Chapter - IV

Results
RESULTS

A field experiment was conducted during 1989 and 1990 with different levels and sources of sulphur in soybean in Vertisol of Powarkheda. The observations made during the period of experimentation under different treatments in both the year as well as their pooled values are presented in the table 4.1 to 4.24 with the following heading.

GROWTH AND YIELD PARAMETERS
RESPONSE OF SULPHUR
NUTRIENT UTILIZATION
NUTRIENT AVAILABILITY
BALANCE SHEET OF SULPHUR
POST HARVEST SOIL PROPERTIES
SEED QUALITY
HARVEST INDEX
YARD STICK VALUE
ECONOMICS OF FERTILIZER SULPHUR
OPTIMUM DOSE OF SULPHUR

4.1 EFFECT OF LEVELS AND SOURCES OF SULPHUR ON GROWTH AND YIELD PARAMETERS

4.1.1 Plant height

The data presented in table 4.1 revealed that the plant height was merely equal in all the treatment in both the years. However, in general the lowest value was recorded at all
<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Height (cm) 1989</th>
<th>Height (cm) 1990</th>
<th>Height (cm) Pooled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS 60 DAS 90 DAS</td>
<td>30 DAS 60 DAS 90 DAS</td>
<td>30 DAS 60 DAS 90 DAS</td>
</tr>
<tr>
<td>0 Control</td>
<td>24.55 44.95 61.28</td>
<td>18.00 41.90 52.55</td>
<td>21.28 43.43 56.91</td>
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<td>25.90 47.92 70.05</td>
<td>19.50 46.15 53.70</td>
<td>22.70 47.04 61.88</td>
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<tr>
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<td>23.48 47.83 62.19</td>
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<td>20.00 47.60 57.90</td>
<td>24.60 48.18 65.14</td>
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<td>20.88 48.18 56.88</td>
<td>24.21 47.48 65.83</td>
</tr>
<tr>
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<td>24.18 46.33 65.60</td>
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<td>22.38 44.21 58.15</td>
</tr>
<tr>
<td>20 Ammonium</td>
<td>28.33 47.88 77.20</td>
<td>20.40 44.85 58.38</td>
<td>24.36 46.36 67.79</td>
</tr>
<tr>
<td>20 Single</td>
<td>25.23 47.45 70.85</td>
<td>19.75 44.45 48.80</td>
<td>22.49 45.95 59.83</td>
</tr>
</tbody>
</table>

| SEm+              | 00.55 01.32 03.51 | 0.77 3.01 04.12 | 00.49 01.55 02.60 |
| CD(P=0. on comparison of 01.66) | NS NS NS | NS NS NS | 01.35 NS NS |
the growth stages from the control followed by the treatment to which the S was applied @ 70 kg ha⁻¹. A close inspection of the data related to plant height expressed that all the treatments during both the year performing normal upto 60 DAS growth. However, during later growth period i.e., during 60 to 90 DAS and onwards the plant growth was relatively restricted during 1990. However, was not so during 1989.

The plant height at 30 DAS significantly increased @ 30 kg S ha⁻¹ over control during first year but it decreased significantly @ 70 kg S ha⁻¹ over at 30 kg S ha⁻¹. Although, the maximum plant height was observed also @ 30 kg S ha⁻¹ during second year but the S treatments were found nonsignificant. Amongst the sources of S, ammonium sulphate @ 20 kg S ha⁻¹ significantly increased the plant height over gypsum and single superphosphate during first year but not so during second year. At 60 DAS, nonsignificant increase of plant height was observed upto 30 and 40 kg S ha⁻¹ during first and second year respectively. Similarly at 90 DAS, nonsignificant increase of the plant height was observed upto 50 and 30 kg S ha⁻¹ during first and second year respectively. The gypsum produced slightly more height than single superphosphate and ammonium sulphate at 60 DAS in both the years. While ammonium sulphate resulted more height than single superphosphate and gypsum at 90 DAS in both year.
The pooled plant height increased with plant age as well as with increasing levels of S upto 30 kg ha\(^{-1}\) at 30 DAS and 60 DAS and upto 40 kg S ha\(^{-1}\) at 90 DAS, reduced at higher than that S level at all the growth stages. However, the plant height at 30 DAS, successively and significantly increased with 10 (22.70 cm) and 30 kg S ha\(^{-1}\) (24.60 cm) but it significantly decreased @ 70 kg S ha\(^{-1}\) over at 30 to 50 kg S ha\(^{-1}\). Ammonium sulphate significantly increased the plant height at 30 DAS over single superphosphate but it was at par with gypsum at the same dose of 20 kg S ha\(^{-1}\). The S treatments were nonsignificant at 60 DAS and 90 DAS. Gypsum gave the highest height at 60 DAS and ammonium sulphate at 90 DAS but these sources where not significant in both stages.

4.1.2 Numbers of root nodules

The data on root nodules per plant are presented in table 4.2 showed that at 30 DAS, the number of root nodules were significantly increased if S was applied @ 20 kg ha\(^{-1}\) through gypsum over control as well as over single superphosphate at the same level. Which was even significantly higher to that if S was applied @ 60/70 kg ha\(^{-1}\) during first year but the S treatments were not significant at 30 DAS, during second year of experiment. The difference in nodule number got merged at the age of 60 DAS in both the years. However, at 60 DAS, the nonsignificant increase of number of
<table>
<thead>
<tr>
<th>Kg/ha</th>
<th>Sources</th>
<th>No. of root nodules 1988</th>
<th>No. of root nodules 1990</th>
<th>No. of root nodules Pooled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30 DAS 60 DAS 90 DAS</td>
<td>30 DAS 60 DAS 90 DAS</td>
<td>30 DAS 60 DAS</td>
</tr>
<tr>
<td>0</td>
<td>Control</td>
<td>05 13 15</td>
<td>06 17 08</td>
<td>05 15</td>
</tr>
<tr>
<td>10</td>
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<td>05 14 23</td>
<td>06 17 10</td>
<td>06 15</td>
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<td>20</td>
<td>Gypsum</td>
<td>10 14 26</td>
<td>07 18 10</td>
<td>09 16</td>
</tr>
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<td>07 20 12</td>
<td>08 16</td>
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<td>Gypsum</td>
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<td>07 21 13</td>
<td>08 17</td>
</tr>
<tr>
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<td>Gypsum</td>
<td>09 11 23</td>
<td>07 23 14</td>
<td>08 17</td>
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<td>Gypsum</td>
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<td>07 21 16</td>
<td>07 18</td>
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<tr>
<td>70</td>
<td>Gypsum</td>
<td>05 10 23</td>
<td>06 23 11</td>
<td>05 16</td>
</tr>
<tr>
<td>20</td>
<td>Ammonium sulphate</td>
<td>07 13 25</td>
<td>07 22 12</td>
<td>07 18</td>
</tr>
<tr>
<td>20</td>
<td>Single super phosphate</td>
<td>06 10 24</td>
<td>06 18 11</td>
<td>06 14</td>
</tr>
<tr>
<td>5Ep+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>01 02 02</td>
<td>01 02 01</td>
<td>01 02</td>
</tr>
</tbody>
</table>

*SEM = 0.05 on comparison of 04 NS 06 NS NS 04 02 NS 04*
root nodules were observed upto 10 and 50 Kg S ha-1 during first and second year respectively. At 90 DAS, application of 10 and 30 Kg S ha-1 successively and significantly increased the number of root nodules during first year and @ 30 Kg S ha-1 during second year over control but higher than that S levels were found at par in both the years. The nature of nodulation in different treatment during 1988 and 1990 was not consistent. A general behaviour of nodulation in soybean crop at 30 DAS and 60 DAS period expressed that relatively better nodulation occurred at 20 Kg S ha-1 and at 90 DAS @ 30 Kg S ha-1 over control and its higher application (70 Kg S ha-1).

The pooled nodule increased with increasing levels of S upto 20 Kg ha-1 in the initial stage (30 DAS) and then upto 30-40 Kg S ha-1 in later growth stages. The pooled number of root nodules at 30 DAS were also significantly higher @ 20 Kg S ha-1 through gypsum over control and at the same level of S through ammonium sulphate/single superphosphate as well as over at 70 Kg S ha-1 at 30 DAS. At 60 DAS, the S treatments were found nonsignificant. However, maximum number of nodules (17) was found @ 40 Kg S ha-1. At 90 DAS, the nodules were successively and significantly increased with 10 and 30 Kg S ha-1 but higher than that S levels were found at par. Although the higher number of nodules were observed with ammonium sulphate than single superphosphate but the S sources were found nonsignificant at 60 DAS and 90 DAS at the same level of S.
4.1.3. **Number of pods**

The data presented in table 4.3 revealed that the significant increase in number of pods per plant were observed @ 30 and 20 kg S ha⁻¹ during first and second year respectively, but higher than that S levels were found nonsignificant at 90 DAS growth. However, at harvest, the significant increase of number of pods per plant was observed @ 30/40 kg S ha⁻¹ during first year but the "S" treatments were not significant during second year although the maximum number of pods were also obtained at 50 Kg S ha⁻¹ in both the years. The sources of S were found at par in both the years.

