Efficacy of Different Herbicides for Control of Weeds in Sorghum (Sorghum bicolor L.) under Rainfed Conditions

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Abstract: Sorghum variety PARC-SS-2 was subjected to five different herbicides with different levels of active ingredients for control of weeds in comparison with hand-weeded and un-weeded check during summer seasons of 1997 and 1998 at the National Agricultural Research Centre Islamabad. Weed population significantly reduced from 73.79 to 90.04 percent due to the application of various herbicides and by 78.69 percent due to hand weeding over the un-weeded check. Reduction in weed population per unit area was more in the increased levels of herbicides. All treatments gave significantly higher grain yields than the unweeded check in both the years. The grain yield of the plots treated with Metolachlor + Atrazine at 1.00 kg ha⁻¹ was significantly more than the plots treated with either dose of other herbicides or hand weeded in both the years. At the two levels of herbicides the increase in yield ranged from 845 to 1144 kg ha⁻¹ through Metolachlor + Atrazine at 1.00 kg ha⁻¹, 328 to 1144 kg ha⁻¹ by hand weeding and 665 to 1750 kg ha⁻¹ by Metolachlor + Atrazine at 0.75 kg ha⁻¹, as compared to no weeding. As such, increase in the levels of herbicides increased the yield. It was found that the yield from hand-weeded plots was more than all the herbicides at either level. However, Metolachlor + Atrazine at 1.00 kg ha⁻¹ (ai), higher level resulted significantly higher yields than the hand weeded ones. The effect of the lower level of Metolachlor + Atrazine at 0.75 kg ha⁻¹ (ai), was at par with hand-weeded plots. Though the difference was there, but it was non-significant statistically. The higher doses of these herbicides which have resulted significant grain yield, could be considered for higher return. The economic analysis revealed that there was increased net income from the plots treated with herbicides or hand weeded over the unweeded check. The highest marginal rate of return (MMR) of 404.16 percent was obtained from T3 (the plots treated with Metolachlor + Atrazine at 1.00 kg ha⁻¹ (ai) followed by T6 (Metolachlor + Atrazine at 0.75 kg ha⁻¹ (ai) with MRR of 297.22 percent while that of hand weeded treatment the MRR was 229.54 percent.

Key Words: Herbicides; efficacy; weed control; sorghum bicolor Rainfed conditions.

Introduction
There are many factors which hinder the increase in crop production per unit area. One of the factors which causes low production, is weeds infestation. Weeds not only use a portion of water and plant nutrients but also compete for sun light resulting in poor growth of the crop. Sorghum seedlings are relatively weak and cannot compete with weeds. Most of the farmers control weeds mechanically or manually. Herbicides could be useful in barani areas where mechanical weed control is precluded by frequent rains in July and August and weeding can not be carried out in time. Therefore chemical weed control could be the alternative in such a situation. A number of herbicides are available for control of different weeds. Some are used for control of annual grasses while there are others which are used for control of broad leaved weeds (Da Silva et al., 1986).

Lee and Choi (1989) have reported that simazine did not control grasses, but controlled broad-leaved weeds. Alachlor controlled all grasses but did not control Acalypha australis and Chenopodium album. A combination of simazine and alachlor controlled weeds more effectively than either herbicide alone. Simazine at 1.5 to 3.0 kg ha⁻¹ when applied post sowing, gave significant weed control during the early developmental stages of sorghum crop and highly significant weed control was however reported at a highest herbicide rate. Grain yield increased by 14-24 percent when treated with simazine + 2 hoeings (Tanchev 1989). Balyan and Singh (1986) have reported that nitrogen and hand weeding effectively controlled weeds and gave similar increases in yield and nitrogen uptake compared with unweeded check. In another study on weed control in sorghum Balyan and Singh (1987) have reported that hand weeding 3 times in combination with application of 2 litres nitrogen ha⁻¹, enhanced N uptake by the crop and increased dry matter (DM) production of the crop and weeds.

