Chapter IV

RESULTS

A field experiment entitled, “Studies on integrated nutrient management through vermicomposting in direct seeded rice-wheat sequence” was conducted at the Experimental Farm of the Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during the Kharif and Rabi seasons of 2003-2004 and 2004-2005, respectively. The results obtained from this study have been presented in this chapter with the help of data tables, suitable figures and diagrams. The analysis of variance tables have been appended in Appendix-I.

4.1 GROWTH PARAMETERS

Observations on various growth parameters under study including plant height, dry matter accumulation and number of shoots/m² were recorded at 30 days interval starting from 30 days after sowing till the harvesting in both the crop seasons.

The effect of vermicompost and chemical fertilizers obtained in respect of paddy crop on these parameters have been presented in Table 4.1-4.10 and depicted graphically in Fig. 4.1-4.3

4.1.1 Plant height

It is apparent from Fig. 4.1 that plant height of paddy crop increased progressively up to 90 days of sowing and after that decreased slightly during both the years of study.
Increasing doses of vermicompost @ 6 t/ha resulted in significant increase in plant height of paddy at all the stages of observation during both the years of study. However, it was found to be at par with vermicompost @ 4 t/ha at harvest stage of crop during 2\textsuperscript{nd} year i.e. *Kharif* 2004. No vermicompost application resulted in lowest plant height at all the stages of observations except at 90 DAS and harvest during *Kharif*, 2003 and 30 DAS during *Kharif* 2004, where it was at par with vermicompost @ 2 t/ha (Table 4.1).

Varying levels of fertilizer application from 1/3 of recommended to recommended dose resulted in significant and consistent increase in plant height of paddy crop at all the stages of observations except at harvest stage during *Kharif* 2004, where it was found to be non-significant.

Recommended dose of fertilizer application produced significantly taller paddy plants than 1/3\textsuperscript{rd} and 2/3\textsuperscript{rd} of recommended dose at all the stages of observations. However, it was found to be at par with 2/3\textsuperscript{rd} of recommended NPK at 90 DAS and harvest stage during *Kharif* 2003 and 30 DAS and at harvest during, *Kharif* 2004. During the entire period of study, absolute control measured shortest plants over all other treatments.

The plant height of paddy at 30 DAS was found to be significantly influenced by the interaction between V x F during *Kharif* 2004 (Table 4.2). Response to graded levels of vermicompost at varying levels of fertilizers was significantly different. At F\textsubscript{1} graded doses of vermicompost did not show significant differences, whereas at F\textsubscript{2} and F\textsubscript{3}, V\textsubscript{3} showed significant increase over other lower levels. But V\textsubscript{0} to V\textsubscript{2} the effect was not significant. Similarly at each
level of vermicompost response to fertilizer levels was significant. At \( V_0 \) and \( V_3 \), increase in fertilizer doses did not increase the plant height significantly, whereas at \( V_1 \), difference between \( F_1 \) and \( F_2 \), and \( F_2 \) and \( F_3 \) was not significant. At \( V_3 \) and \( F_2 \) and \( F_3 \) remaining at par with each other, caused significant increase over \( F_1 \).

**Table 4.2 Interaction effect of vermicompost and fertilizer levels on plant height of paddy at 30 days after sowing (Kharif 2004)**

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>( F_1 )</th>
<th>( F_2 )</th>
<th>( F_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_0 )</td>
<td>23.1</td>
<td>24.6</td>
<td>24.8</td>
</tr>
<tr>
<td>( V_1 )</td>
<td>23.2</td>
<td>23.5</td>
<td>26.7</td>
</tr>
<tr>
<td>( V_2 )</td>
<td>25.3</td>
<td>26.5</td>
<td>26.7</td>
</tr>
<tr>
<td>( V_3 )</td>
<td>26.0</td>
<td>32.4</td>
<td>35.3</td>
</tr>
<tr>
<td><strong>SEm</strong></td>
<td>+1.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CD (5%)</strong></td>
<td>3.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At harvest stage of *Kharif* 2004 (Table 4.3), irrespective of fertilizer levels, in general, application of vermicompost increased the plant height of paddy crop over no vermicompost. At \( F_1 \) level, \( V_1 \), \( V_2 \) and \( V_3 \) remaining at par with each other, resulted in significantly higher plant height over \( V_0 \). At \( F_2 \) level \( V_2 \) and \( V_3 \), remaining at par with each other, resulted in higher plant height of paddy over \( V_0 \), however, \( V_0 \) and \( V_1 \) were also found to be at par with each other. Across vermicompost levels, application of various fertilizer levels increased the plant height, but not to a significant level. At \( V_0 \), \( F_2 \) and \( F_3 \) remaining at par with each other, resulted in significantly higher plant height than \( F_1 \) level. At \( V_1 \) and \( V_2 \)
level $F_1$, $F_2$ and $F_3$ were found to be non significant. At $V_3$ level $F_3$ and $F_2$ remaining at par with each other, resulted in significantly higher plant height than $F_1$, however, $F_1$ and $F_2$ were also found to be at par with each other.

**Table 4.3  Interaction effect of vermicompost and fertilizer levels on plant height of paddy at harvest stage (Kharif 2004)**

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>Fertilizer levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F_1$</td>
</tr>
<tr>
<td>$V_0$</td>
<td>56.9</td>
</tr>
<tr>
<td>$V_1$</td>
<td>64.2</td>
</tr>
<tr>
<td>$V_2$</td>
<td>67.1</td>
</tr>
<tr>
<td>$V_3$</td>
<td>68.5</td>
</tr>
<tr>
<td>SEm±</td>
<td>1.63</td>
</tr>
<tr>
<td>CD (5%)</td>
<td>4.79</td>
</tr>
</tbody>
</table>

**4.1.2  Dry matter accumulation**

The effect of different treatments on dry matter accumulation of paddy crop has been presented in Table 4.4 and have been depicted graphically in Fig. 4.2. A perusal of data revealed that in general, dry matter accumulation increased significantly and consistently up to harvest stage of paddy crop. Increase in dry matter accumulation was slow up to 60 DAS and then it increased up to 90 DAS and after that rate of dry matter accumulation decreased, during both the years of study.