The pooled number of pods per plant increased with increasing levels of S up to 40 Kg S ha⁻¹ at 90 DAS and up to 50 Kg S ha⁻¹ at harvest and then declined higher than that S level. The number of pods per plant significantly increased (40) with 20 Kg S ha⁻¹ over control at 90 DAS. However, at harvest, it successively and significantly increased with 20 and 50 Kg S ha⁻¹ but it significantly reduced @ 70 Kg S ha⁻¹ over at 40/50 Kg S ha⁻¹ in both the stages. The sources of S were found at par though the maximum number of pods were found with ammonium sulphate in both the stages.
<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>No. of pods 1989</th>
<th>No. of pods 1990</th>
<th>No. of pods Pooled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90 DAS</td>
<td>Harvest</td>
<td>90 DAS</td>
</tr>
<tr>
<td>Control</td>
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<td>45</td>
<td>18</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>46</td>
<td>48</td>
<td>17</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>57</td>
<td>60</td>
<td>23</td>
</tr>
<tr>
<td>30 Gypsum</td>
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<td>25</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>63</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>63</td>
<td>74</td>
<td>24</td>
</tr>
<tr>
<td>70 Gypsum</td>
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<tr>
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<td>24</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>50</td>
<td>59</td>
<td>22</td>
</tr>
</tbody>
</table>

SEm+ 05 08 02 03 03 03
C3 CD(P=0.05) on comparison of 14 16 06 NS 07 09
4.1.4. Total drymatter yield

The data presented in table 4.4 showed that nonsignificant increase of total drymatter yield at 30 DAS and 60 DAS upto 60 Kg S ha⁻¹ during first year and upto 40 Kg S ha⁻¹ during second year. At 90 DAS, it successively and significantly increased with 20 and 40 Kg S ha⁻¹ during first year. While it was found significant @ 30 Kg S ha⁻¹ over control during second year but higher than that S levels were found at par. At harvest, the nonsignificant increase of total drymatter yield was observed with increasing levels of S upto 50 and 80 Kg S ha⁻¹ during first and second year respectively. Application of 10 and 20 Kg S ha⁻¹ significantly increased seed yield over control during first and second year respectively but higher than that S levels were found at par. While the stover yield increased with increasing levels of S upto 60 kg S ha⁻¹ but the S levels were not significant in both the year. Amongst the sources of S, in general, ammonium sulphate has resulted higher total drymatter yield than gypsum and single superphosphate at all the growth stages in both the years but these sources were found nonsignificant.

The pooled total drymatter at 30 DAS, 60 DAS and 90 DAS increased with increasing levels of S upto 40 Kg S ha⁻¹ as well as at harvest upto 60 kg S ha⁻¹. Though it was nonsignificant at 30 DAS and 60 DAS. However, it successively and significantly increased at 90 DAS with 20 & 40 Kg S ha⁻¹.
Table 4.4
Effect of levels and sources of S on dry matter yield at different growth stages of soybean

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Total drymatter (kg ha-1) 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
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<td>1457</td>
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<tr>
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</tr>
<tr>
<td>50 Gypsum</td>
<td>1607</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>1704</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>1548</td>
</tr>
<tr>
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<td>1738</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>1568</td>
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<tr>
<td>SEM+</td>
<td>73</td>
</tr>
<tr>
<td>CD(P=0.05) on comparison of</td>
<td>NS</td>
</tr>
</tbody>
</table>

S Kg ha-1 Sources Total drymatter yield (kg ha-1) 1990

<table>
<thead>
<tr>
<th></th>
<th>30 DAS</th>
<th>60 DAS</th>
<th>90 DAS</th>
<th>Harvest</th>
<th>Seed</th>
<th>Stover</th>
</tr>
</thead>
<tbody>
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<td>Ø Control</td>
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<td>3113</td>
<td>5417</td>
<td>6067</td>
<td>2280</td>
<td>3788</td>
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<td>3722</td>
<td>6243</td>
<td>6559</td>
<td>2459</td>
<td>4236</td>
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<td>6995</td>
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<td>7031</td>
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<td>8514</td>
<td>7241</td>
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<td>6531</td>
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<td>20 Single super phosphate</td>
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<td>7635</td>
<td>6698</td>
<td>2400</td>
<td>4298</td>
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<td>2283</td>
<td>NS</td>
<td>269</td>
<td>NS</td>
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</table>

S Kg ha-1 Sources Total drymatter yield (Kg ha-1) Pooled

<table>
<thead>
<tr>
<th></th>
<th>30 DAS</th>
<th>60 DAS</th>
<th>90 DAS</th>
<th>Harvest</th>
<th>Seed</th>
<th>Stover</th>
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</thead>
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<td>1863</td>
<td>3252</td>
<td>6147</td>
<td>5634</td>
<td>2023</td>
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</tr>
<tr>
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<td>4139</td>
<td>10900</td>
<td>6610</td>
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<td>4208</td>
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<td>6584</td>
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<tr>
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<td>7849</td>
<td>6260</td>
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<td>103</td>
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<td>NS</td>
<td>1886</td>
<td>548</td>
<td>185</td>
<td>291</td>
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</table>
seed yield with 10 and 30 Kg S ha-1 and stover yield with 10 & 60 Kg S ha-1. While at harvest, it was found significant @ 10 Kg S ha-1 over control but higher than that S levels were found at par. The drymatter yield at 90 DAS and seed yield significantly reduced @ 70 Kg S ha-1 over at 30–60 Kg S ha-1. Ammonium sulphate has resulted higher total drymatter yield than gypsum and single superphosphate in all the growth stages but these sources were found nonsignificant.

4.1.5 Response of sulphur.

The data presented in table 4.5 indicated that the response of S increased with increasing levels of S upto 40 kg S ha-1 during first year and upto 60 kg S ha-1 during second year. However, the unit response of S to grain yield was decreased with increasing levels of S. The mean maximum per unit response was found 28.1 kg @ 10 kg S ha-1. The response was found more during first year than second year. Amongst the sources of S, ammonium sulphate gave more response than gypsum and single superphosphate @ 20 kg S ha-1 during both the year and gave the mean value 19.05, 17.23 and 13.25 kg respectively.

4.2 EFFECT OF LEVELS AND SOURCES OF S ON NUTRIENT UTILIZATION BY SOYBEAN CROP.

4.2.1 Nitrogen content.

The data presented in table 4.6, revealed that, in general, the increasing levels of S, upto 40 kg S ha-1 increased the N content (%) in both the years but it reduced at higher than that S levels, though the S treatments were not significant at all the growth stages except in stover during 1989 in which the N content was found significant @ 10 Kg S ha-1 over control but higher than that S levels were found at par. The sources of S were found nonsignificant in both the years. Although the highest N content at 30 DAS and 90 DAS was recorded with gypsum at 60 DAS and in stover with single superphosphate and in seed with ammonium sulphate during first year. While during second year, ammonium sulphate
**Table 4.5**

Effect of levels and sources of Sulphur on response of applied sulphur to soybean seed production

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Response of applied</th>
<th>Response of applied S(kg-1)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1989</td>
<td>1990</td>
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<td>10 Gypsum</td>
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<td>30 Gypsum</td>
<td>510</td>
<td>393</td>
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<td>40 Gypsum</td>
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<td>447</td>
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</tr>
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<td>20 Ammonium</td>
<td>411</td>
<td>351</td>
</tr>
<tr>
<td>sulphate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>410</td>
<td>120</td>
</tr>
<tr>
<td>S Kg ha⁻¹ Sources</td>
<td>Total N content (%)</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1989</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 DAS  60 DAS  90 DAS Seed Stover</td>
<td></td>
</tr>
<tr>
<td>0 Control</td>
<td>2.25  2.43  2.53  6.20  0.83</td>
<td></td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>2.48  2.55  2.80  6.40  1.15</td>
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<tr>
<td>20 Gypsum</td>
<td>2.60  2.95  2.83  6.40  1.20</td>
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</tr>
<tr>
<td>30 Gypsum</td>
<td>2.60  2.95  2.88  6.43  1.23</td>
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<tr>
<td>40 Gypsum</td>
<td>2.73  2.83  2.88  7.18  1.23</td>
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<tr>
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<td>2.45  2.75  2.80  7.18  1.23</td>
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<tr>
<td>60 Gypsum</td>
<td>2.40  2.58  2.86  6.83  1.30</td>
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</tr>
<tr>
<td>70 Gypsum</td>
<td>2.20  2.50  2.85  6.68  1.18</td>
<td></td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>2.40  2.68  2.78  7.15  0.96</td>
<td></td>
</tr>
<tr>
<td>20 Single Super phosphate</td>
<td>2.30  2.70  2.78  6.28  1.30</td>
<td></td>
</tr>
<tr>
<td>SEm+</td>
<td>0.14  0.14  0.16  0.40  0.09</td>
<td></td>
</tr>
<tr>
<td>CD(P=0.05) on comparison of</td>
<td>NS  NS  NS  NS  0.26</td>
<td></td>
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<tr>
<td>S Kg ha⁻¹ Sources</td>
<td>Total N content (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 DAS  60 DAS  90 DAS Seed Stover</td>
<td></td>
</tr>
<tr>
<td>0 Control</td>
<td>2.48  3.60  1.00  5.90  0.80</td>
<td></td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>2.65  3.78  1.40  6.23  0.83</td>
<td></td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>3.10  3.80  1.43  6.35  0.83</td>
<td></td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>3.23  4.30  1.43  6.50  0.83</td>
<td></td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>3.30  4.13  1.43  6.88  0.90</td>
<td></td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>3.23  3.90  1.40  6.85  0.83</td>
<td></td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>3.20  3.85  1.38  6.83  0.83</td>
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</tr>
<tr>
<td>70 Gypsum</td>
<td>3.06  3.80  1.35  6.60  0.80</td>
<td></td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>3.23  3.85  1.43  6.28  0.90</td>
<td></td>
</tr>
<tr>
<td>20 Single Super phosphate</td>
<td>2.90  3.85  1.33  7.18  0.83</td>
<td></td>
</tr>
<tr>
<td>SEm+</td>
<td>0.24  0.45  0.10  0.24  0.06</td>
<td></td>
</tr>
<tr>
<td>CD(P=0.05) on comparison of</td>
<td>NS  NS  NS  NS  NS</td>
<td></td>
</tr>
<tr>
<td>S Kg ha⁻¹ Sources</td>
<td>Total N content (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pooled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 DAS  60 DAS  90 DAS Seed Stover</td>
<td></td>
</tr>
<tr>
<td>0 Control</td>
<td>2.36  3.01  1.76  6.05  0.81</td>
<td></td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>2.68  3.16  2.10  6.31  0.99</td>
<td></td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>2.85  3.23  2.13  6.38  1.01</td>
<td></td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>2.94  3.55  2.16  6.48  1.03</td>
<td></td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>3.01  3.48  2.18  6.93  1.06</td>
<td></td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>2.91  3.33  2.15  6.91  1.03</td>
<td></td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>2.80  3.21  2.13  6.78  1.06</td>
<td></td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>2.64  3.15  2.10  6.74  0.99</td>
<td></td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>2.81  3.26  2.14  6.71  0.94</td>
<td></td>
</tr>
<tr>
<td>20 Single Super phosphate</td>
<td>2.60  3.28  2.05  6.73  1.10</td>
<td></td>
</tr>
<tr>
<td>SEm+</td>
<td>0.13  0.22  0.09  0.23  0.05</td>
<td></td>
</tr>
<tr>
<td>CD(P=0.05) on comparison of</td>
<td>0.38  0.38  NS  NS  0.14</td>
<td></td>
</tr>
</tbody>
</table>
resulted the highest N content at all the growth stages except in seed, in which single superphosphate resulted the highest N content.