Bishnoi et al. (1990) have reported significant effects of chemical weed control on weed population and grain yield with conventional tillage practices. Gopal and Kondap (1986) have reported that atrazine stimulated the availability and uptake of nutrients by sorghum at low as well as high fertility levels. Latehana (1987) has reported that at rates above 1.0 kg ha⁻¹ (ai), atrazine caused significantly higher crop mortality than lower rates. The present study was carried out to evaluate the efficacy of different herbicides for control of weeds in sorghum.

Materials and Methods
The trials were carried out during kharif (monsoon) seasons of 1997 and 1998 at the National Agricultural Research Centre Islamabad (located at 33°N and 518 m above sea level where the annual rainfall ranges from 500 to 1500 mm and the soil is clay-loam with a pH of 7.8 to 8.2). Sorghum variety PARC-SS-2 was subjected to five different herbicides with different levels of active ingredients and hand-weeded and an un-weeded check. A randomized complete block design with three replications was used to conduct the trial. The treatments were:

T1 Pendiethalin at 1.00 kg ha⁻¹ ai (pre-emergence).
T2 Oxadiazon at 0.35 kg ha⁻¹ ai (pre-emergence).
T3 Metolachlor + Atrazine at 1.00 kg ha⁻¹ ai (pre-emergence).
T4 Pendiethalin at 0.75 kg ha⁻¹ ai (post-emergence).
T5 Oxadiazon at 0.25 kg ha⁻¹ ai (post-emergence).
T6 Metolachlor + Atrazine at 0.75 kg ha⁻¹ ai (post-emergence).
T7 Topogard at 0.50 kg ha⁻¹ ai (post-emergence).
T8 Dicuron-MA at 0.90 kg ha⁻¹ ai (post-emergence).
T9 Hand weeding (twice).
T10 Unweeded Check

Planting was done with rotary hand dibler on ridges 75 cm apart with 15 cm plant to plant distance. Urea and DAP fertilizers were applied at 60 kg ha⁻¹ nitrogen and 30 kg ha⁻¹ P₂O₅. Half of N...
Results and Discussion

Weeds density: The data on weeds population showed significantly reduced from 73.79 to 90.04 percent due to the application of various herbicides and by 78.69 percent due to hand weeding over the un-weeded check (Table 1). The reduction in weeds population per unit area was observed in the increased levels of herbicides. It ranged from 75.73 to 79.13 percent in Pendimethalin, 73.79 to 79.97 percent in Oxadiazone and 86.89 to 90.04 percent in Metolachlor + Atrazine. In Topogard and Dicuran the population density of weeds was control by 83.98 and 84.95 percent, while in the hand weeded plots it was recorded 78.64 percent. Dowler et al. (1983) have reported that the use of atrazine alone or in combination with metolachlor or pendimethalin as early postemergence treatments was the most promising method for control of weeds in sorghum. Greer and Denman (1983) were of the opinion that the use of herbicides along with good cultural practices would help control weeds and make crop production more profitable.

Dry matter from weeds: The dry matter accumulation from weeds was found to decrease with increase in the levels of herbicides (Table 1). The dry matter of weeds from the control plots was significantly more than all the treatments in the two years study. Amongst the herbicides, Metolachlor + Atrazine at 1.00 kg ha\textsuperscript{-1} (ai), showed the maximum efficacy giving only 533 kg ha\textsuperscript{-1} dry matter of weeds as against 5247 and 1033 kg ha\textsuperscript{-1} from the un-weeded and hand weeded plots, respectively. The dry matter obtained from the lower levels of herbicides ranged from 747 to 467 kg ha\textsuperscript{-1} and at the highest levels of herbicides it was from 533 to 1313 kg ha\textsuperscript{-1}. The dry matter of weeds of hand weeded plots was significantly more than the plots treated with Metolachlor + Atrazine at 1.00 kg ha\textsuperscript{-1} (ai). The difference with other treatments was non-significant. Though there were differences among the hand weeded and chemically treated plots in the following year, but these were non-significant. The overall results showed that herbicides with Atrazine as an active ingredient, were more effective for weed control and the crop plants fully utilized enough moisture and nutrients from the soil for which the weeds compete. Balyan and Singh (1986) have reported that nitrogen and hand weedicides effectively controlled weeds and gave similar increases in yield and nitrogen up-take compared with unweeded check. In another study on weed control in sorghum, Balyan and Singh (1987) have reported that by hand weeding three times and application of 2 litres nitrogen ha\textsuperscript{-1} enhanced N uptake by the crop and increased DM production.

