Effect of Seedbed Preparation, Sowing Method and Nitrogen Fertilizer Level on Sorghum Grain Yield in Rainfed Areas, Gedarif, Sudan

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Abstract

Sorghum yield in mechanized rainfed areas of Eastern Sudan is low; however, there are opportunities for yield improvement through managing cultural practices. A field experiment was conducted for two consecutive rainy seasons, 2003 and 2004, in the mechanized rainfed area northern Gedarif State, Sudan. The objective was to assess the effects of seedbed preparation, seeding method and Nitrogen fertilizer level on sorghum grain yield. The seedbed preparation methods were; untilled seedbed (T0) and tilled seedbed (T1) by the conventional machine wide level disk (WLD) plow. The seeding methods were, broadcasting by the WLD (M1) and row crop planter (M2). The Nitrogen fertilizer levels were 0 (N0), 47.6 (N1) and 95.2 (N2) kg urea/ha. Split-split plot design with four replicates was used with seedbed preparation as the main plot, seeding methods as sub-plot and Nitrogen level as sub-sub plot. Sowing was done in the second and the third week of July for the first and the second season, respectively. The fertilizer was applied one month after crop emergence. The untilled seedbed significantly (P = 0.001) out yielded the tilled seedbed by 58%. Seeding by the row crop planter increased grain yield by 15% over WLD seeding method. The addition of 95.2 kg urea/ha significantly (P = 0.001) out yielded the 0 kg urea/ha by 49%. The effect of fertilizer was more noticeable in the good rainy season (2003). The highest yield was obtained by the combination of T0M2N2 (1912.8 kg/ha) and T0M2N0 (1025.5 kg/ha) for the two seasons, respectively. Higher sorghum grain yield in the mechanized rainfed areas northern Gedarif State can be achieved by using untilled seedbed, row crop planter and applying 95.2 kg urea/ha.

Keywords: rainfed sorghum yield, seedbed, seeding, fertilization, Sudan

Introduction

Sorghum (Sorghum bicolor) is the staple food in the Sudan and several African countries. In the Sudan it is grown in the central clay plans under irrigation and rain conditions. Gedarif State is the main producer of sorghum and has an annual coverage of about 6 millions feddan (one feddan = 0.42 ha). Usually farmers start to cultivate their fields in July with about 100 to 125 mm of rainfall. They use the conventional machine, the wide level disk (WLD) plow with seeder box, for seedbed preparation and seeding operations. Neither a definite rotation is followed nor fertilizers applied. The resultant is low average sorghum grain yield (100 kg/ha) (MFC, 2009) compared to the yield at research sites. There is, however, an opportunity to increase sorghum grain yield through improvement of its management practices such as seedbed preparation method, good seeding machines and optimum nitrogen fertilization.

Tillage system that can be used under non-optimal as well as ideal conditions, considering the timeliness of seeding operation and water conservation, is essential for maximizing crop yields under rainfed conditions (Willock, 1980). An earlier study by Willock (1984) showed that shallow seedbed preparation by the WLD is adequate for the Vertisols of the Sudan. The main advantages of this implement are: its ability to till the soil; kill weeds and seed in a single operation pass and its flexibility to work under varying soil moisture and trash conditions; in addition to its acceptable work rate. On the other hand, no-tillage system consists of one pass of planting and chemical application (fertilizers and herbicides) in which the soil and the surface residues are minimally disturbed (Parr et al., 1990). This system saves fuel and time (Cakir et al., 2003) and also improves soil moisture content through initiating soil cracks (Saeed and Eissa, 2002). Besides, it
reduces operation costs compared to the other tillage methods (Saeed and Eissa, 2007). Currently, there is limited knowledge about the effect of zero-tillage on sorghum yield.