Data in Table 4.4 shows the effect of vermicompost and NPK fertilizers on dry matter accumulation of paddy crop during both the years. Application of vermicompost @ 6 t/ha resulted in significantly higher dry matter
accumulation at all the stages of crop growth during both the years of experimentations except at 90 DAS (*Kharif* 2003) which was followed by vermicompost @ 4 t/ha. Lowest dry matter accumulation was recorded in plots where no vermicompost was applied.

The effect of levels of NPK fertilizers was also found to be significant at all the stages of observations during both the years of study. The increase in NPK fertilizer levels resulted in consistent and significant increase in dry matter accumulation of paddy crop during both the years and at all the stages of observations, with significantly higher dry matter accumulation in plots receiving 100% of recommended doses of NPK fertilizers and lower in plots supplied with 1/3rd of recommended doses of NPK fertilizers in paddy. However, recommended NPK fertilizer and 2/3rd of recommended NPK fertilizer treatments were found to be at par with each other during 30 DAS, 90 DAS and harvest during *Kharif* 2003 and 30 DAS, 60 DAS during *Kharif* 2004.

The absolute control treatment proved to be significantly inferior in terms of dry matter accumulation over all other treatments at all the stages of observations and during both the years of study.

The interaction effect of vermicompost and fertilizer levels on dry matter accumulation of paddy crop was found to be significant at 60 days after sowing and at harvest stage of the crop, during both the years of study (Table 4.5, 4.6, 4.7 and 4.8).
During *Kharif* 2003 (Table 4.5) at \( F_1 \) and \( F_2 \) levels, application of vermicompost, increased the dry matter accumulation significantly in paddy crop. At \( F_1 \) and \( F_2 \) levels \( V_3 \) resulted in significantly higher dry matter accumulation over other levels of vermicompost i.e. \( V_0 \), \( V_1 \) and \( V_2 \), however, \( V_1 \) and \( V_2 \) were found to be at par with each other. At \( F_3 \) level, \( V_2 \) and \( V_3 \) remaining at par with each other, resulted in higher dry matter accumulation over \( V_0 \) and \( V_1 \), however, \( V_0 \) and \( V_1 \) were also found to be at par with each other. Across vermicompost levels, at \( V_0 \) levels, \( F_3 \) resulted in significantly higher dry matter accumulation than \( F_1 \) and \( F_2 \) levels, however, \( F_1 \) and \( F_2 \) were found to be at par with each other. At \( V_2 \) level, equivalent and significant increase in dry matter accumulation was recorded upto \( F_3 \). At \( V_1 \) and \( V_3 \) level, \( F_2 \) and \( F_3 \) remaining at par with each other resulted in higher dry matter accumulation than \( F_1 \) level, however \( F_1 \) and \( F_2 \) were also found to be at par with each other.

**Table 4.5** Interaction effect of vermicompost and fertilizer levels of dry matter accumulation (g/m\(^2\)) at 60 days after sowing (*Kharif* 2003)

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>( F_1 )</th>
<th>( F_2 )</th>
<th>( F_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_0 )</td>
<td>123.3</td>
<td>144.0</td>
<td>179.3</td>
</tr>
<tr>
<td>( V_1 )</td>
<td>158.7</td>
<td>175.3</td>
<td>184.7</td>
</tr>
<tr>
<td>( V_2 )</td>
<td>160.7</td>
<td>190.0</td>
<td>239.3</td>
</tr>
<tr>
<td>( V_3 )</td>
<td>206.0</td>
<td>219.3</td>
<td>244.3</td>
</tr>
</tbody>
</table>

SEm\(\pm\) 8.1

CD (5%) 23.8
At harvest stage of paddy during *Kharif* 2003 (Table 4.6) at F₁ level, V₃ remaining at par with V₂ resulted in significantly higher dry matter accumulation than V₀ level and V₁ and V₂ were also found to be at par with each other. At F₂ level V₃ remaining at par with V₂ resulted in higher dry matter accumulation of paddy than V₀ and V₁ level, V₀, V₁ and V₂ were also found to be at par with each other. At F₃ level, V₃ remaining at par with V₂ resulted in higher dry matter accumulation of paddy than V₀ and V₁ level, however V₀ and V₁, and V₁ and V₂ were also found to be at par with each other.

**Table 4.6  Interaction effect of vermicompost and fertilizer levels on dry matter accumulation (g/m²) at harvest (*Kharif* 2003)**

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>F₁</th>
<th>F₂</th>
<th>F₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₀</td>
<td>527.3</td>
<td>624.7</td>
<td>624.7</td>
</tr>
<tr>
<td>V₁</td>
<td>606.7</td>
<td>627.3</td>
<td>640.3</td>
</tr>
<tr>
<td>V₂</td>
<td>634.3</td>
<td>646.7</td>
<td>658.0</td>
</tr>
<tr>
<td>V₃</td>
<td>652.0</td>
<td>672.0</td>
<td>685.3</td>
</tr>
<tr>
<td>SEm±</td>
<td>11.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (5%)</td>
<td>33.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At V₀ level, F₂ and F₃ remaining at par with each other resulted in higher dry matter accumulation over F₁ level. At V₁, V₂ and V₃ level, F₂ and F₃ remaining at par with each other resulted in higher dry matter accumulation than F₁ level, however, F₁ and F₂ were also found to be at par with each other.