Grain Yield: The grain yield was proportionate to the control of weeds either by herbicide or by hand weeding (Table 1). All treatments gave significantly higher grain yields than the unweeded check in both the years. The grain yield of the plots treated with Metolachlor + Atrazine at 1.00 kg ha\textsuperscript{-1} (ai) was significantly more than the plots treated with either dose of other herbicides or hand weeded in both the years. Though the difference was non-significant statistically but the two levels of

Table 1: Efficacy of different herbicides for control of weeds in sorghum under rainfed conditions (NARC Islamabad).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
<th>T10</th>
<th>LSD at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weed density</td>
<td>1997</td>
<td>39</td>
<td>46</td>
<td>18</td>
<td>47</td>
<td>51</td>
<td>23</td>
<td>26</td>
<td>34</td>
<td>37</td>
<td>193</td>
</tr>
<tr>
<td>1.5 m² area</td>
<td>1998</td>
<td>47</td>
<td>53</td>
<td>23</td>
<td>53</td>
<td>57</td>
<td>31</td>
<td>40</td>
<td>28</td>
<td>51</td>
<td>219</td>
</tr>
<tr>
<td>Mean</td>
<td>43</td>
<td>49</td>
<td>20</td>
<td>50</td>
<td>54</td>
<td>27</td>
<td>33</td>
<td>31</td>
<td>44</td>
<td>206</td>
<td></td>
</tr>
<tr>
<td>% mean weed control over check</td>
<td>79</td>
<td>76</td>
<td>90</td>
<td>76</td>
<td>74</td>
<td>87</td>
<td>84</td>
<td>85</td>
<td>79</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Weight dry matter</td>
<td>1997</td>
<td>1162</td>
<td>1336</td>
<td>488</td>
<td>700</td>
<td>1100</td>
<td>723</td>
<td>1036</td>
<td>1150</td>
<td>866</td>
<td>4760</td>
</tr>
<tr>
<td>1.00 kg ha\textsuperscript{-1}</td>
<td>1998</td>
<td>1000</td>
<td>1290</td>
<td>578</td>
<td>966</td>
<td>1234</td>
<td>467</td>
<td>1200</td>
<td>1482</td>
<td>1200</td>
<td>568</td>
</tr>
<tr>
<td>Mean</td>
<td>1081</td>
<td>1313</td>
<td>533</td>
<td>833</td>
<td>1167</td>
<td>747</td>
<td>1118</td>
<td>1316</td>
<td>1033</td>
<td>5209</td>
<td></td>
</tr>
<tr>
<td>Grain yield</td>
<td>1997</td>
<td>1678</td>
<td>1310</td>
<td>1931</td>
<td>1507</td>
<td>1129</td>
<td>1878</td>
<td>1004</td>
<td>991</td>
<td>1693</td>
<td>1009</td>
</tr>
<tr>
<td>kg\textsuperscript{-1}</td>
<td>1998</td>
<td>1422</td>
<td>1156</td>
<td>2166</td>
<td>1633</td>
<td>1078</td>
<td>1622</td>
<td>1156</td>
<td>1289</td>
<td>1733</td>
<td>800</td>
</tr>
<tr>
<td>Mean</td>
<td>1550</td>
<td>1233</td>
<td>2049</td>
<td>1570</td>
<td>1104</td>
<td>1750</td>
<td>1080</td>
<td>1140</td>
<td>1713</td>
<td>905</td>
<td></td>
</tr>
<tr>
<td>Grain yield increase over check kg ha\textsuperscript{-1}</td>
<td>645</td>
<td>328</td>
<td>1144</td>
<td>665</td>
<td>199</td>
<td>845</td>
<td>175</td>
<td>235</td>
<td>808</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Stover yield</td>
<td>1997</td>
<td>9.3</td>
<td>8.9</td>
<td>15.1</td>
<td>8.0</td>
<td>6.2</td>
<td>12.7</td>
<td>7.6</td>
<td>8.8</td>
<td>11.5</td>
<td>7.6</td>
</tr>
<tr>
<td>kg ha\textsuperscript{-1}</td>
<td>1998</td>
<td>12.4</td>
<td>7.9</td>
<td>121.0</td>
<td>8.9</td>
<td>10.2</td>
<td>10.8</td>
<td>8.6</td>
<td>8.5</td>