Seeding operation on the other hand, is an important agricultural practice since it affects seeding pattern, crop establishment and hence the final yield. The WLD, as a seeding machine, lacks accuracy of seeding depth, even seed distribution and compacts soil around the seed resulting in poor seed germination and variation in crop emergence. Moreover, the random distribution of the plant makes it difficult to control weeds mechanically (Sim Sim, 1989). It is envisaged that the use of row crop planter can solve the agronomic problems associated with WLD and give better crop stand and higher sorghum yield under rainfed conditions. Sim Sim (1989) reported that culti-planter (a row crop planter) obtained significantly higher sorghum grain yield compared to the seeding by WLD. Yousif (2003) reported the advantages of row crop planting over broadcasting and these include: even seeding depth as well as even crop emergence, ease of the subsequent operations, such as mechanical weeding and fertilizer application. Besides that application of herbicides is more effective, since all herbicide drops fall on weed plants, whereas in broadcasting some drops may fall on crop plants. The use of row crop planter in the mechanized rainfed areas is limited to some private agricultural companies although the Ministry of Agriculture in Gedarif State has introduced row crop planters through Technology Transfer Centers. The interaction effect between seeding methods and other cultural practices on sorghum grain yield in rainfed areas is still unclear.

Fertilizers use in the Sudan is largely confined to irrigated crops especially those of high market value such as cotton, wheat and vegetables. Several studies, however, indicated the response of sorghum yield to addition of Nitrogen fertilizers in rainfed areas (Yousif, et al., 2008; EL Mahi and Salih, 2012). The response is more effective in wet rainy seasons and less effective in dry season (Elhassan et al., 2007). Recently application of 95.2 kg urea/ha was recommended in the Northern rainfed areas of Gedarif State (Hassan et al., 2008). There is limited knowledge on the effect of different Nitrogen fertilizer rates in relation to other cultural practices on sorghum grain yield in rainfed areas.

It was envisioned that high yield of sorghum can be obtained by the selection of the appropriate seedbed preparation method, good seeding machines and optimum Nitrogen fertilization. The objective of this experiment was to assess the effect of seedbed preparation, seeding methods and Nitrogen fertilizer level on sorghum yield under rainfed conditions Northern Gedarif State.

**Materials and Methods**

**Description of experimental site**

The experiment was carried out for two consecutive rainy seasons, 2003 and 2004, at Gedarif University Research Farm. The site is located in semi-arid zone, Northern Gedarif mechanized rainfed area. The soil is heavy clay soil (65%), alkaline (PH = 7.8), with 0.663% organic matter content and 0.075% Nitrogen content. According to the procedure described by Hazelton and Murphy (2007) this soil is rated as very low organic materials and low nitrogen content. The area receives its rainfall mainly in summer with most of effective rainfall occurring within June to October. The rainfall distribution is erratic within the year and from year to year. The long term average annual rainfall is around 600 mm. The amounts of rain and the duration of rainy days during both seasons were recorded at the experimental site (Table 1). The area is suitable for sorghum production.

<table>
<thead>
<tr>
<th>Months</th>
<th>Rain (mm)</th>
<th>Rainy days</th>
<th>Rain (mm)</th>
<th>Rainy days</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>74.1</td>
<td>7</td>
<td>103.3</td>
<td>10</td>
</tr>
<tr>
<td>July</td>
<td>491.6</td>
<td>18</td>
<td>202.5</td>
<td>9</td>
</tr>
<tr>
<td>August</td>
<td>118.5</td>
<td>10</td>
<td>123.8</td>
<td>9</td>
</tr>
<tr>
<td>September</td>
<td>112.5</td>
<td>8</td>
<td>84.4</td>
<td>6</td>
</tr>
<tr>
<td>October</td>
<td>11.0</td>
<td>2</td>
<td>55.5</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>807.7</td>
<td>45</td>
<td>569.9</td>
<td>36</td>
</tr>
</tbody>
</table>

**Experimental procedure**

In the first week of September 2002, when all weeds had germinated and before seed setting, the experimental area was divided into two blocks. One block was sprayed with Phomac (a non selective herbicide) at a rate of 1.5 L/fed (0.54 kg a. i. /fed) with tractor mounted sprayer. The second block was plowed twice by the WLD plow to 5 - 8 cm deep, one at the same time of herbicide application and the second one week before sowing in the subsequent seasons. The experimental area was used in 2003 and 2004 seasons to assess the two seedbed preparation methods, two seeding methods and three levels of Nitrogen fertilizer on grain yield of Arfa Gadama sorghum variety.
The sprayed block represented the untilled seedbed (T0) while the plowed block represented the tilled seedbed (T1). The seeding methods were; broadcasting by the WLD plow with seeder box (M1) and row planting by a row crop planter (mechanical drive TATU row planter with horizontal seed plate and double disk furrow opener and press wheel) in rows 80 cm apart (M2). The two seeding machines were adjusted to give the optimum plant density (10 plants/m²). The Nitrogen fertilizer levels were: 0 kg urea/ha (N0), 47.6 kg urea/ha (N1) and 95.8 kg urea/ha (N2). The three factors were arranged in a split-split plot design with four replications according to the procedure described by Gomez and Gomez (1984); with seedbed preparation as main plots, seeding method as sub-plots and nitrogen fertilizer dose as sub-sub plots. Sub plot size was 12 x 10 m². The experiment was sown in the second and the third weeks of July for the first and the second seasons, respectively. Urea was applied one month after crop emergence.