The pooled N content increased with increasing levels of S upto 40 Kg S ha⁻¹ but higher than that S it showed decreasing trend at all growth stages. The N content in plant changes periodically with plant age. In general, the concentration of N increased at all the treatment upto 60 DAS period and then started declined sharply attaining minimum value at harvest. The pooled N content at 30 DAS, significantly increased @ 20 Kg S ha⁻¹ over control but higher than that S levels were found at par. The S treatments were found nonsignificant at 60 DAS, 90 DAS and in seed at harvest. However, N content in stover at harvest, significantly increased @ 10 kg S ha⁻¹ over control but higher than that S levels were found at par. The sources of S were found nonsignificant amongst themselves.

4.2.1.2 Nitrogen uptake

The data on N uptake presented in table 4.7 showed that increasing levels of S upto 40 Kg ha⁻¹ increased the N uptake at 30 DAS and 60 DAS in both the years but the S treatments were found at par. However, at 90 DAS and at harvest, it was found significant @ 20 Kg S ha⁻¹ over control in both the years except at 90 DAS during first year in which the N uptake was found significant @ 30 Kg Sha⁻¹ over control
### Table 4.7
Effect of levels and sources of S on nitrogen uptake at different growth stages of soybean

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Nitrogen uptake (kg ha⁻¹) 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>32.80</td>
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<tr>
<td>40 Gypsum</td>
<td>43.34</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>41.71</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>41.05</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>34.53</td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>41.63</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>36.12</td>
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</tbody>
</table>

SEM⁺ 3.46 10.42 33.44 12.87 11.41 7.05
CD(P=0.05) on comparison of NS NS 97.05 37.35 20.46

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Nitrogen uptake (kg ha⁻¹) 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>46.22</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>58.65</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>66.41</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>71.14</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>79.49</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>86.93</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>86.80</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>78.48</td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>78.06</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>64.87</td>
</tr>
</tbody>
</table>

SEM⁺ 9.09 19.91 11.92 9.96 8.31 3.64
CD(P=0.05) on comparison NS NS 34.59 28.90 24.1 NS

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Nitrogen uptake (kg ha⁻¹) Pooled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
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<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>39.51</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>48.66</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>53.73</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>56.51</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>61.41</td>
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<tr>
<td>50 Gypsum</td>
<td>54.17</td>
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<td>60 Gypsum</td>
<td>53.82</td>
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<tr>
<td>70 Gypsum</td>
<td>47.00</td>
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<tr>
<td>20 Ammonium sulphate</td>
<td>59.94</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>50.49</td>
</tr>
</tbody>
</table>

SEM⁺ 4.69 10.79 18.92 7.77 6.83 2.97
CD(P=0.05) on comparison NS NS 53.44 21.93 19.28 8.40
but it significantly decreased @ 70 Kg S ha⁻¹ over 40 Kg S ha⁻¹ at 90 DAS and at harvest during first and second year respectively. The N uptake by seed and stover increased with increasing levels of S up to 60 Kg S ha⁻¹ in both the years except N uptake by seed and stover during first and second year respectively which increased up to 50 and 40 Kg S ha⁻¹ but the S treatments were not significant for them. However, the significant N uptake by seed and stover increased significantly @ 20 and 60 kg S ha⁻¹ over control during second and first year respectively but higher/lower than that S level were found at par. The sources of "S" were found nonsignificant at all the growth stages.

The pooled N uptake increased with increasing levels of S up to 40 Kg S ha⁻¹ at all the growth stages (except seed) but it decreased at higher than that S level though the S treatments were not significant at 30 DAS and 60 DAS. However, it successively and significantly increased at 90 DAS with 20 and 40 Kg S ha⁻¹ and at harvest (seed + stover) as well as by seed with 10 and 40 Kg S ha⁻¹. While N uptake by stover significantly increased @20 kg S ha⁻¹ over control but higher than that S levels were found at par. The N uptake decreased significantly @ 70 Kg S ha⁻¹ over at 40 kg S ha⁻¹ at 90 DAS, at harvest and seed. The sources of S were found nonsignificant amongst themselves. However, the ammonium sulphate resulted the highest N uptake at all the growth
stages except in stover in which single superphosphate produced the best result.

4.2.2.1 Phosphorus content

Data presented in table 4.8 clearly indicated that in general, the P content of the plant increases with plant age as well as with increasing levels of S particularly up to 40 kg S ha⁻¹ during first year but the S treatments were found nonsignificant at 30 DAS, 60 DAS and in seed at harvest. However, it was found significant during second year at 30 DAS and 60 DAS @ 10 kg S ha⁻¹ over control but the S treatments were not significant at 90 DAS and in seed. While the S @40 kg ha⁻¹ significantly increased the P content at 90 DAS and in stover at harvest during first year as well as in stover during second year @20 kg S ha⁻¹ over control. The S content decreased significantly @ 70 kg S ha⁻¹ over at 10/20 kg S ha⁻¹ at 90 DAS during first year as well as at 30 DAS and 60 DAS during second year. Amongst the sources of S, single superphosphate and ammonium sulphate significantly increased the P content in stover over gypsum during first year at the same level of 20 kg S ha⁻¹. While gypsum found significantly superior to single superphosphate at 30 DAS during second year but these sources were found at par in rest of the stages.

Pooled P content increases with increasing levels of S up to 20 Kg S ha⁻¹ at 30 DAS and 60 DAS and up to 40 kg S
### Table 4.8
Effect of levels and sources of S on Phosphorus content at different growth stages of soybean

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Total P content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1989</td>
</tr>
<tr>
<td></td>
<td>30 DAS 60 DAS 90 DAS Seed Stover</td>
</tr>
<tr>
<td>0 Control</td>
<td>0.142 0.172 0.273 0.391 0.108</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>0.160 0.180 0.293 0.421 0.126</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>0.168 0.181 0.285 0.423 0.134</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>0.166 0.184 0.300 0.427 0.144</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>0.169 0.188 0.335 0.451 0.171</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>0.168 0.170 0.298 0.426 0.150</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>0.163 0.161 0.256 0.419 0.149</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>0.150 0.160 0.251 0.398 0.148</td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>0.154 0.222 0.297 0.417 0.191</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>0.148 0.190 0.264 0.373 0.164</td>
</tr>
<tr>
<td>SEM+ CD(=0.05) on comparison of NS</td>
<td>0.012 0.013 0.014 0.015 0.017</td>
</tr>
<tr>
<td>NS</td>
<td>0.040 0.049</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Total P content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>30 DAS 60 DAS 90 DAS Seed Stover</td>
</tr>
<tr>
<td>0 Control</td>
<td>0.234 0.172 0.124 0.318 0.031</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>0.287 0.212 0.156 0.360 0.074</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>0.287 0.242 0.162 0.383 0.091</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>0.269 0.235 0.171 0.399 0.121</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>0.240 0.211 0.170 0.397 0.107</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>0.237 0.209 0.165 0.397 0.105</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>0.236 0.208 0.160 0.397 0.101</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>0.197 0.199 0.153 0.373 0.095</td>
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<tr>
<td>20 Ammonium sulphate</td>
<td>0.255 0.221 0.167 0.438 0.115</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>0.221 0.209 0.148 0.355 0.112</td>
</tr>
<tr>
<td>SEM+ CD(=0.05) on comparison 0.047 0.037</td>
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<td>NS</td>
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<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Total P content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pooled</td>
</tr>
<tr>
<td></td>
<td>30 DAS 60 DAS 90 DAS Seed Stover</td>
</tr>
<tr>
<td>0 Control</td>
<td>0.188 0.172 0.199 0.354 0.070</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>0.223 0.196 0.224 0.391 0.100</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>0.226 0.211 0.228 0.403 0.112</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>0.218 0.209 0.235 0.413 0.135</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>0.205 0.199 0.252 0.424 0.139</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>0.203 0.189 0.231 0.411 0.127</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>0.199 0.185 0.208 0.408 0.125</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>0.174 0.180 0.202 0.385 0.122</td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>0.204 0.221 0.232 0.428 0.153</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>0.184 0.200 0.236 0.364 0.148</td>
</tr>
<tr>
<td>SEM+ CD(=0.05) on comparison 0.010 0.009</td>
<td>0.009 0.015 0.011</td>
</tr>
<tr>
<td>NS</td>
<td>0.048 0.031</td>
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</table>
ha-1 at 90 DAS, at harvest and seed and stover. The P content significantly increased @ 20 kg S ha-1 at all the growth stages except at 30 DAS in which it was found significant @ 10 Kg S ha-1 over control but it decreased significantly @ 70 Kg S ha-1 over that @ 10/20 Kg S ha-1 at 30 DAS, 60 DAS and 90 DAS. Amongst the sources of S, gypsum produced significantly higher P content at 30 DAS and ammonium sulphate at 90 DAS and in seed than single super-phosphate at the same dose of 20 kg S ha-1. While ammonium sulphate and single superphosphate were found significantly superior to gypsum for P content in stover but these sources were found nonsignificant at 60 DAS.