Dry matter accumulation of paddy at 60 days after sowing was found to be significantly influenced by the interaction between V x F during *Kharif* 2004 (Table 4.7). At F₁ level, V₃ remaining at par with V₂, resulted in higher dry matter
accumulation than $V_0$ and $V_1$ levels, however, $V_1$ and $V_2$ were also found to be at par with each other. At $F_2$ levels, $V_3$ remaining at par with $V_2$ resulted in higher dry matter accumulation than $V_0$ and $V_1$, however, $V_0$ & $V_1$ and $V_1$ & $V_2$ were also found to be at par with each other. At $F_3$ level, $V_3$ resulted in significantly higher dry matter accumulation than all other levels $viz.$, $V_0$, $V_1$ and $V_2$, however, $V_2$ and $V_3$ were also found to be at par with each other. At various vermicompost level at $F_3$ resulted in significantly higher dry matter accumulation than $F_1$ and $F_2$, however, $F_1$ and $F_2$ were found to be at par with each other. At $V_0$, $V_1$ and $V_2$ levels all the three levels of fertilizers were found to be at par with each other, except at $V_0$ where $F_2$ & $F_3$ and $F_1$ & $F_2$ were found to be at par with each other.

### Table 4.7 Interaction effect of vermicompost and fertilizer levels on dry mater accumulation (g/m²) at 60 days after sowing (*Kharif* 2004)

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>Fertilizer levels</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F_1$</td>
<td>$F_2$</td>
<td>$F_3$</td>
<td></td>
</tr>
<tr>
<td>$V_0$</td>
<td>138.0</td>
<td>151.3</td>
<td>159.0</td>
<td></td>
</tr>
<tr>
<td>$V_1$</td>
<td>166.3</td>
<td>170.7</td>
<td>183.7</td>
<td></td>
</tr>
<tr>
<td>$V_2$</td>
<td>174.0</td>
<td>179.7</td>
<td>183.7</td>
<td></td>
</tr>
<tr>
<td>$V_3$</td>
<td>195.7</td>
<td>196.7</td>
<td>244.0</td>
<td></td>
</tr>
<tr>
<td>SEm±</td>
<td>7.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (5%)</td>
<td>23.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dry matter accumulation of paddy at harvest stage of crop was found to be significantly influenced by the interaction between $V$ x $F$ during *Kharif* 2004 (Table 4.8). At $F_1$ level, $V_2$ and $V_3$ remaining at par with each other resulted in higher dry matter accumulation than other levels, however, $V_0$ and $V_1$ were also
found to be at par with each other. At F₂ level, V₃ resulted in higher dry matter accumulation than all other levels, however, V₁ and V₂ were found to be at par with each other. At F₃ level, V₃ also resulted in higher dry matter accumulation than all other levels, however V₀ & V₁ and V₁ & V₂ were also found to be at par with each other. At V₃ level, F₃ resulted in significantly higher dry matter accumulation than F₁ and F₂, however, F₂ and F₃ were found to be at par with each other. At V₀ and V₂ levels, F₃ remaining at par with F₂ resulted in higher dry matter accumulation than F₁, however, F₁ and F₂ were also found to be at par with each other. At V₁ level, F₂ and F₃ remaining at par with each other resulted in higher dry matter accumulation than F₁ level.

Table 4.8 Interaction effect of vermicompost and fertilizer levels on dry matter accumulation (g/m²) at harvest (Kharif 2004)

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>Fertilizer levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F₁</td>
</tr>
<tr>
<td>V₀</td>
<td>566.0</td>
</tr>
<tr>
<td>V₁</td>
<td>598.7</td>
</tr>
<tr>
<td>V₂</td>
<td>653.0</td>
</tr>
<tr>
<td>V₃</td>
<td>684.3</td>
</tr>
</tbody>
</table>

SEm+ 17.9
CD (5%) 52.7

4.1.3 Number of shoots/m²

A perusal of data on number of shoots/m² presented in Table 4.9 and depicted graphically in Fig. 4.3 shows an increase upto 90 DAS of paddy crop, irrespective of all treatments and thereafter number of shoots decreased steadily till the harvest of the crop, during both the crop seasons. Among different
vermicompost levels, vermicompost @ 6 t/ha resulted in significantly higher number of shoots/m², which was at par with vermicompost application @ 4 t/ha at 60 and 90 DAS during Kharif 2003 and at 60 DAS and harvest stage of crop during Kharif 2004, whereas, without vermicompost application, significantly lower number of shoots were recorded during both the years of study, however, it was found to be at par with vermicompost @ 2 t/ha during 30 DAS during Kharif 2003 and 30 and 60 DAS during Kharif 2004.

Application of NPK fertilizers also significantly influenced the number of shoots/m², which increased significantly and consistently with the increase in levels of NPK fertilizers, during both the years of study, with recommended dose of NPK fertilizers application resulted in significantly higher number of shoots/m², remaining at par with 2/3rd of recommended NPK fertilizer application at harvest stage of paddy crop during both the years of study. 1/3rd of NPK fertilizers resulted in lowest number of shoots/m² at all the stages of observation, however, it was at par with 2/3rd of recommended NPK at 30 and 60 days after sowing during both the years.

Absolute control resulted in significantly lower number of shoots/m² than all other treatments during both the years of study.

The interaction effect of vermicompost and fertilizers on number of shoots/m² at 30 days after sowing was found to be significantly influencing the number of shoots/m² during both the years (Table 4.10, 4.11). Across fertilizers levels at F₁ and F₂, V₃ remaining at par with V₂ resulted in significantly higher
shoots/m² than other levels, however, V₂ and V₃ and V₁, V₂ and V₃ were also found to be at par with each other. At F₃ level, V₃ resulted in significantly higher number of shoots than V₀, V₁ and V₂, however, V₀ and V₁ were also found to be at par with each other. Across vermicompost levels, at V₀ and V₁ levels, all fertilizer levels were found to be at par with each other with respect to number of shoots/m². At V₂ and V₃ level, F₂ and F₃ remaining at par with each other resulted in significantly higher number of shoots/m² than F₁ level, however, F₁ and F₂ were also found to be at par with each other.