Data collection and analysis
At harvest data was recorded on number of plants, number of heads per square meter and grain yield. Three samples, each measuring one square meter (square quadrant for broadcasting and 1.25 m length for row planter), were taken randomly from the middle of each sub-plot to determine the mentioned parameters. The statistical procedure, analysis of variance, was used to describe the differences between the three factors and their interactions. The software M-stat-C was used.

Results and Discussions

Grain yield
Effect of seedbed preparation
Results of the two seasons and their combined analysis showed that the untilled seedbed gave significantly (P = 0.001) higher grain yield than the tilled treatment (Table 2). Similar results were found by Yousif et al. (2009). Saeed and Eissa (2002), however, found no significant differences between different tillage treatments on sorghum grain yield. The overall increase in yield from untilled seedbed was about 58 % over tilled seedbed. This indicates the superiority of untilled seedbed over the tilled seedbed. Dafaalla and Awad (2008) reported that field conditions determine the selection of suitable method for seedbed preparation in Vertisols soils of the Sudan. In rainfed areas the growing period is short requiring that seedbed preparation and planting be performed as early as possible. If one or two effective rains pass low yield or even total crop failure will be expected, hence, implementing untilled seedbed (direct seeding) is acceptable, possible and justifiable in rained areas if all its requirements are available.

Effect of seeding method
In the first season, row crop planting gave lower sorghum grain yield compared to broadcasting by the WLD method, but the difference was not significant, Table 2. While in the second season row crop planting gave significantly (P = 0.001) higher sorghum grain yield compared to broadcasting. The results of the second season are in line with that reported by Sim Sim (1989). The result of the combined analysis for the two seasons showed no significant difference between the two seeding methods. Row crop planting, however, out yielded the broadcasting method by 15%. Generally each of the two seeding methods has its own advantages and disadvantages when considering agronomic aspects, work rate and farmer’s technical knowhow besides field conditions and operation cost. The use of untilled seedbed is usually fixed with row crop planting. Therefore, row crop planter could be used with untilled seedbed to increase sorghum yield in the mechanized rainfed area of Northern Gedarif.

Effect of Nitrogen level
Table 2 shows that Nitrogen fertilizer had highly significant (P = 0.001) effect on grain yield in the first season, where grain yield increased progressively with the increase of nitrogen from 0, 47.6 to 95.2 kg urea/ha. The Nitrogen fertilizer had no significant effect on grain yield in the second season as shown in Table 2. The lack of sorghum yield response to Nitrogen fertilizer in the second season could be attributed to its lower rainfall amount (Table 1). This is associated with improved nutrient uptake due increase soil moisture during the rainy season. Results of the combined analysis of the two seasons showed that increasing Nitrogen fertilizer from 0 kg urea/ha to 95.2 kg urea/ha resulted in highly significant (P = 0.001) increase in grain yield (Table 2). The treatments of 95.2 kg urea/ha and 47.6 kg urea/ha out yielded the treatment of 0 kg urea/ha by about 49% and 15%, respectively. Previous studies detected the positive response of sorghum yield to nitrogen fertilizer in rainfed agriculture (Farah, 1985; Babiker and Taha, 1995). However, the use of nitrogen fertilizer in rainfed areas was criticized on the ground of cost, unavailability and unpredicted soil moisture level.
Table 2. Effect of seedbed preparation, seeding method and fertilizer level on sorghum grain yield (Kg/ha), two seasons