4.2.2.2 Phosphorus uptake

The data presented in table 4.9 indicated that the P uptake of plant increased with plant age as well as with increasing levels of S up to 40 kg S ha-1 but it decreased at higher than that S level during both the year. The P uptake at 30 DAS and 60 DAS during first year as well as at 30 DAS during second year were found nonsignificant. However, it was found significant @ 10 Kg S ha-1 over control at 60 DAS during second year. The P uptake successively and significantly increased at 90 DAS with 20 and 40 kg S ha-1 and at harvest with 10 and 40 kg S ha-1 during first year as well as significant @ 20 kg S ha-1 over control in both the stages during second year. The P uptake by seed and stover
**Table 4.9**

Effect of levels and sources of S on Phosphorus uptake at different growth stages of soybean

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Phosphorus uptake (kg ha-1)</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>0 Control</td>
<td>2.08</td>
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<tr>
<td>10 Gypsum</td>
<td>2.55</td>
<td>6.70</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>2.57</td>
<td>6.75</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>2.62</td>
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<td>40 Gypsum</td>
<td>2.69</td>
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</tr>
<tr>
<td>50 Gypsum</td>
<td>2.71</td>
<td>6.59</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>2.78</td>
<td>6.57</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>2.30</td>
<td>5.74</td>
</tr>
<tr>
<td>20 Ammonium</td>
<td>2.66</td>
<td>8.66</td>
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<tr>
<td>sulphate</td>
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<td></td>
</tr>
<tr>
<td>super phosphate</td>
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<tr>
<td><strong>SEM+</strong></td>
<td>0.23</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>CD(P=0.05)</strong> on comparison of</td>
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<th>Phosphorus uptake (kg ha-1)</th>
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<th>S Kg ha-1 Sources</th>
<th>Phosphorus uptake (kg ha-1)</th>
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significantly increased @ 10 and 40 kg S ha⁻¹ over control respectively during first year as well as by seed @ 20 S ha⁻¹ over control during second year but the S treatments were found nonsignificant for P uptake by stover. The P uptake @ 70 kg S ha⁻¹ significantly decreased over @ 30/40 kg S ha⁻¹ at 90 DAS and at harvest during first year. Amongst the sources of S, ammonium sulphate and gypsum were found significantly superior to single superphosphate at 90 DAS during first year. While ammonium sulphate and single superphosphate resulted significantly higher P uptake by stover than gypsum at the same level of 20 kg S ha⁻¹ during first year. Whereas during second year, and ammonium sulphate showed significantly higher P uptake at 60 DAS and by seed respectively over single superphosphate but these sources were not significant in rest of the growth stages.

The pooled P uptake increased with increasing levels of S upto 40 kg S ha⁻¹. However, higher than that S level it showed decreasing trend at all growth stages except at 30 DAS in which it was found maximum (4.29 kg ha⁻¹) @ 10 kg S ha⁻¹ but the S treatments were found at par. However, the P uptake at 60 DAS and 90 DAS significantly increased @ 20 and 30 kg S ha⁻¹ over control respectively. However, it successively and significantly increased at harvest with 10 and 30 kg S ha⁻¹ and by seed and stover with 10 and 40 kg S ha⁻¹. The P uptake @ 70 kg S ha⁻¹ significantly reduced over @ 30/40 kg S ha⁻¹ at 90 DAS, at harvest as well as by seed. Amongst the sources of S, ammonium sulphate gave significantly higher P uptake than single superphosphate at 60 DAS, at harvest and by seed. It was also found significantly superior to gypsum for P uptake at harvest as well as by stover.
4.2.3.1 Potassium content

The data presented in table 4.10 revealed that in general, the K content of plant increased with increasing levels of S up to 40 kg ha\(^{-1}\) during first year and up to 30 kg S ha\(^{-1}\) during second year at all the growth stages but higher than that S level it showed the decreasing trend. The K content at 30 DAS significantly increased at 20 and 30 kg S ha\(^{-1}\) over control during first and second year respectively but it decreased significantly at 60/70 kg S ha\(^{-1}\) over 30/40 kg S ha\(^{-1}\) in both the years. The S treatments were found nonsignificant at 60 DAS, 90 DAS and in seed during first year as well as at 90 DAS during second year. However, it was found significant at 30 kg S ha\(^{-1}\) over control during second year. The K content in seed during second year, significantly increased at 20 kg S ha\(^{-1}\) over control. While its content in stover significantly increased over control at 40 kg S ha\(^{-1}\) during first year and at 10 kg S ha\(^{-1}\) during second year. Though the sources of S were found nonsignificant during both the year, the highest K content was observed with ammonium sulphate at 20 kg S ha\(^{-1}\) at all the growth stages during both the year except at 60 DAS and 30 DAS during first and second year respectively in which gypsum produced the highest K content.

The K content increased with increasing levels of S up to 40 kg ha\(^{-1}\). However, higher than that S level it
Table 4.10
Effect of levels and sources of S on Potassium content at different
growth stages of soybean

<table>
<thead>
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<th>S Kg ha-1 Sources</th>
<th>Total K content (%)</th>
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<td>30 Gypsum</td>
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<tr>
<td>40 Gypsum</td>
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<td>50 Gypsum</td>
<td>2.10 2.18 2.13 2.15 1.90</td>
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<tr>
<td>20 Single</td>
<td>2.20 2.50 1.99 2.08 1.40</td>
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</tr>
<tr>
<td>SEM+ CD(P=0.05) on comparison of</td>
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<td>0.41</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.42</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

| Total K content 1990 |  |
|----------------------|---|---|---|---|---|---|---|---|
| 30 DAS 60 DAS 90 DAS Seed Stover |
| 0 Control            | 3.35 2.45 2.41 0.99 2.29 |
| 10 Gypsum            | 3.48 2.51 2.65 1.09 3.20 |
| 20 Gypsum            | 3.51 2.71 2.69 1.29 3.49 |
| 30 Gypsum            | 3.81 2.83 3.18 1.29 3.55 |
| 40 Gypsum            | 3.86 2.91 2.75 1.28 3.55 |
| 50 Gypsum            | 3.75 2.86 2.74 1.24 3.58 |
| 60 Gypsum            | 3.51 2.86 2.73 1.23 3.58 |
| 70 Gypsum            | 3.40 2.86 2.70 1.16 3.60 |
| 20 Ammonium sulphate super phosphate | 3.39 2.99 2.90 1.29 3.73 |
| 20 Single            | 3.35 2.78 2.75 1.23 3.51 |
| SEM+ CD(P=0.05) on comparison of | 0.14 0.11 0.14 0.10 0.26 | 0.40 | 0.32 | NS | 0.29 | 0.75 |

| S Kg ha-1 Sources | Total K content (%) Pooled |  |
|-------------------|----------------------------|---|---|---|---|---|---|---|---|
|                   | 30 DAS 60 DAS 90 DAS Seed Stover |
| 0 Control         | 2.48 2.23 2.12 1.32 1.80 |
| 10 Gypsum         | 2.64 2.52 2.29 1.53 2.29 |
| 20 Gypsum         | 2.78 2.63 2.36 1.65 2.52 |
| 30 Gypsum         | 3.00 2.73 2.65 1.69 2.58 |
| 40 Gypsum         | 3.01 2.75 2.45 1.73 2.76 |
| 50 Gypsum         | 2.93 2.53 2.43 1.69 2.74 |
| 60 Gypsum         | 2.59 2.52 2.38 1.67 2.74 |
| 70 Gypsum         | 2.53 2.46 2.33 1.58 2.70 |
| 20 Ammonium sulphate super phosphate | 2.82 2.76 2.53 1.68 2.68 |
| 20 Single         | 2.78 2.68 2.37 1.68 2.46 |
| SEM+ CD(P=0.05) on comparison of | 0.10 0.01 0.08 0.06 0.15 | 0.29 | 0.28 | 0.21 | 0.18 | 0.43 |
showed decreasing trend at all growth stages. The pooled K content at 30 DAS and 60 DAS significantly increased @20 and 10 kg S ha⁻¹ over control respectively. However, it successively and significantly increased at 90 DAS with 20 and 30 kg S ha⁻¹, in seed and stover with 10 and 40 kg Sha⁻¹. The K content decreased significantly @ 60/70 kg S ha⁻¹ over 30/40 kg S ha⁻¹ at 30 DAS, 60 DAS and 90 DAS. Amongst the sources of S, the highest K content was observed with ammonium sulphate @ 20 kg S ha⁻¹ at all the growth stages.