**Table 4.10 Interaction effect of vermicompost and fertilizer levels on number of shoots/m² of paddy at 30 days after sowing (Kharif 2003)**

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>F¹</th>
<th>F₂</th>
<th>F₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₀</td>
<td>250.0</td>
<td>263.3</td>
<td>276.7</td>
</tr>
<tr>
<td>V₁</td>
<td>265.7</td>
<td>271.7</td>
<td>276.7</td>
</tr>
<tr>
<td>V₂</td>
<td>280.0</td>
<td>300.0</td>
<td>343.3</td>
</tr>
<tr>
<td>V₃</td>
<td>296.7</td>
<td>331.7</td>
<td>396.7</td>
</tr>
<tr>
<td>SEm±</td>
<td>15.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (5%)</td>
<td>44.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

During Kharif 2004 (Table 4.11) across fertilizer levels at F₁, V₃ remaining at par with V₂ and V₁ resulted in significantly higher number of shoots than V₀, however, V₀, V₁, V₂ were also found to be at par with each other. At F₂ level, V₃ remaining at par with V₂, resulted in significantly higher number of shoots.
shoots/m² than V₀ and V₁, however, V₀F₁ and V₁F₂ were also found to be at par with each other. At F₃ level, V₃ resulted in significantly higher number of shoots/m² than all other levels of vermicompost, however, V₀ and V₁ were also found to be at par with each other. Across vermicompost levels, at V₀ and V₁ level, F₂ and F₃ were found to be at par with each other with respect to number of shoots/m². At V₂ level, F₂ and F₃ remaining at par with each other, resulted in significantly higher number of shoots than F₁, however, F₁ and F₂ were also found to be at par with each other. At V₃ level, F₃ resulted in significantly higher number of shoots than F₁ and F₂, however, F₁ and F₂ were also found to be at par with each other.

### Table 4.11 Interaction effect of vermicompost and fertilizer levels on number of shoots/m² of paddy at 30 days after sowing (Kharif 2004)

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>F₁</th>
<th>F₂</th>
<th>F₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₀</td>
<td>275.0</td>
<td>288.7</td>
<td>297.7</td>
</tr>
<tr>
<td>V₁</td>
<td>303.0</td>
<td>304.7</td>
<td>314.7</td>
</tr>
<tr>
<td>V₂</td>
<td>323.0</td>
<td>343.0</td>
<td>386.3</td>
</tr>
<tr>
<td>V₃</td>
<td>347.7</td>
<td>377.7</td>
<td>452.7</td>
</tr>
<tr>
<td>SEm±</td>
<td>16.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (5%)</td>
<td>48.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2 Developmental Stages

Number of days taken to attain panicle initiation, flowering and maturity stage of paddy crop

It is evident from Table 4.12 and Fig. 4.4 that application of vermicompost significantly affected the number of days taken to attain panicle initiation, flowering and maturity stage of paddy crop. Increase in the levels of vermicompost resulted in lowering the number of days to reach panicle initiation, flowering and maturity stage during both the years of study. Plots supplied with vermicompost @ 6 t/ha took significantly lower number of days to attain panicle initiation, flowering and maturity stage than all other levels of vermicompost, except at panicle initiation stage during both the years where it was at par with vermicompost @ 4 t/ha; whereas, without vermicompost paddy crop took significantly higher number of days for attaining these stages. Crop supplied with vermicompost @ 6 t/ha took significantly lower number of days for attaining the physiological maturity stages as compared to other three levels of vermicompost viz. 4 t/ha, 2 t/ha and no vermicompost, during both the years of study.

Effect of different levels of NPK fertilizers on panicle initiation and flower stage during Kharif 2003 was found to be non-significant, however, during Kharif 2004, number of days taken to attain panicle initiation stage and maturity stage were found to be significantly affected by levels of NPK fertilizers. Recommended dose of NPK fertilizers took lowest number of days to attain panicle initiation stage and physiological maturity stage.
Absolute control treatments took significantly more number of days to attain panicle initiation, flowering stage and number of days to attain physiological maturity of paddy crop, than all other treatments and during both the years of study.

4.3 **YIELD ATTRIBUTES AND YIELD**

Data pertaining to the effect of vermicompost levels and NPK levels on paddy crop viz. number of panicles/m², number of spikelets/panicle, panicle weight/plant, 1000-grain weight and spikelet fertility per cent has been presented in Table 4.13 and depicted graphically in Fig. 4.5 and 4.6.

4.3.1 **Number of panicles/m²**

Data in Table 4.13 shows that application of vermicompost @ 6 t/ha resulted in significantly higher number of panicles/m² which was found to be at par with vermicompost @ 4 t/ha during the first year of study i.e. *Kharif* 2003. During second year (*Kharif* 2004) of study, application of vermicompost @ 6 t/ha resulted in significantly higher number of panicles/m² than all other three levels of vermicompost.

The effect of different levels of NPK fertilizers on number of panicles/m² was found to be non-significant, however, with the increase in levels of NPK fertilizers, number of panicles/m² also increased and recommended dose of NPK fertilizers resulted in higher number of panicles. Similar trend was obtained during the second year of study i.e. *Kharif* 2004.

Absolute control was found to be inferiormost in terms of number of panicles/m² than all other treatments.
**Number of spikelets/panicle**

As depicted in Fig. 4.5, it is clear that application of vermicompost @ 6 t/ha resulted in significantly higher number of spikelets/panicle during *Kharif* 2003, however, it was found to be at par with vermicompost @ 4 t/ha during *Kharif*, 2004. Without vermicompost, crop produced lower number of spikelets/panicle, however, it was at par with vermicompost @ 2 t/ha during *Kharif*, 2004.

Application of recommended dose of NPK fertilizers resulted in significantly higher number of spikelets/panicle during *Kharif* 2003, however, it was also found to be at par with 2/3rd of recommended NPK fertilizer application, during *Kharif* 2004.