<table>
<thead>
<tr>
<th></th>
<th>Season 2003</th>
<th>Season 2004</th>
<th>Combine analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of seedbed preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untilled seedbed</td>
<td>1198.3</td>
<td>565.7</td>
<td>892.0</td>
</tr>
<tr>
<td>Tilled seedbed</td>
<td>761.6</td>
<td>368.4</td>
<td>565.0</td>
</tr>
<tr>
<td>S.E. (±)</td>
<td>15.89</td>
<td>37.29</td>
<td>20.71</td>
</tr>
<tr>
<td>Sig. level</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Effect of seeding methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadcasting</td>
<td>997.9</td>
<td>356.8</td>
<td>677.4</td>
</tr>
<tr>
<td>Row planting</td>
<td>962.0</td>
<td>597.4</td>
<td>779.7</td>
</tr>
<tr>
<td>S. E. (±)</td>
<td>15.89</td>
<td>37.29</td>
<td>20.71</td>
</tr>
<tr>
<td>Sig. level</td>
<td>N.S.</td>
<td>***</td>
<td>N. S.</td>
</tr>
<tr>
<td>Effect of Nitrogen fertilizer level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 kg urea/ha</td>
<td>695.9</td>
<td>507.4</td>
<td>601.7</td>
</tr>
<tr>
<td>47.6 kg urea/ha</td>
<td>938.2</td>
<td>431.5</td>
<td>684.9</td>
</tr>
<tr>
<td>95.2 kg urea/ha</td>
<td>1305.7</td>
<td>492.2</td>
<td>898.9</td>
</tr>
<tr>
<td>S. E. (±)</td>
<td>19.49</td>
<td>44.79</td>
<td>25.35</td>
</tr>
<tr>
<td>Sig. level</td>
<td>***</td>
<td>N.S</td>
<td>***</td>
</tr>
</tbody>
</table>

*** = significant at 0.001, N. S = not significant

Interactions effect

Results showed that there were highly significant (P = 0.001) interactions between seedbed preparation and seeding methods in the second season and the combined analysis (Table 3). Seeding sorghum by row crop planter (M2) in untilled seedbed (T0) gave the highest yield. The interaction between seeding methods and fertilizer rates were highly significant in the first season and combined analysis of the two seasons (Table 3). The increase in sorghum grain yield as a result of increase of nitrogen from 0 kg urea/ha to 95.2 kg urea/ha was more pronounced in the row crop planter method (M2) than the broadcasting method (M1).

Table 3. Interaction effect on grain yield (Kg/ha), two seasons

<table>
<thead>
<tr>
<th></th>
<th>Season 2003</th>
<th>Season 2004</th>
<th>Combine two seasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction effect of seedbed and seeding methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untilled seedbed</td>
<td>Broadcast</td>
<td>Broadcast</td>
<td>Broadcast</td>
</tr>
<tr>
<td></td>
<td>1198.0</td>
<td>1198.6</td>
<td>791.8</td>
</tr>
<tr>
<td></td>
<td>Row planting</td>
<td>Row planting</td>
<td>Row planting</td>
</tr>
<tr>
<td></td>
<td>798.0</td>
<td>725.2</td>
<td>563.1</td>
</tr>
<tr>
<td>S.E. (±)</td>
<td>22.49</td>
<td>51.72</td>
<td>29.27</td>
</tr>
<tr>
<td>Sig. level</td>
<td>N.S.</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Interaction effect of fertilizer level and seeding methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 kg urea/ha</td>
<td>853.2</td>
<td>538.6</td>
<td>673.8</td>
</tr>
<tr>
<td></td>
<td>341.1</td>
<td>637.3</td>
<td>693.3</td>
</tr>
<tr>
<td>95.2 kg urea/ha</td>
<td>1103.8</td>
<td>1507.5</td>
<td>738.8</td>
</tr>
<tr>
<td>S.E. (±)</td>
<td>27.56</td>
<td>63.33</td>
<td>35.87</td>
</tr>
<tr>
<td>Sig. level</td>
<td>***</td>
<td>N.S</td>
<td>***</td>
</tr>
</tbody>
</table>