4.2.3.2 Potassium uptake

The data presented in table 4.11 revealed that increasing level of S up to 40 kg ha⁻¹ increased the K uptake in both the year except at 90 DAS, harvest and by stover during second year in which the maximum value were obtained @ 30, 50 and 60 kg S ha⁻¹ respectively. During first year at 30 DAS, it significantly increased @ 20 kg S ha⁻¹ over control but it was not significant during second year. The S treatments were nonsignificant at 60 DAS and 90 DAS. However, it was found significant @ 20 and 30 kg Sha⁻¹ over control at 60 DAS and 90 DAS during second year. At harvest, the K uptake was significantly higher @ 30 kg S ha⁻¹ and 10 kg Sha⁻¹ than control during first and second year respectively. However, the K uptake by seed significantly increased @ 10 kg Sha⁻¹ over control during both the year. Whereas the K uptake
Table 4.11
Effect of levels and sources of S on Potassium uptake at different growth stages of soybean

<table>
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<th>S Kg ha-1 Sources</th>
<th>Potassium uptake (kg ha-1)</th>
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<td></td>
<td>1989</td>
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<td>30 DAS  60 DAS  90 DAS  Harvest  Seed  Stover</td>
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<tr>
<td>0 Control</td>
<td>23.31  67.68  124.26  77.58  32.72  44.85</td>
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<td>10 Gypsum</td>
<td>27.85  94.71  158.86  91.33  42.27  49.06</td>
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<td>31.85  85.03  202.62  99.54  44.01  55.54</td>
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<td>32.81  87.96  228.09  105.34 47.92  57.42</td>
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<tr>
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<td>34.19  88.89  300.67  126.02 50.02  76.00</td>
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<td>50 Gypsum</td>
<td>33.62  85.67  259.94  122.66 48.88  73.78</td>
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<td>60 Gypsum</td>
<td>28.50  83.95  233.10  119.54 45.98  73.57</td>
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<td>70 Gypsum</td>
<td>25.58  74.93  167.47  110.45 41.90  68.55</td>
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<td>20 Ammonium sulphate</td>
<td>38.86  106.03  214.92  104.75 45.43  59.32</td>
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<td>20 Single Super phosphate</td>
<td>34.70  92.85  161.61  100.25 46.10  54.15</td>
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<td>2.61  9.70  35.72  7.86  2.76  6.68</td>
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<th>Potassium uptake (kg ha-1)</th>
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<tr>
<td></td>
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<td>30 DAS  60 DAS  90 DAS  Harvest  Seed  Stover</td>
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<td>62.63  75.82  132.32  105.03 17.86  87.17</td>
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<td>72.26  93.95  165.88  162.61 26.81  135.60</td>
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<td>73.91  105.13 195.20  184.89 33.37  151.32</td>
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<td>30 Gypsum</td>
<td>85.86  117.03 285.91  187.66 34.61  153.08</td>
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<td>92.66  130.46 248.04  187.70 34.55  153.15</td>
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<td>80.28  121.99 247.53  189.00 33.79  155.21</td>
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<td>74.17  119.69 233.04  194.79 32.81  161.99</td>
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<td>65.49  115.66 213.74  184.57 28.91  157.66</td>
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<td>82.52  113.17 260.69  202.31 34.15  168.17</td>
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<td>75.44  86.59  222.19  181.36 30.86  150.51</td>
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<td>7.81  9.14  26.68  16.17  2.90  15.47</td>
</tr>
<tr>
<td>CD(P=0.05) on comparison NS</td>
<td>26.52  77.41  46.92  8.42  NS</td>
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<th>S Kg ha-1 Sources</th>
<th>Potassium uptake (kg ha-1)</th>
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<td>30 DAS  60 DAS  90 DAS  Harvest  Seed  Stover</td>
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<td>42.97  71.75  128.29  91.30  25.28  66.01</td>
</tr>
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<td>49.96  94.33  162.37  126.97 34.54  92.43</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>52.78  100.98 198.81  142.11 38.68  115.43</td>
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<tr>
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<td>59.33  107.49 257.00  148.51 41.26  105.25</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>63.42  114.68 274.35  156.86 42.28  114.58</td>
</tr>
<tr>
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<td>56.95  103.83 253.73  155.83 41.34  114.49</td>
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<td>51.33  101.82 233.07  157.17 39.39  117.78</td>
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<tr>
<td>20 Ammonium sulphate</td>
<td>60.69  109.60 237.80  153.53 39.79  113.74</td>
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<tr>
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<td>55.07  94.72  191.10  140.80 38.48  102.33</td>
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<td>3.83  6.83  21.76  9.05  1.89  8.49</td>
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<tr>
<td>CD(P=0.05) on comparison 10.81</td>
<td>19.29  61.45  25.55  5.32  23.96</td>
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by stover was found significant @ 40 kg S ha-1 over control during first year but it was not significant during second year. The K uptake @ 70 kg S ha-1 significantly decreased over 40 kg S ha-1 at 30 DAS and by seed during first year. Ammonium sulphate resulted the highest K uptake at all the growth stages during both the year but these sources were found at par. The actual uptake was found to increase with plant age up to 90 DAS. A luxuriant uptake of K was recorded during 60 DAS to 90 DAS period in both the year.

The pooled K consumption increased with increasing levels of S upto 40 kg S ha-1 at all the growth stages, but higher than that S level it showed decreasing trend. However, it significantly increased @ 30 kg Sha-1 over control at 30 DAS. However, it increased successively and significantly at 60 DAS and at harvest with 10 & 40 kg S ha-1, at 90 DAS with 20 and 40 kg S ha-1, by seed with 10 and 30 kg S ha-1 and by stover with 10 and 60 kg S ha-1. The K uptake @ 70kg S ha-1 significantly reduced over 30 to 50 kg S ha-1 at 30 DAS, 60 DAS, 90 DAS and seed. Ammonium sulphate resulted the highest K uptake at all the growth stages but the S sources were found at par.

4.2.4.1 Sulphur content

The data presented in table 4.12 indicate that in general, the S content increased with increasing levels of S up to 40 kg S ha-1 at all the growth
Table 4.12
Effect of levels and sources of S on Sulphur content at different growth stages of soybean

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<tr>
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<td>Gypsum</td>
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<td>Ammonium sulphate</td>
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<td>Single super phosphate</td>
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<td>CD(P=0.05) on comparison</td>
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S Kg ha-1 Sources

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S Kg ha-1 Sources

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<td>30 DAS</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
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<td>50</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
stages during both the year. However, during first year, the S content significantly and successively increased with 20 and 40 kg S ha-1 at 30 DAS but the S treatments were not significant at 60 DAS, 90 DAS and in seed. However, it was found significant @ 10 kg S ha-1 over control at 30 DAS, 60 DAS & 90 DAS during second year. The S content successively and significantly increased in seed with 20 and 40 kg Sha-1 & in stover with 10 & 30 kg Sha-1 during second year as well as in stover with 20 and 50 kg S ha-1 during first year. The S content @70 kg S ha-1 significantly decreased over 40 kg S ha-1 at 30 DAS during first year & over 20 to 40 kg S ha-1 at 30 DAS over 20 kg S ha-1 & over 20 to 60 kg S ha-1 in stover during second year. The sources of S were found nonsignificant at all the growth stages during both the year.

The pooled S content increased with increasing levels of S up to 40 kg S ha-1 at all plant stages. With further increase of S level, the concentration were found to decrease. However, the S content at 30 DAS, 60 DAS, 90 DAS and in stover significantly increased @ 10 kg S ha-1 over control. The application of S @ 30 kg S ha-1 also significantly improved the S content at 30 DAS and in stover over at 10 kg S ha-1. However, in seed, it also successively and significantly increased with 20 to 40 kg S ha-1 but higher than that S level were found at par. The S content at 30 DAS and in stover @ 70 kg S ha-1 significantly lower over 20 to 50 kg S
ha-1 and 40 to 60 kg S ha-1 respectively. Ammonium sulphate produced significantly higher S content in seed than single superphosphate at the same level of S but these sources were found at par in rest of the growth stages.

4.2.4.2 Sulphur uptake

The data presented in Table 4.13 revealed that in general, the S uptake also increased with increasing levels of S up to 40 kg ha-1 and showed decreasing trend at higher than that S level at all growth stages during both the year. During first year, the S uptake at 30 DAS and 90 DAS successively and significantly increased with 20 and 40 kg S ha-1, at harvest with 10, 30 and 50 kg S ha-1 but it was found nonsignificant at 60 DAS. While the S uptake by seed and stover at harvest significantly increased @ 20/30 kg S ha-1 over control. During second year, it was significantly increased @ 10 kg S ha-1 over control at all the growth stages except by seed in which it was also found successive significant @ 20 & 40 kg S ha-1 over control. However, higher S application @ 30 and 40 kg S ha-1 also increased the S uptake over at 10 kg S ha-1 at harvest and by stover respectively, but higher than 10 kg S ha-1 were found at par at 60 DAS & 90 DAS. The S uptake @ 70 kg S ha-1 significantly decreased over 30/40 kg S ha-1 at 30 DAS and 90 DAS during first year and at 30 DAS, at harvest as well as by seed and stover during second year. Ammonium sulphate
### Table 4.13
Effect of levels and sources of S on Sulphur uptake at different growth stages of soybean

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Sulphur uptake (kg ha⁻¹)</th>
<th>1989</th>
<th>30 DAS</th>
<th>60 DAS</th>
<th>90 DAS</th>
<th>Harvest</th>
<th>Seed</th>
<th>Stover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø Control</td>
<td>1.26</td>
<td>4.57</td>
<td>6.47</td>
<td>4.08</td>
<td>3.49</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>1.41</td>
<td>5.07</td>
<td>10.28</td>
<td>6.20</td>
<td>4.47</td>
<td>1.74</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>1.88</td>
<td>5.41</td>
<td>12.80</td>
<td>6.88</td>
<td>4.75</td>
<td>2.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>2.22</td>
<td>5.53</td>
<td>14.46</td>
<td>7.94</td>
<td>5.25</td>
<td>2.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>2.61</td>
<td>5.69</td>
<td>19.87</td>
<td>9.20</td>
<td>5.68</td>
<td>3.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>2.19</td>
<td>5.68</td>
<td>16.68</td>
<td>10.21</td>
<td>6.01</td>
<td>4.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>1.83</td>
<td>5.15</td>
<td>14.95</td>
<td>9.04</td>
<td>5.29</td>
<td>3.75</td>
<td></td>
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</tr>
<tr>
<td>70 Gypsum</td>
<td>1.65</td>
<td>4.33</td>
<td>10.68</td>
<td>8.64</td>
<td>5.08</td>
<td>3.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>1.95</td>
<td>7.15</td>
<td>12.56</td>
<td>8.28</td>
<td>6.01</td>
<td>2.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>1.53</td>
<td>5.28</td>
<td>10.32</td>
<td>6.61</td>
<td>4.50</td>
<td>2.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SEM+** CD(P=0.05) on comparison of