Absolute control proved to be inferiormost than all other treatments as far as number of spikelets/panicle was concerned.

**Weight/panicle**

The data on weight/panicle has been given in Table 4.13 and depicted in Fig. 4.5. Data reveals that with the increase in the levels of vermicompost as well as NPK fertilizer levels, weight per panicle also steadily and consistently increased. A perusal of data reveals that application of vermicompost @ 6 t/ha resulted in significantly higher panicle weight per plant during both the years of study, however, it was found to be at par with application of vermicompost @ 4 t/ha, during *Kharif* 2004. Significantly lower weight/panicle of paddy crop was recorded with no application or without vermicompost application.
Different levels of NPK fertilizers, significantly affected the weight/panicle during Kharif 2004 only and recommended dose of NPK fertilizers, remaining at par with 2/3rd of recommended NPK fertilizers, resulted in significantly higher weight/panicle than 1/3rd of recommended NPK fertilizers.

Absolute control resulted in significantly lower panicle weight/panicle than all other treatments.

1000-grain weight

Data on 1000-grain weight has also been presented in Table 4.13 and depicted in Fig. 4.6. It reveals that, generally with the increase in levels of vermicompost and alongwith increase in the levels of NPK fertilizers, 1000-grain weight of paddy also increased.

The perusal of data reveals that the effect of vermicompost levels on 1000-grain weight was significant only during Kharif 2004. Application of vermicompost @ 6 t/ha produced significantly heavier grains than no vermicompost application and vermicompost @ 4 t/ha and 2 t/ha were found to be at par with each other.

Application of recommended dose of NPK fertilizers produced significantly heavier grains than other two levels of fertilizers during Kharif 2004 and 1/3rd of recommended dose of NPK fertilizers produced lighter grains.

Absolute control produced significantly lighter grains than all other treatments and proved to be inferiormost with respect to 1000-grain weight.
Spikelet fertility percentage

The effect of different treatments on spikelet fertility percentage of paddy crop has been presented in Table 4.13 and depicted graphically in Fig. 4.6. A perusal of data revealed that in general, spikelet fertility % decreased with increase in the level of vermicompost application and levels of NPK fertilizers.

A perusal of data in Table 4.13 shows that the effect of vermicompost levels was significant during *Kharif* 2004 only, where no vermicompost resulted in higher spikelet fertility than other three levels of vermicompost.

Application of recommended dose of NPK fertilizers resulted in significantly lower spikelet fertility percentage, which was found to be at par with 2/3rd of recommended NPK fertilizer application (*Kharif* 2004). Application of 1/3rd of recommended dose of fertilizers resulted in significantly higher spikelet fertility percentage.

Absolute control resulted in higher spikelet fertility percentage than all other treatments.

Yield

Data on grain yield, straw yield and harvest index has been given in Table 4.14 and illustrated in Fig. 4.7. The analysis of variance has been appended in Appendix V.

Grain yield

A perusal of grain yield data reveals that during *Kharif* 2003 season, application of vermicompost @ 6 t/ha resulted in significantly higher grain yield of paddy crop than all other treatments *viz.* no vermicompost, vermicompost @ 2
t/ha and 4 t/ha, however, it was found to be at par with application of vermicompost @ 4 t/ha. Lowest grain yield of paddy was recorded in no vermicompost treatment.

Increase in the yield of paddy crop due to application of vermicompost @ 6 t/ha was 4%, 15.6% and 27.8% higher over vermicompost @ 4 t/ha, vermicompost @ 2 t/ha and no vermicompost application, respectively.

During *Kharif* 2004, application of vermicompost @ 6 t/ha resulted in significantly higher grain yield of paddy crop than all other treatments. Application of vermicompost @ 4 t/ha and 2 t/ha were found to be statistically similar with respect to grain yield of paddy. No application of vermicompost resulted in lowest grain yield of paddy. Increase in paddy grain yield due to application of 6 t/ha vermicompost was found to be 12.7%, 15.3% and 29.2% higher over 4 t/ha, 2 t/ha and no vermicompost application, respectively.

Application of recommended dose of NPK fertilizers during *Kharif* 2003, resulted in significantly higher grain yield of paddy than 1/3rd of recommended dose of NPK, however, it was found to be at par with application of 2/3rd of recommended dose of NPK fertilizers. 1/3rd of recommended dose of NPK fertilizers resulted in lowest grain yield of paddy. Application of recommended dose of fertilizers resulted in 5.43 and 17.6% increase in grain yield over application of 2/3rd of recommended NPK and 1/3rd of recommended NPK fertilizer application, respectively.
Similarly, during *Kharif* 2004 application of recommended dose of NPK fertilizers resulted in significantly higher grain yield of paddy over other treatments. Application of $1/3^{rd}$ of recommended NPK fertilizers resulted in significantly lower grain yield of paddy. Increase in grain yield due to application of recommended dose of NPK fertilizers over application of $2/3^{rd}$ and $1/3^{rd}$ of recommended NPK fertilizers was 10.8 and 17.4%, respectively.

Absolute control resulted in significantly lowest grain yield than all other treatments during *Kharif* 2003 and *Kharif* 2004.

Pooled analysis in Table 4.14 and Fig. 4.8 shows that application of vermicompost @ 6 t/ha resulted in significantly higher grain yield over all other levels of vermicompost, however, it was found to be at par with vermicompost @ 4 t/ha level. Vermicompost @ 4 t/ha and vermicompost 2 t/ha were also found to be at par with each other with respect to grain yield of paddy.

Similarly application of recommended NPK fertilizer also resulted in significantly higher grain yield of paddy, however, it was found to be at par with application of $2/3^{rd}$ of recommended NPK fertilizers. $1/3^{rd}$ of recommended NPK fertilizer resulted in lowest grain yield of paddy.

Absolute control treatment resulted in significantly lower grain yield than that of all other treatments.