*** = significant at 0.001, N. S = not significant

The interaction between seedbed preparation methods and fertilizer rates were highly significant (P = 0.001) in the first season and the combined analysis of the two seasons (Table 4). The increase in sorghum grain yield as a result of increase of nitrogen from 0 kg urea/ha to 95.2 kg urea/ha was more pronounced in the untilled seedbed than the tilled seedbed. Table 5 shows that there were significant differences between the treatments in sorghum grain yield in the first and the second seasons, but not in their combined analysis. The highest yield was obtained by the treatment of TOM2N2 (1912.8 kg/ha), TOM2N0 (1025.5 kg/ha) and TOM2N2 (1296.6 kg/ha) for the first, second season and their combination, respectively. It is clear that the use of untilled seedbed (T0) and row crop planter (M2) plus addition of fertilizer (95.2 kg urea/ha) is the best combination to obtain the highest sorghum grain yield. This combination of seedbed preparation method, seeding method and fertilizer level offers optimum conditions for minimum soil structure disruption, nutrient availability and uptake and therefore higher grain yield. The treatment of T1M2N0 gave the lowest yield in both seasons and their combined analysis. This means that the use of row crop planter in tilled field without addition of Nitrogen fertilizer will
not help in vertical upgrading of sorghum yield in rainfed areas. The overall mean grain yield was significantly \((P = 0.001)\) lower in the second season compared to the first season (Table 5). This could be due to relatively lower rainfall amount and prolonged dry periods during September and October 2004 (Table 1).

Table 4. Interaction effect between seedbed method and fertilizer level on sorghum grain yield (Kg/ha), two seasons

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Season 2003</th>
<th>Season 2004</th>
<th>Combine two seasons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Untilled</td>
<td>Tilled</td>
<td>Untilled</td>
</tr>
<tr>
<td></td>
<td>seedbed</td>
<td>seedbed</td>
<td>seedbed</td>
</tr>
<tr>
<td>0 kg urea/ha</td>
<td>857.8</td>
<td>534.1</td>
<td>688.5</td>
</tr>
<tr>
<td>47.6 kg urea/ha</td>
<td>1040.5</td>
<td>835.9</td>
<td>511.9</td>
</tr>
<tr>
<td>95.2 kg urea/ha</td>
<td>1696.7</td>
<td>914.6</td>
<td>556.7</td>
</tr>
<tr>
<td>S.E. (±)</td>
<td>27.56</td>
<td>63.33</td>
<td>35.87</td>
</tr>
</tbody>
</table>

Sig. level

*** = significant at 0.001, N. S = not significant

Yield components

The differences in grain yield between seedbed preparation, seeding methods and Nitrogen fertilizer levels could be attributed to differences in number of plants and / or number of heads per m\(^2\) as shown in Table 6. Number of plants per m\(^2\) in the untilled seedbed was significantly higher than in the tilled seedbed in both seasons. The improvement in plant establishment could be attributed to improvement in soil moisture content as a result of mulching from plant residues. Ahmed et al. (2004) reported that Phomac treated block resulted in higher soil moisture content than the plowed block six weeks after treatment.

In both seasons, seeding by the row crop planter (M2) resulted in significantly higher number of plants and number of heads per m\(^2\) compared to broadcasting method by the WLD (Table 6). Increasing Nitrogen fertilizer from 0 kg urea/ha to 95.2 kg urea/ha resulted in gradual increase in number of plants and number of heads per m\(^2\) in the two seasons, but the differences were not significant (Tables 6).