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Sulphur uptake (kg ha⁻¹)</th>
<th>1990</th>
<th>30 DAS</th>
<th>60 DAS</th>
<th>90 DAS</th>
<th>Harvest</th>
<th>Seed</th>
<th>Stover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø Control</td>
<td>1.60</td>
<td>1.24</td>
<td>2.15</td>
<td>2.85</td>
<td>2.14</td>
<td>0.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>3.61</td>
<td>4.36</td>
<td>5.47</td>
<td>7.19</td>
<td>4.44</td>
<td>2.75</td>
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</tr>
<tr>
<td>20 Gypsum</td>
<td>4.08</td>
<td>4.88</td>
<td>7.47</td>
<td>8.65</td>
<td>5.20</td>
<td>3.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>4.10</td>
<td>5.28</td>
<td>8.35</td>
<td>11.21</td>
<td>7.31</td>
<td>3.90</td>
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<td></td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>4.67</td>
<td>6.01</td>
<td>7.32</td>
<td>13.25</td>
<td>6.73</td>
<td>4.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>3.59</td>
<td>5.66</td>
<td>7.19</td>
<td>11.74</td>
<td>7.55</td>
<td>4.19</td>
<td></td>
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<tr>
<td>60 Gypsum</td>
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<td>6.63</td>
<td>11.69</td>
<td>7.54</td>
<td>4.34</td>
<td></td>
<td></td>
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<tr>
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<td>4.63</td>
<td>5.44</td>
<td>7.11</td>
<td>5.54</td>
<td>1.57</td>
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</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>4.24</td>
<td>5.28</td>
<td>8.05</td>
<td>9.72</td>
<td>6.41</td>
<td>3.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>4.29</td>
<td>3.81</td>
<td>7.03</td>
<td>7.32</td>
<td>4.69</td>
<td>2.63</td>
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</table>

**SEM+** CD(P=0.05) on comparison

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Sulphur uptake (kg ha⁻¹)</th>
<th>Pooled</th>
<th>30 DAS</th>
<th>60 DAS</th>
<th>90 DAS</th>
<th>Harvest</th>
<th>Seed</th>
<th>Stover</th>
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<tbody>
<tr>
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<td>2.94</td>
<td>0.43</td>
<td>3.47</td>
<td>2.81</td>
<td>0.68</td>
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<tr>
<td>10 Gypsum</td>
<td>2.51</td>
<td>4.72</td>
<td>0.78</td>
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<td>4.45</td>
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<td>10.14</td>
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<td>2.79</td>
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<td>11.41</td>
<td>9.57</td>
<td>6.28</td>
<td>3.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>3.64</td>
<td>5.85</td>
<td>13.60</td>
<td>11.22</td>
<td>7.31</td>
<td>3.92</td>
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<tr>
<td>50 Gypsum</td>
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<td>5.67</td>
<td>11.94</td>
<td>10.97</td>
<td>6.78</td>
<td>4.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 Gypsum</td>
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<td>5.41</td>
<td>10.79</td>
<td>10.46</td>
<td>6.41</td>
<td>4.05</td>
<td></td>
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<tr>
<td>70 Gypsum</td>
<td>2.92</td>
<td>4.48</td>
<td>0.86</td>
<td>7.88</td>
<td>5.31</td>
<td>2.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>3.99</td>
<td>6.22</td>
<td>10.31</td>
<td>9.00</td>
<td>6.21</td>
<td>2.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>2.91</td>
<td>4.55</td>
<td>0.86</td>
<td>6.96</td>
<td>4.59</td>
<td>2.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SEM+** CD(P=0.05) on comparison
showed the significantly higher S uptake at harvest than single superphosphate at the same S level during first year. It was also proved superior to gypsum / single superphosphate for S uptake by seed during first year. The maximum S uptake was also observed with ammonium sulphate by most of the growth stages during second year i.e. 30 DAS, 60 DAS & by stover but these sources were found at par during second year.

The pooled S uptake also increased with increasing levels of S upto 40 kg ha⁻¹ but it reduced higher than that S level. The S uptake at 30 DAS and 60 DAS than that S level were found nonsignificant at 60 DAS. However, it was further increased significantly @ 40 kg S ha⁻¹ over 10 kg S ha⁻¹ at 30 DAS. While the S uptake at 90 DAS and by stover was found significant @20 kg S ha⁻¹ over control. It was successively and significantly increased with 10 and 30 kg S ha⁻¹ by seed as well as by seed+stover. The higher application of S @ 70 kg S ha⁻¹ significantly decreased the S uptake over @ 40 kg S ha⁻¹ at 30 DAS, 90 DAS, by seed and seed+stover. Ammonium sulphate resulted the highest S uptake at all the growth stages. However, it produced significantly higher S uptake by seed than single superphosphate at the same level of 20 kg S ha⁻¹ but these sources were found at par in rest of the growth stages.
4.2.4.3 Sulphur utilization

The data presented in table 4.14 clearly indicated that the utilization of applied S decreased with increasing levels of S during both the year as well as in their mean value. The maximum utilization was found 21.20 and 43.40 per cent during first and second year respectively @ 10 kg S ha-1 which gave the mean maximum value 32.30 per cent. The utilization of S was found lower than second year. Amongst the sources of S, ammonium sulphate resulted higher S utilization than gypsum and single superphosphate at the same level of S @ 20 kg S ha-1 during both the year and giving the mean value of 27.65 per cent.

4.3 EFFECT OF LEVELS AND SOURCES S ON SEED QUALITY OF SOYBEAN

4.3.1 Crude protein content

The data presented in table 4.15 showed that increasing levels of S up to 40 kg ha-1 increased the crude protein content during both the years as well as in their pooled values but higher than that S level reduced the crude protein content, though the S treatments were found non-significant in all the cases. The pooled maximum protein content 45% was recorded @ 40 kg S ha-1. Amongst the sources of S, ammonium sulphate produced higher crude protein content in seed than gypsum and single superphosphate at the same dose of 20 kg S ha-1 during both the year as well as in their pooled value (45.08%).
Table 4.14
Effect of levels and sources of Sulphur on utilization of applied sulphur in soybean

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Utilization of applied S(%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1989</td>
</tr>
<tr>
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<td>21.20</td>
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<td>30 Gypsum</td>
<td>12.87</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>12.80</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>12.26</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>8.27</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>6.51</td>
</tr>
<tr>
<td>20 Ammonium sulphate</td>
<td>21.00</td>
</tr>
<tr>
<td>20 Single super phosphate</td>
<td>12.65</td>
</tr>
</tbody>
</table>
Table 4.15

Effect of levels and sources of sulphur on crude protein, oil content and oil yield of soybean

<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
<th>Crude protein content (%)</th>
<th>Oil content(%)</th>
<th>Oil yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Control</td>
<td>38.13</td>
<td>36.25</td>
<td>37.19</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>39.54</td>
<td>44.22</td>
<td>41.88</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>40.01</td>
<td>44.38</td>
<td>42.79</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>41.72</td>
<td>44.89</td>
<td>43.20</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>45.16</td>
<td>44.85</td>
<td>45.00</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>44.85</td>
<td>44.69</td>
<td>44.77</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>42.82</td>
<td>43.75</td>
<td>43.28</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>42.50</td>
<td>42.50</td>
<td>42.50</td>
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<tr>
<td>20 Ammonium sulphate</td>
<td>45.16</td>
<td>45.00</td>
<td>45.08</td>
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<tr>
<td>20 Single super phosphate</td>
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<td>44.85</td>
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<td>CD(P=0.05)on comparison of</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
4.3.2 Oil content

The data on oil content in seed presented in table 4.15 indicated that the oil content increased with increasing levels of S upto 40 kg ha\(^{-1}\) during first year and upto 20 kg S ha\(^{-1}\) during second year but higher than that S levels showed decreasing trend in both the year, though the S treatments were not significant during first year. However, the significant increase of oil content was recorded @ 20 kg S ha\(^{-1}\) over control during second year as well as in the pooled oil content. The pooled oil content 18.75 % was recorded @ 40 kg S ha\(^{-1}\). Ammonium sulphate was found significantly superior to single superphosphate at the same rate of 20 kg S ha\(^{-1}\) during second year. While the pooled oil content with ammonium sulphate(18.76%) and gypsum(18.65%) were found significantly superior to single superphosphate (18.43%) at the same level of 20 kg S ha\(^{-1}\).

4.3.3 Oil yield

The data presented in table 4.15 revealed the oil yield increased with increasing levels of S up to 40 kg ha\(^{-1}\) during first year and upto 60 kg ha\(^{-1}\) during second year but higher than that S level reduced the oil yield. However, the oil yield significantly increased @ 10 and 20 kg S ha\(^{-1}\) during first and second year respectively but it decreased significantly @70 kg S ha\(^{-1}\) over @20 to 60 kg S ha\(^{-1}\) during second year. Ammonium sulphate produced significantly
higher oil yield than single superphosphate at the same level during second year but these sources were found at par during first year.

The pooled oil yield also increased with increasing levels of S upto 40 kg ha\(^{-1}\) but higher than that S level it showed decreasing trend. However, it significantly and successively increased with 10 and 30 kg S ha\(^{-1}\) but it decreased significantly @70 kg S ha\(^{-1}\) over 20 to 60 kg Sha\(^{-1}\). Amongst the sources of S, ammonium sulphate produced higher oil yield than single superphosphate and gypsum at the same rate of 20 kg S ha\(^{-1}\) but these sources were found at par.