The interaction effect of vermicompost and fertilizer levels was found to be significantly influencing the grain yield (Table 4.15) during both the years of study. Across fertilizer levels, at $F_1$, $V_3$ remaining at par with $V_2$ resulted in significantly higher grain yield over $V_1$ and $V_0$ and $V_0$ resulted in lowest grain
yield. At F2 level, V3 remaining at par with V2, resulted in significantly higher grain yield over other levels, however, V1 & V2 and V2 & V3 were found to be at par with each other. At F3 level, V3 remaining at par with V2 and V1 resulted in significantly higher grain yield of paddy, however V0 and V1 were found to be at par with each other.

### Table 4.15 Interaction effect of vermicompost and fertilizer levels on grain yield of paddy (Kharif 2003 and Kharif 2004)

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>Fertilizer levels</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kharif 2003</td>
<td>Kharif 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
<td>F3</td>
<td>F1</td>
</tr>
<tr>
<td>V0</td>
<td>1252</td>
<td>1875</td>
<td>2172</td>
<td>1547</td>
</tr>
<tr>
<td>V1</td>
<td>1845</td>
<td>2126</td>
<td>2220</td>
<td>2041</td>
</tr>
<tr>
<td>V2</td>
<td>2241</td>
<td>2350</td>
<td>2475</td>
<td>2050</td>
</tr>
<tr>
<td>V3</td>
<td>2369</td>
<td>2481</td>
<td>2489</td>
<td>2681</td>
</tr>
<tr>
<td>SEm±</td>
<td>108</td>
<td>108</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD (5%)</td>
<td>316</td>
<td>317</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Across vermicompost levels, at V3 & V2 all the fertilizer levels showed non significant differences with respect to grain yield. At V1 level, F2 and F3 remaining at par with each other resulted in significantly higher grain yield of paddy, however, F1 and F2 were found to be at par with each other. At V0 level F2 and F3 remaining at par with each other resulted in significantly higher grain yield of paddy.
During Kharif 2004, across fertilizer levels, V₃ resulted in significantly higher grain yield of paddy over all other levels of vermicompost, however, at F₂ & F₃, V₂ & V₃; V₁ & V₂ and V₀ & V₁ and at F₁ level, V₁ & V₂ were found to be at par with each other with respect to grain yield. Across vermicompost levels, at V₃ level, all the fertilizer levels were found to be at par with each other with respect to grain yield. At V₂ & V₀ level, F₃ remaining at par with F₂ resulted in significantly higher grain yield over F₁ level. At V₁ level, F₃ remaining at par with F₂ resulted in significantly higher grain yield over F₁, however, F₁ and F₂ were also found to be at par with each other.

A perusal of interaction effect of pooled analysis (Table 4.16) shows that across fertilizer levels at F₁, V₂ and V₃ remaining at par with each other, resulted in highest grain yield of paddy over all other levels, however, V₁ and V₂ were also found to be at par with each other. At F₂ and F₃ levels, V₃, V₂ and V₁ remaining at par with each other resulted in higher grain yield of paddy, however, V₀, V₁ and V₂ were also found to be at par with each other with respect to grain yield. Across vermicompost levels at V₂ and V₃ all the fertilizer levels showed non-significant differences with respect to grain yield of paddy. At V₁ level F₂ and F₃ remaining at par with each other resulted in higher grain yield over F₁, however, F₁ and F₂ were also found to be at par with each other. At V₀ level, F₃ and F₂ remaining at par with each other resulted in significantly higher grain yield over F₁ level.
Table 4.16 Interaction effect of vermicompost and fertilizer levels on grain yield of paddy (pooled)

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>Fertilizer levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F₁</td>
</tr>
<tr>
<td>V₀</td>
<td>1399</td>
</tr>
<tr>
<td>V₁</td>
<td>1943</td>
</tr>
<tr>
<td>V₂</td>
<td>2321</td>
</tr>
<tr>
<td>V₃</td>
<td>2525</td>
</tr>
<tr>
<td>SEm±</td>
<td>192</td>
</tr>
<tr>
<td>CD (5%)</td>
<td>539</td>
</tr>
</tbody>
</table>

**Straw yield**

An examination of straw yield data reveals that during *Kharif* 2003, application of vermicompost @ 6 t/ha resulted in significantly higher straw yield than all other treatments, whereas, no application of vermicompost resulted in significantly higher straw yield of paddy. Application of vermicompost @ 6 t/ha resulted in 9.3, 25.8 and 41.8% increase in straw yield over vermicompost @ 4 t/ha, vermicompost @ 2 t/ha and no vermicompost, respectively.

During *Kharif* 2004, similar trend was observed for straw yield. Application of vermicompost @ 6 t/ha resulted in significantly higher straw yield than any other treatment, whereas, no vermicompost resulted in lower straw yield of paddy crop. Increase in straw yield due to application of 6 t/ha vermicompost was 16.0, 31.5 and 46.4% higher over vermicompost @ 4 t/ha, vermicompost @ 2 t/ha and no vermicompost, respectively.
In *Kharif* 2003 application of recommended dose of NPK fertilizers resulted in significantly highest straw yield and 1/3\(^{rd}\) of recommended dose of NPK fertilizers resulted in lowest straws yield of paddy crop. Application of recommended dose of NPK fertilizers resulted in 7.6\% and 16.4\% increase in straw yield over 2/3\(^{rd}\) of recommended NPK fertilizer and 1/3\(^{rd}\) of recommended NPK fertilizers. Similar results were also recorded in the *Kharif* season of 2004. Increase in straw yield due to application recommended dose of NPK fertilizers was 11.3\% and 18.1\% higher than application of 2/3\(^{rd}\) of recommended NPK fertilizer 1/3\(^{rd}\) of recommended dose of NPK fertilizers.

Absolute control treatment resulted in significantly lower straw yield than that of all other treatments.

