1973 to the extent of 8.5 cm and 4.1 cm near mulches at 13 days and 43 days after seeding, respectively, while the corresponding moisture levels in the control plots were hardly 1.0 to 2.0 cm. Filling cracks in the soil with sorghum stubble did not result in any improvement in the moisture storage over that of the control. In plots with 8 m spacing, moisture

![Fig. 3. Moisture levels and yields as affected by distance from vertical mulch row in preliminary trial.](image-url)
values approached control values beyond 2 m on either side of the mulches while in plots with 2 and 4 m spacing available moisture was always higher than in the control at all the points in between mulches.

Under normal and above normal conditions of 1973–1976, the moisture distribution at the cessation of the rains was similar irrespective of spacing. Hence the data pertaining only to 1973–1974 are given for comparison (Fig.4). Moisture sampling near mulches 4 days after seeding revealed the presence of 5–7 cm of moisture in 2 and 4 m plots while on the control plot only 3.1 cm was recorded. On the 8 m plot higher values were recorded near mulch rows and low values at a distance of 3.0–4.0 m from mulch. However, these differences between mulches and control disappeared by the second sampling i.e., 48 days after seeding, because the post-sowing rainfall was favourable with good distribution.
Moisture storage in the profile was not affected by placing the vertical mulches to different depths (Table II). Although higher values were recorded with mulches (2–4 cm), on the whole, the differences among depths of mulching were marginal in all seasons.

TABLE II

Moisture content (cm) at 45 days as affected by depth of mulching (1974–1975)

<table>
<thead>
<tr>
<th>Mulch depth</th>
<th>Distance from vertical mulch (cm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>150</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>*Control</td>
<td>4.4</td>
<td>5.6</td>
<td>6.0</td>
<td>N.R.</td>
</tr>
<tr>
<td>30</td>
<td>8.9</td>
<td>7.1</td>
<td>7.1</td>
<td>7.8</td>
</tr>
<tr>
<td>50</td>
<td>10.2</td>
<td>9.1</td>
<td>7.0</td>
<td>8.4</td>
</tr>
<tr>
<td>60</td>
<td>8.9</td>
<td>7.1</td>
<td>7.4</td>
<td>9.4</td>
</tr>
<tr>
<td>90</td>
<td>9.3</td>
<td>8.2</td>
<td>8.1</td>
<td>9.4</td>
</tr>
</tbody>
</table>

*Control values at different points along the slope.
N.R. = Not recorded.

Grain and straw yields

During 1971–1972, there was a steep fall in the grain yields in the observational trial beyond 1.2 m from the mulch row (Fig.3). Straw yields, on the other hand, varied only slightly as the distance from the mulch row increased. The grain yields in 1972–1973 were practically nil beyond 1.2 m. Straw yields also declined considerably beyond this distance.

The plot-wise yields are presented in Fig.5. As can be seen from the figure,
447.5, 177.0 and 44.0% increases in grain yields were recorded on 5 m spaced mulch plots as against corresponding increases of 147.5, 74.5 and 33.0% for 10 m plots under extreme drought, below normal and normal years, respectively. Straw yields were 13.2 times higher than that of the control in 1972–1973, while under the wet conditions of 1973–1974 the differences were marginal. There were increases of 75.2 and 42.6% in grain yields and 143.5 and 176.9% in straw yields with 5 and 10 m mulches, respectively, across the years.

No statistical analysis could be applied to the data from the replicated spacing trial for the 1972–1973 season as some of the plots were damaged by birds. As against near crop failure in the control plot, 4 and 8 m plots gave 4.1 and 2.4 q/ha of grain yields (410 and 240 kg/ha; 1 q = 100 kg) (Table III).

TABLE III
Sorghum yields (q/ha) as affected by spacing of mulches (regular trial)

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Straw</td>
<td>Grain</td>
<td>Straw</td>
<td>Grain</td>
</tr>
<tr>
<td>2 m</td>
<td>5.23</td>
<td>21.90</td>
<td>16.41</td>
<td>30.33</td>
<td>14.95</td>
</tr>
<tr>
<td>4 m</td>
<td>4.12</td>
<td>20.18</td>
<td>16.92</td>
<td>32.51</td>
<td>17.75</td>
</tr>
<tr>
<td>8 m</td>
<td>2.36</td>
<td>14.81</td>
<td>16.14</td>
<td>28.59</td>
<td>17.70</td>
</tr>
<tr>
<td>Control</td>
<td>0.17</td>
<td>9.49</td>
<td>11.20</td>
<td>26.50</td>
<td>11.23</td>
</tr>
<tr>
<td>C.D. (0.05)</td>
<td>4.59</td>
<td>3.90</td>
<td>N.S.</td>
<td>9.92</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

N.S. = Not significant.

Similarly, straw yields were 2.1 and 1.6 times higher than that of the control for the above two mulch spacings. Different mulch spacings did not differ significantly. However, on the whole, with mulches increases of 4.3–49.6% in grain yields and 15.0–55.3% in straw yields over the control were recorded under wet conditions of 1975–1976. Grain yields during 1975–1976 were low due to problems of excess moisture and earhead pests. The mean percent increases for grain and straw yields over all the years were found to be 40.1 and 37.3 for 2 m; 51.5 and 40.8 for 4 m; 41.8 and 35.7 for 8 m and 11.0 and 13.0 for cracks filled with straw, over the control, respectively.

The grain and straw yields as affected by mulches placed at different depths are presented in Fig.6. The yields for 50 cm depth were not furnished as the yield levels were identical to 60 cm depth. The differences between various depths were very marginal, indicating that mulching the top of the salt zone is adequate. This practice also reduces the requirement of straw.

Thus it is clear that vertical mulching increases the effective rainfall and thereby improves crop production considerably, particularly in dry years. Fairbourn and Gardner (1972) also reported increased soil water storage as
Fig. 6. Effect of depth of vertical mulching in relation to sub soil salinity on sorghum yields.

the major factor responsible for higher yields in sorghum. Evaporation losses were also reported to be less in vertical mulched plots (Fairbourn and Gardner, 1974; Gardner, 1974). The present studies also indicated that the beneficial effects of vertical mulch may last for 4 years or more. The trenches were found to be stable in conducting surface run-off into the sub-soil in spite of the partial decomposition of the straw after the second year. Parr (1959) attributed such lasting effects to improvement in soil structure.

Although mulches gave grain yields of 2–5 q/ha as against 0.20 q/ha in the control under dry conditions (Table III) the beneficial effects of mulches were reduced to about 45.1% for grain and 37.9% for straw when averaged over seasons and spacings due to three wet seasons out of 4 years. Analysis of 100 years rainfall data for the occurrence of drought revealed that 5 out of every 10 years are dry to very dry years (Anonymous, 1972). Hence, the beneficial effects of vertical mulches would be much more than reported above.

Closer spacings gave higher yields than did wider intervals under dry conditions. Apart from economic considerations, 2 m spacing also resulted in problems of excess moisture as one to two rows on either side of the mulch suffered in wet seasons, which did not happen on the 4 and 8 m plots. Thus the results suggest a spacing of 4 m to be ideal for conserving more moisture in dry years and avoiding problems of excess moisture in wet years and hence achieving greater stability in crop production.

The requirement of sorghum stubble for 4 m spacing and a depth of 30–40 cm is 9–12 t/ha. Although fodder is an acute problem in the semi-arid tropics, cattle generally do not relish the lower 1/3 portion of the stubble which could be effectively diverted for mulching in a phased manner to overcome the scarcity of sorghum straw.

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