4.4 EFFECT OF LEVELS AND SOURCES OF SULPHUR ON NUTRIENT AVAILABILITY

4.4.1.1 Available nitrogen:–

The data presented in table 4.16 indicated that, in general the available N in different soil depth increased with increasing levels of S upto 30 to 50 kg ha\(^{-1}\) at all plant growth stages during 1989 but it showed reduction at higher than that S level. Amongst the sources of S, ammonium sulphate has resulted higher available N than single superphosphate and gypsum at all growth stages during 1989.

In general, the post harvest available N status during first year was found more than second year.

4.4.1.2 Available phosphorus:–

The data showed in table 4.17 indicated that the increasing levels of S upto 40/50 kg ha\(^{-1}\) increased the available P in various soil depth at all growth stages during 1989. However, when S level increased than that
Table 4.16
Effect of levels and sources of sulphur on available N in soil at different growth stages of soybean

<table>
<thead>
<tr>
<th>S kg ha⁻¹ Sources</th>
<th>30 DAS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0-15</td>
<td>15-30</td>
</tr>
<tr>
<td>0 Control</td>
<td>413</td>
<td>391</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>415</td>
<td>345</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>483</td>
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<td>30 Gypsum</td>
<td>460</td>
<td>402</td>
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<td>495</td>
<td>426</td>
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<tr>
<td>50 Gypsum</td>
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<td>437</td>
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<td>368</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>414</td>
<td>414</td>
</tr>
<tr>
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<td>448</td>
<td>506</td>
</tr>
<tr>
<td>20 Single sup. phosphate</td>
<td>448</td>
<td>460</td>
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<table>
<thead>
<tr>
<th>S Kg ha⁻¹ Sources</th>
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<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>368</td>
<td>357</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>368</td>
<td>368</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>444</td>
<td>360</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>391</td>
<td>368</td>
</tr>
<tr>
<td>40 Gypsum</td>
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<td>357</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>403</td>
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<td>380</td>
<td>322</td>
</tr>
<tr>
<td>70 Gypsum</td>
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<td>344</td>
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<td>20 Ammonium Sulphate</td>
<td>485</td>
<td>379</td>
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<tr>
<td>20 Single Sup. phosphate</td>
<td>472</td>
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### TABLE 4.17
Effect of levels and sources of sulphur on available P in soil at different growth stages of soybean

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level it showed reduction in availability of P in soil in both the year. The behaviour of S sources was found quite similar as observed in case of available N. In general, the P status was higher after first harvest than second one.

4.4.1.3 Available potassium:

The data presented in table 4.18 also showed that application of increasing levels of S upto 60 kg ha\(^{-1}\) increased in various soil depth at all growth stages during 1989 but it reduced at 70 kg S ha\(^{-1}\) in both the year. Amongst the sources of S higher K status was also observed with ammonium sulphate than gypsum and single superphosphate in both the year. In general, the available K status was found higher after first harvest than second year.

4.4.1.4 Available sulphur:

The data presented in table 4.19 clearly indicated that increasing levels of S upto 40 to 60 kg ha\(^{-1}\) increased the available S in various soil depth at all growth stages during 1989. However, higher than that S level showed reduction in the availability of sulphur in both the year. Ammonium sulphate as a source of sulphur produced higher availability of S at various soil depths at all growth stages during both the year. In general, the post harvest available soil status was found more during second year than first year.
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4.4.2 EFFECT OF LEVELS AND SOURCES OF \( S \) ON POST HARVEST PHYSICO-CHEMICAL SOIL PROPERTIES:

4.4.2.1 pH and electrical conductivity:

The data presented in table 4.20 indicated that the increasing levels of \( S \) through gypsum has resulted a little effect on \( pH \) and electrical conductivity after two year experiment. In general, the \( pH \) and electrical conductivity were found to increase with 20/30 kg \( S \) ha\(^{-1}\) at various soil depth but higher than that \( S \) level the trend was found irregular in both the cases. Amongst the sources of \( S \), the higher \( pH \) value was observed with ammonium sulphate upto 45 cm soil depth but it was the lowest at 45-60 cm depth amongst the sources of \( S \). However, the maximum value of electrical conductivity was observed with gypsum amongst the sources of \( S @ 20 \) kg ha\(^{-1}\).

4.4.2.2 Available nutrient status:

The data presented in table 4.21 clearly indicated that the post harvest available N, P and K in general, increased with increasing levels of \( S \) upto 30/40 kg ha\(^{-1}\) at all soil depth but the reduction in these nutrient status was observed when the \( S \) level increased to more than 30/40 kg \( S \) ha\(^{-1}\), though the \( S \) levels through gypsum were found at par amongst themselves for the N and K status at all soil depth. Amongst the sources of \( S \), ammonium sulphate was found superior to gypsum and single superphosphate for all the nutrients and at all soil depth but these sources
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Effect of levels and sources of sulphur on post harvest pH and Electrical conductivity

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### Table 4.21
Effect of levels and sources of sulphur on post harvest available nutrients in soil

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<td>Gypsum</td>
<td>270 264 201 184</td>
<td>63 70 72 70</td>
</tr>
<tr>
<td>50</td>
<td>Gypsum</td>
<td>270 253 184 178</td>
<td>48 54 36 48</td>
</tr>
<tr>
<td>60</td>
<td>Gypsum</td>
<td>270 224 212 167</td>
<td>44 51 38 41</td>
</tr>
<tr>
<td>70</td>
<td>Gypsum</td>
<td>230 218 195 161</td>
<td>57 37 48 45</td>
</tr>
<tr>
<td>20</td>
<td>Ammonium</td>
<td>253 236 230 241</td>
<td>43 56 54 43</td>
</tr>
<tr>
<td>20</td>
<td>Sulphate</td>
<td>238 218 218 230</td>
<td>50 52 50 43</td>
</tr>
<tr>
<td></td>
<td>phosphates</td>
<td>50 52 50 43</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEm⁺</td>
<td>15 19 18 13</td>
<td>4 5 5 3</td>
</tr>
<tr>
<td></td>
<td>CD(p=0.05)</td>
<td>NS NS NS NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>on comparison</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S kg ha⁻¹</th>
<th>Sources</th>
<th>Av. K (kg ha⁻¹)</th>
<th>Av. S (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-15 15-30 30-45 45-60</td>
<td>0-15 15-30 30-45 45-60</td>
</tr>
<tr>
<td>0</td>
<td>Control</td>
<td>426 381 314 336</td>
<td>3.01 3.68 3.62 3.49</td>
</tr>
<tr>
<td>10</td>
<td>Gypsum</td>
<td>440 392 347 342</td>
<td>3.80 4.00 3.44 3.74</td>
</tr>
<tr>
<td>20</td>
<td>Gypsum</td>
<td>455 396 370 358</td>
<td>5.50 4.02 6.37 5.00</td>
</tr>
<tr>
<td>30</td>
<td>Gypsum</td>
<td>465 426 392 433</td>
<td>6.54 5.14 6.68 5.42</td>
</tr>
<tr>
<td>40</td>
<td>Gypsum</td>
<td>403 403 386 358</td>
<td>7.07 5.26 8.00 5.71</td>
</tr>
<tr>
<td>50</td>
<td>Gypsum</td>
<td>415 387 370 358</td>
<td>7.81 5.27 8.96 6.98</td>
</tr>
<tr>
<td>60</td>
<td>Gypsum</td>
<td>441 420 370 358</td>
<td>9.70 5.48 7.47 5.70</td>
</tr>
<tr>
<td>70</td>
<td>Gypsum</td>
<td>426 420 403 398</td>
<td>9.80 7.76 6.96 3.40</td>
</tr>
<tr>
<td>20</td>
<td>Ammonium</td>
<td>459 420 420 420</td>
<td>9.18 3.98 6.04 6.72</td>
</tr>
<tr>
<td>20</td>
<td>Sulphate</td>
<td>415 409 403 386</td>
<td>6.18 4.36 4.98 7.50</td>
</tr>
<tr>
<td></td>
<td>phosphates</td>
<td>6.18 4.36 4.98 7.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEm⁺</td>
<td>18 20 24 24</td>
<td>1.53 0.68 1.40 0.95</td>
</tr>
<tr>
<td></td>
<td>CD(p=0.05)</td>
<td>NS NS NS NS</td>
<td>4.44 1.99 NS 2.76</td>
</tr>
<tr>
<td></td>
<td>on comparison</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
were also found at par amongst themselves.

The available P status, significantly increased @ 10/20 kg S ha⁻¹ over control at all soil depth. However, the P status was also found significantly superior @ 30/40 kg S ha⁻¹ over @ 10/20 kg S ha⁻¹ at 30-45 and 45-60 cm but it significantly decreased @ 50 to 70 kg S ha⁻¹ over 30/40 kg S ha⁻¹.

The S status at 0-15 and 15-30 cm soil depth was found to increase with increasing levels of S upto 70 kg S ha⁻¹ while this increasing trend was observed upto 50 kg S ha⁻¹ at 30-45 and 45-60 cm soil depth. However, the S status was found significantly higher @ 50 kg S ha⁻¹ at 0-15 and 45-60 cm soil depth but it decreased significantly @ 70 kg S ha⁻¹ over 50 kg S ha⁻¹ at 45 to 60 cm. While it was significantly increased @ 70 kg S ha⁻¹ over control at 15-30 cm.