A perusal of pooled data in Table 4.14 shows that application of vermicompost @ 6 t/ha resulted in significantly highest straw yield of paddy followed by vermicompost @ 4 t/ha, whereas, no vermicompost application resulted in lowest straw yield of paddy crop. Application of recommended dose of NPK fertilizer resulted in significantly higher straw yield of paddy crop, however, it was found to be at par with 2/3\(^{rd}\) of recommended NPK fertilizer application.

Absolute control treatment resulted in significantly lower straw yield than that of all other treatments.

The interaction effect of vermicompost and fertilizer levels was found to be significantly influencing the straw yield of paddy during both the years of study (Table 4.17). During *Kharif* 2003, across fertilizer levels, V\(_3\) resulted in significantly higher straw yield of paddy over all other levels of vermicompost.
Across vermicompost levels at V₃ level, F₃ and F₂ remaining at par with each other resulted in significantly higher straw yield over F₁ level, however, F₁ and F₂ were also found to be at par each other. At V₂ level, F₃ resulted in significantly higher straw yield of paddy over other levels, and F₁ and F₂ were found to be at par with each other. At V₀ level, F₃ resulted in significantly higher straw yield over other levels of fertilizers.

**Table 4.17 Interaction effect of vermicompost and fertilizer levels on straw yield of paddy (Kharif 2003 and Kharif 2004)**

<table>
<thead>
<tr>
<th>Vermicompost</th>
<th>Fertilizer levels</th>
<th>Kharif 2003</th>
<th>Kharif 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F₁</td>
<td>F₂</td>
<td>F₃</td>
</tr>
<tr>
<td>V₀</td>
<td>2531</td>
<td>3233</td>
<td>3803</td>
</tr>
<tr>
<td>V₁</td>
<td>3718</td>
<td>4187</td>
<td>4313</td>
</tr>
<tr>
<td>V₂</td>
<td>4676</td>
<td>4904</td>
<td>5359</td>
</tr>
<tr>
<td>V₃</td>
<td>5185</td>
<td>5478</td>
<td>5799</td>
</tr>
<tr>
<td>SEm±</td>
<td></td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>CD (5%)</td>
<td></td>
<td>323</td>
<td></td>
</tr>
</tbody>
</table>

During *Kharif* 2004, across fertilizer levels, V₃ resulted in significantly higher straw yield over all other levels of vermicompost *viz.* V₀, V₁ and V₂. Across vermicompost levels at V₃, F₃ resulted in significantly higher straw yield over F₁ and F₂, however, F₁ and F₂ were also found to be at par with each other. At V₂ level the differences between all the fertilizer levels with respect to straw yield were found to be non-significant. At V₁ level, F₂ and F₃ remaining at par with each other resulted in significantly higher straw yield over F₁ levels. At V₀ level F₃ resulted in significantly higher straw yield over all other levels *viz.*, F₁ and F₂.
**Harvest index**

A perusal of data in Table 4.14 reveals that with the increase in levels of vermicompost, harvest index decreased to a significant level, during both the yeas of study. Highest harvest index was recorded with no vermicompost application, however, it was found to be at par with application of 2 t/ha of vermicompost. Higher levels of vermicompost, resulted in lower harvest index values.

No significant difference were found at different levels of NPK fertilizers and the effect of various NPK levels on harvest index were found to be non significant during both the years of study i.e. *Kharif* 2003 and *Kharif* 2004.

Absolute control treatment and all other treatments were found to be at par with each other with respect to harvest index. Similar results were also recorded in the pooled analysis (Table 4.14).

**Nutrient uptake**

Data on nutrient uptake viz. N, P and K uptake has been given in Table 4.18 and depicted diagrammatically in Fig. 4.9. Analysis of variance table has been given in Appendix V.

**Nitrogen uptake**

A perusal of data in Table 4.18 reveals that during both the years of study i.e. *Kharif* 2003 and *Kharif* 2004, receiving vermicompost @ 6 t/ha resulted in significantly highest uptake of nitrogen, remaining at par with application of vermicompost @ 4 t/ha during *Kharif* 2003. Without vermicompost lowest
nitrogen uptake was recorded by paddy crop, during both the years of study. During *Kharif*, 2004, vermicompost @ 4 t/ha and vermicompost @ 2 t/ha were found to be similar with respect to nitrogen uptake.

Similarly during both the years of study, paddy crop receiving recommended dose of fertilizers, resulted in significantly higher uptake of nitrogen and application of 1/3\textsuperscript{rd} of recommended dose resulted in lowest nitrogen uptake, however, it was found to be at par with application of 2/3\textsuperscript{rd} of recommended dose of NPK fertilizers during *Kharif*, 2004.

Absolute control resulted in significantly lower nitrogen uptake than all other treatments during both the years of study.

A perusal of pooled data in Table 4.18 reveals that application of vermicompost @ 6 t/ha resulted in significantly higher N-uptake by paddy crop, however, it was found to be at par with application of vermicompost @ 4 t/ha. No vermicompost resulted in significantly lowest N-uptake by paddy crop.

Application of recommended dose of NPK fertilizer resulted in significantly higher nitrogen uptake by paddy crop, whereas 1/3\textsuperscript{rd} of recommended NPK application resulted in lowest nitrogen uptake by paddy crop.

Absolute control resulted in significantly lower nitrogen uptake than all other treatments.
**P-uptake**

A perusal of data in Table 4.18 reveals that during both the years of study i.e. *Kharif* 2003, *Kharif* 2004, paddy crop receiving vermicompost @ 6 t/ha resulted in significantly higher uptake of P than other treatments *viz.* vermicompost @ 4 t/ha, vermicompost @ 2 t/ha and no vermicompost, whereas, no vermicompost resulted in lowest P-uptake by paddy crop.

Similarly during both the years of study, paddy crop receiving recommended dose of NPK fertilizers resulted in significantly higher uptake of phosphorus and application of $1/3^{\text{rd}}$ of recommended dose of NPK fertilizer dose resulted in lowest phosphorus uptake by paddy crop.