Table 5. Combined effect of season, seedbed preparation, seeding method and Nitrogen fertilizer level on grain yield of sorghum (kg/ha)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Season 2003</th>
<th>Season 2004</th>
<th>Combine analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 0M1N0</td>
<td>1099.3</td>
<td>351.8</td>
<td>725.4</td>
</tr>
<tr>
<td>T 0M1N1</td>
<td>1014.6</td>
<td>372.7</td>
<td>693.5</td>
</tr>
<tr>
<td>T 0M1N2</td>
<td>1480.6</td>
<td>432.9</td>
<td>956.8</td>
</tr>
<tr>
<td>T 0M2N0</td>
<td>616.2</td>
<td>1025.5</td>
<td>820.9</td>
</tr>
<tr>
<td>T 0M2N1</td>
<td>1066.7</td>
<td>651.4</td>
<td>858.9</td>
</tr>
<tr>
<td>T 0M2N2</td>
<td>1912.8</td>
<td>680.2</td>
<td>1296.6</td>
</tr>
<tr>
<td>T 1M1N0</td>
<td>607.4</td>
<td>330.4</td>
<td>468.9</td>
</tr>
<tr>
<td>T 1M1N1</td>
<td>1059.1</td>
<td>327.5</td>
<td>693.3</td>
</tr>
<tr>
<td>T 1M1N2</td>
<td>727.3</td>
<td>325.3</td>
<td>526.5</td>
</tr>
<tr>
<td>T 1M2N0</td>
<td>461.0</td>
<td>322.3</td>
<td>391.5</td>
</tr>
<tr>
<td>T 1M2N1</td>
<td>612.9</td>
<td>374.9</td>
<td>493.9</td>
</tr>
<tr>
<td>T 1M2N2</td>
<td>1102.2</td>
<td>530.5</td>
<td>816.4</td>
</tr>
<tr>
<td>Means</td>
<td>979.97</td>
<td>477.09</td>
<td>728.50</td>
</tr>
<tr>
<td>S.E. (±)</td>
<td>38.96</td>
<td>89.56</td>
<td>50.72</td>
</tr>
</tbody>
</table>

Sig. level

*** = significant at 0.001, N. S = not significant

Conclusions

Improvement of sorghum grain yield in rainfed areas could be attained by the selection of suitable combination of seedbed preparation method, seeding method and Nitrogen fertilizer level along with the weather conditions. Untilled seedbed (T0) significantly out yielded the conventional seedbed preparation method (T1). Seeding by the row crop planter (M2) helped in better crop establishment and improved grain yield compared to broadcasting method (M1). Addition of Nitrogen fertilizer positively improve sorghum grain yield, and the effect was more noticeable in the season of high rain fall. The highest yield was obtained from T0M2N2 package in the first season and from T0M2N0 in the second season. Combination of untilled
seedbed and the use of row crop planting coupled with addition of 95.2 kg urea/ha could be used to increase the grain yield of rain grown sorghum.

Table 6. Effect of seedbed preparation, seeding method and fertilizer dose on number of plants and heads per m² in two seasons

<table>
<thead>
<tr>
<th>Plant/ m²</th>
<th>Number of heads/ m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season 2003</td>
</tr>
<tr>
<td>Effect of seedbed preparation method</td>
<td></td>
</tr>
<tr>
<td>Untilled seedbed</td>
<td>10.1</td>
</tr>
<tr>
<td>Tilled seedbed</td>
<td>8.8</td>
</tr>
<tr>
<td>Means</td>
<td>9.4</td>
</tr>
<tr>
<td>S.E (±)</td>
<td>0.29</td>
</tr>
<tr>
<td>Sig. level</td>
<td>**</td>
</tr>
<tr>
<td>Effect of seeding method</td>
<td></td>
</tr>
<tr>
<td>Broadcasting</td>
<td>9.0</td>
</tr>
<tr>
<td>Row planting</td>
<td>9.9</td>
</tr>
<tr>
<td>Means</td>
<td>9.4</td>
</tr>
<tr>
<td>S.E (±)</td>
<td>0.29</td>
</tr>
<tr>
<td>Sig. level</td>
<td>*</td>
</tr>
<tr>
<td>Effect of Nitrogen level</td>
<td></td>
</tr>
<tr>
<td>0 kg urea/ha</td>
<td>9.1</td>
</tr>
<tr>
<td>47.6 kg urea/ha</td>
<td>9.1</td>
</tr>
<tr>
<td>95.2 kg urea/ha</td>
<td>10.1</td>
</tr>
<tr>
<td>Means</td>
<td>9.4</td>
</tr>
<tr>
<td>S.E (±)</td>
<td>0.35</td>
</tr>
<tr>
<td>Sig. level</td>
<td>N.S</td>
</tr>
</tbody>
</table>

*, **and *** = significant at 0.05, 0.01 and 0.001, respectively N. S = not significant

References


Willcocks, TJ, 1980. Tillage requirements of Vertisols Soils in South Kordofan and the role of the agricultural mechanization project at Kadugli, Sudan. Overseas Divin, NIAE