4.4.2.2 Balance sheet of sulphur:

The balance of available sulphur in soil was calculated on the basis of mean value of presowing (1989 & 1990) and post harvest soil test value, mean yield and
Table 4.22

Effect of levels and sources of S on balance sheet of sulphur in soil

<table>
<thead>
<tr>
<th>S Sources</th>
<th>Pre sowing Soil Av. S (kg ha⁻¹)</th>
<th>Sulphur Uptake (kg ha⁻¹)</th>
<th>Post harvest Av. S (kg ha⁻¹)</th>
<th>Balance S (kg ha⁻¹)</th>
<th>Difference S (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Control</td>
<td>8.2</td>
<td>3.47</td>
<td>2.97</td>
<td>4.73</td>
<td>-1.76</td>
</tr>
<tr>
<td>10 Gypsum</td>
<td>8.69</td>
<td>6.70</td>
<td>4.05</td>
<td>12.19</td>
<td>-9.14</td>
</tr>
<tr>
<td>20 Gypsum</td>
<td>8.91</td>
<td>7.76</td>
<td>4.93</td>
<td>21.15</td>
<td>-18.22</td>
</tr>
<tr>
<td>30 Gypsum</td>
<td>8.92</td>
<td>9.57</td>
<td>5.45</td>
<td>29.35</td>
<td>-23.90</td>
</tr>
<tr>
<td>40 Gypsum</td>
<td>9.05</td>
<td>11.22</td>
<td>5.85</td>
<td>37.83</td>
<td>-31.98</td>
</tr>
<tr>
<td>50 Gypsum</td>
<td>9.16</td>
<td>10.97</td>
<td>6.33</td>
<td>48.19</td>
<td>-41.86</td>
</tr>
<tr>
<td>60 Gypsum</td>
<td>8.68</td>
<td>10.46</td>
<td>6.79</td>
<td>58.22</td>
<td>-51.43</td>
</tr>
<tr>
<td>70 Gypsum</td>
<td>8.01</td>
<td>7.88</td>
<td>6.18</td>
<td>70.13</td>
<td>-63.95</td>
</tr>
<tr>
<td>80 Ammonium Sulphate</td>
<td>8.38</td>
<td>9.00</td>
<td>6.23</td>
<td>19.38</td>
<td>-13.15</td>
</tr>
<tr>
<td>90 Single Superphos</td>
<td>8.24</td>
<td>6.96</td>
<td>4.60</td>
<td>21.28</td>
<td>-16.68</td>
</tr>
</tbody>
</table>
uptake and presented in table 4.22. It is clear from the table that application of increasing levels of S @ 10 to 70 kg ha\(^{-1}\) in soil, decreased the availability of S in soil from -8.14 to -63.95 kg S ha\(^{-1}\). Amongst the sources of S, maximum decrease of available S was observed with single superphosphate (-16.68 kg S ha\(^{-1}\)) followed by gypsum (-16.22 kg S ha\(^{-1}\)) and ammonium sulphate (-13.15 kg S ha\(^{-1}\)).

4.5 HARVEST INDEX:

The data on harvest index presented in table 4.23 showed that application of increasing levels of S increases the harvest index up to 30 (38.84\%) and 40 (38.33 \%) kg S ha\(^{-1}\) during first and second year respectively but it decreased at higher than that S levels during both the years. However, the highest mean value 38.57\% was observed at 30 kg S ha\(^{-1}\). Although, the maximum value of harvest index was observed with gypsum amongst the different sources of S during both the years as well as in the mean value.

4.6 YARD STICK VALUE

The data presented in table 4.23 indicated that yard stick value decreased with increasing levels of S through gypsum during both the years. The mean maximum value 28.18\% was recorded in no-S treatment. Amongst the S levels, mean maximum value of 27.85\% @ 10 kg S ha\(^{-1}\) and minimum value of 15.27 \% @ 70 kg S ha\(^{-1}\) was recorded. Amongst the sources of S, higher yard stick value was recorded with ammonium sulphate than gypsum and single superphosphate during both the years. The mean maximum value of 26.20 per cent was also recorded with ammonium sulphate followed by 25.80\% with gypsum and 24.92\% with single superphosphate.
### Table 4.23
Effect of levels and sources of S on harvest index of soybean

<table>
<thead>
<tr>
<th>S Kg/ha</th>
<th>Sources</th>
<th>Harvest index(%)</th>
<th>Yard stick value(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1989</td>
<td>1990</td>
</tr>
<tr>
<td>0</td>
<td>Control</td>
<td>33.88</td>
<td>37.58</td>
</tr>
<tr>
<td>10</td>
<td>Gypsum</td>
<td>37.18</td>
<td>36.73</td>
</tr>
<tr>
<td>20</td>
<td>Gypsum</td>
<td>37.74</td>
<td>37.55</td>
</tr>
<tr>
<td>30</td>
<td>Gypsum</td>
<td>38.84</td>
<td>38.29</td>
</tr>
<tr>
<td>40</td>
<td>Gypsum</td>
<td>37.33</td>
<td>38.33</td>
</tr>
<tr>
<td>50</td>
<td>Gypsum</td>
<td>36.49</td>
<td>37.78</td>
</tr>
<tr>
<td>60</td>
<td>Gypsum</td>
<td>34.7</td>
<td>37.66</td>
</tr>
<tr>
<td>70</td>
<td>Gypsum</td>
<td>35.12</td>
<td>35.12</td>
</tr>
<tr>
<td>20</td>
<td>Ammonium sulphate</td>
<td>37.15</td>
<td>36.78</td>
</tr>
<tr>
<td>20</td>
<td>Single super phosphate</td>
<td>37.39</td>
<td>35.83</td>
</tr>
</tbody>
</table>

### Table 4.24
Effect of levels and sources of S on economics of sulphur fertilizer

<table>
<thead>
<tr>
<th>S Kg ha-1 Sources</th>
<th>Grain (kg ha-1)</th>
<th>Stover (kg ha-1)</th>
<th>Cost of N:P:20:5:20:S (Rs.)</th>
<th>Total cost (Rs.)</th>
<th>Net income (Rs.)</th>
<th>Net return (Rs.)</th>
<th>B:C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>Control</td>
<td>2023</td>
<td>3610</td>
<td>886.16</td>
<td>8200.16</td>
<td>18639.5</td>
<td>104439.34</td>
</tr>
<tr>
<td>10</td>
<td>Gypsum</td>
<td>2286</td>
<td>3903</td>
<td>881.89</td>
<td>8235.89</td>
<td>20992.2</td>
<td>126872.20</td>
</tr>
<tr>
<td>20</td>
<td>Gypsum</td>
<td>2368</td>
<td>3924</td>
<td>1077.62</td>
<td>8391.62</td>
<td>21697.6</td>
<td>133059.88</td>
</tr>
<tr>
<td>30</td>
<td>Gypsum</td>
<td>2475</td>
<td>3947</td>
<td>1173.35</td>
<td>8487.19</td>
<td>22616.3</td>
<td>1412911.5</td>
</tr>
<tr>
<td>40</td>
<td>Gypsum</td>
<td>2482</td>
<td>4073</td>
<td>1269.08</td>
<td>8553.08</td>
<td>22726.2</td>
<td>1414312.1</td>
</tr>
<tr>
<td>50</td>
<td>Gypsum</td>
<td>2461</td>
<td>4116</td>
<td>1364.81</td>
<td>8870.81</td>
<td>22564.9</td>
<td>138868.89</td>
</tr>
<tr>
<td>60</td>
<td>Gypsum</td>
<td>2401</td>
<td>4209</td>
<td>1460.54</td>
<td>8774.54</td>
<td>22082.1</td>
<td>1331755.6</td>
</tr>
<tr>
<td>70</td>
<td>Gypsum</td>
<td>2160</td>
<td>4028</td>
<td>1558.27</td>
<td>8870.27</td>
<td>20141.2</td>
<td>1127093.93</td>
</tr>
<tr>
<td>20</td>
<td>Ammonium sulphate</td>
<td>2405</td>
<td>4099</td>
<td>1110.57</td>
<td>8424.57</td>
<td>22082.1</td>
<td>1365753.5</td>
</tr>
<tr>
<td>20</td>
<td>Single super phosphate</td>
<td>2288</td>
<td>3972</td>
<td>1154.28</td>
<td>8468.28</td>
<td>21038.8</td>
<td>1256852.52</td>
</tr>
</tbody>
</table>
4.7 ECONOMICS OF FERTILIZER SULPHUR:

The data on economics of fertilizer S were calculated on the basis of mean seed and stover yield of soybean (1989 & 1990) and presented in Table 4.24. It indicated that increasing levels of S from 10 to 40 kg S ha⁻¹ increased the net profit from Rs 12697.20 to Rs 14143.12 but there was reduction in net profit at higher S levels. However, the benefit cost ratio 1.68 was found to increased up to 30 kg S ha⁻¹. Amongst the sources of S, the maximum return of Rs 13557.53 was observed with ammonium sulphate followed by Rs 13305.98 with gypsum and Rs 12563.52 with single superphosphate at the same level of 20 kg S ha⁻¹. The benefit cost ratio was also found maximum (1.62) with ammonium sulphate followed by gypsum (1.58) and single superphosphate (1.48).

4.8 OPTIMUM DOSE OF SULPHUR

During first year, the optimum level of S was calculated 39 kg ha⁻¹ for the maximum expected soybean yield of 2284 kg ha⁻¹ with the help of quadratic equation \( Y = 1827.54 + 23.27 X - 0.2966 X^2 \). During second year, it was calculated 36 kg S ha⁻¹ with the expected yield of 2705 kg ha⁻¹ using the equation \( Y = 2254.87 + 2356X - 0.3083 X^2 \). However, on the basis of pooled yield, the optimum dose was found 38 kg S ha⁻¹ which gave the expected yield of 2500 kg ha⁻¹ soybean seed using the equation \( 2037.66 + 23.85 X - 0.3073 X^2 \).