<td>10.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Mean</td>
<td>10.9</td>
<td>8.4</td>
<td>13.6</td>
<td>8.5</td>
<td>8.2</td>
<td>11.7</td>
<td>8.1</td>
<td>8.6</td>
<td>10.9</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>Stover yield increase over check kg ha\textsuperscript{-1}</td>
<td>4.0</td>
<td>1.5</td>
<td>6.6</td>
<td>1.5</td>
<td>1.3</td>
<td>4.8</td>
<td>1.2</td>
<td>1.7</td>
<td>4.0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
herbicides, the increase in yield ranged from 845 to 1144 kg ha\(^{-1}\) with application of Metolachlor + Atrazine at 0.50 kg ha\(^{-1}\); 328 to 1144 kg ha\(^{-1}\) by hand weeding and 665 to 1750 kg ha\(^{-1}\) by Metolachlor + Atrazine at 1.00 kg ha\(^{-1}\), as compared to no weeding. As such, increase in the levels of herbicides increased the yield. The hand-weeded plots also yielded significantly more grain yield than the unweeded plots. Comparing the yield from hand-weeded plots with the herbicide treated plots, it was found that the yield from hand-weeded plots was more than all the herbicides at either level. However, Metolachlor + Atrazine at 1.00 kg ha\(^{-1}\) (ai) at higher levels resulted significantly higher yields than the hand weeded ones. These results are partially in agreement with Bishnoi et al. (1990). Gopal and Kondap (1986) have reported that atrazine stimulated the availability and uptake of nutrients by sorghum at low and specially at high fertility levels. Latehanna (1987) has reported that at rates above 1.0 kg ha\(^{-1}\) (ai), atrazine caused significantly higher crop mortality than lower rates. The effect of the lower level of Metolachlor + Atrazine at 1.00 kg ha\(^{-1}\) (ai) was at par with hand-weeded plots. Though the difference is there, but it was non-significant statistically. The higher doses of these herbicides which have resulted significant grain yield, could be considered for higher return. It may be pointed out that the percentage weed control by lower levels of Metolachlor + Atrazine at 1.00 kg ha\(^{-1}\) (ai), was not up to the extent as observed in case of hand weeding, but still, their ultimate effect upon crop yield was encouraging. The reason might be the differential weed-complex and weed growth per unit area and the differential affectivity of the herbicide towards the most competitive weed flora which were responsible for the crop yield.

The economic analysis presented in Table 2 revealed that there was increased net income from the plots treated with herbicides or hand weeded over the unweeded check. The increase in net benefit still the yield was high. In the following year, yield from the plots treated with Metolachlor + Atrazine at 1.00 kg ha\(^{-1}\) (ai) was again significantly higher than rest of the treatments. At ranged from 58.40 to 404.16 percent. The highest MRR of 404.16 percent was obtained from T3 (the plots treated with Metolachlor + Atrazine at 1.00 kg ha\(^{-1}\) (ai) followed by T6 (Metolachlor + Atrazine at 0.75 kg ha\(^{-1}\) (ai) with MRR of 297.22 percent while that of hand weeded treatment the MRR was 229.54 percent.

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