Absolute control resulted in significantly lower phosphorus uptake than all other treatments, during both the years of study.

A perusal of pooled data in Table 4.18 shows that application of vermicompost @ 6 t/ha resulted in significantly higher P uptake by paddy crop, however, it was found to be at par with application of 4 t/ha of vermicompost. No vermicompost application resulted in significantly lowest P-uptake by paddy crop.

Application of recommended dose of NPK fertilizers resulted in significantly higher phosphorus uptake by paddy crop, whereas, $1/3^{\text{rd}}$ of recommended NPK application resulted in lowest P-uptake.

Absolute control resulted in significantly lower P-uptake than all other treatments.


**K-uptake**

A perusal of data in Table 4.18 reveals that during both the years of study i.e. *Kharif* 2003 and *Kharif* 2004, paddy crop receiving vermicompost @ 6 t/ha resulted in significantly higher uptake of potassium than other treatments *viz.* vermicompost @ 4 t/ha, vermicompost @ 2 t/ha and no vermicompost, whereas, no vermicompost resulted in lowest potassium uptake by paddy crop, whereas, application of vermicompost @ 4 t/ha and vermicompost @ 2 t/ha were found to be at par with each other in respect of potassium uptake and no vermicompost resulted in lowest potassium uptake by paddy crop.

Application of recommended dose of NPK fertilizer resulted in significantly higher uptake of potassium during both the years of study, whereas, application of 1/3rd of recommended dose of NPK fertilizer dose resulted in lowest potassium uptake by paddy crop.

Absolute control treatment resulted in significantly lower potassium uptake than all other treatments during both the years of study.

A perusal of pooled data in Table 4.18 shows that application of vermicompost @ 6 t/ha resulted in significantly higher K-uptake by paddy crop, however, it was found to be at par with application of 4 t/ha vermicompost. No vermicompost application resulted in significantly K-uptake by paddy crop.

Application of recommended dose of NPK fertilizers resulted in significantly higher K-uptake by paddy crop, whereas, 1/3rd of recommended NPK application resulted in lowest K-uptake.

Absolute control resulted in significantly lower K-uptake than all other treatments.
**Economic studies**

In the present study, the prices of inputs such as seed, fertilizers, labour and units of outputs (grain and straw) paid by CSK, Himachal Pradesh Krishi Vishvavidyalaya during 2003-2004 and 2004-2005 formed the basis of working out the cost of production under various treatments (Appendix II). Using the total cost of cultivation, gross returns, net returns and net returns per rupee invested for each treatment were worked out and has been presented in Table 4.19, 4.20 and Fig. 4.10 and 4.11. The analysis of variance has been appended in Appendix V.

**Gross returns**

With an increase in vermicompost levels from 0 to 6 t/ha, there was a significant and consistent increase in gross returns (Table 4.19) of paddy crop during both the years of study. With 6 t/ha vermicompost application, remaining at par with vermicompost @ 4 t/ha resulted in significantly higher gross returns than other treatments in vermicompost @ 2 t/ha and no vermicompost.

Similarly with an increase in levels of NPK fertilizer from 1/3rd of recommended NPK to recommended NPK, there was a significant increase in gross returns, with recommended NPK fertilizer application remaining at par with 2/3rd of recommended NPK fertilizer application, resulted in higher gross returns than 1/3rd of recommended NPK fertilizer application.

Absolute control treatment resulted in significantly lower gross returns than other treatments during both the years of study.
A perusal of pooled data in Table 4.20 shows that application of vermicompost @ 6 t/ha resulted in significantly higher gross returns of paddy crop, however it was found to be at par with application of 4 t/ha vermicompost application. Application of vermicompost @ 4 t/ha and 2 t/ha were also found to be at par with each other, whereas, no vermicompost application resulted in significantly lower gross returns than all other levels of vermicompost.

Application of recommended dose of NPK fertilizers resulted in significantly higher gross returns, however, it was found to be at par with application of 2/3rd of recommended NPK fertilizers, whereas, 1/3rd of recommended NPK fertilizers resulted in lowest gross returns.

Absolute control treatment resulted in significantly lower gross returns than all other treatments.

**Net returns**

A perusal of data in Table 4.19 reveals that with an increase in vermicompost level from 0 to 6 t/ha, there was a significant and consistent decrease in net returns of paddy crop during both the years of study, with 6 t/ha vermicompost application resulted in lowest net returns of paddy crop.

With an increase in the levels of NPK fertilizers, from 1/3rd of NPK fertilizer application to recommended doses of NPK fertilizer, net returns significantly increased and application of recommended dose of NPK fertilizers remaining at par with 2/3rd of recommended NPK fertilizers, resulted in higher net returns than that of 1/3rd of recommended NPK fertilizer.
Absolute control treatment resulted in lowest net returns than other treatments during both the years of study.

A perusal of pooled data (Table 4.20) revealed that application of vermicompost @ 6 t/ha resulted in lowest net returns in paddy, however, it was at par with application of vermicompost @ 4 t/ha. No application of vermicompost remaining at par with vermicompost @ 2 t/ha resulted in highest net return.

Application of recommended dose of NPK fertilizers, remaining at par with 2/3rd of recommended NPK fertilizer application resulted in higher net returns than 1/3rd of recommended NPK fertilizer application.

Absolute control treatment resulted in lowest net returns than all other treatments.

**Net returns per rupee invested**

With an increase in vermicompost levels from 0 t/ha to 6 t/ha, the net returns per rupee invested decreased significantly, with 6 t/ha application of vermicompost resulted in lowest net returns per rupee invested.

With an increase in level of NPK fertilizers from 1/3rd of recommended NPK to recommended NPK, the net returns per rupee invested significantly increased with recommended NPK fertilizer application resulted in significantly higher net returns per rupee invested, however, it was found to be at par with application of 2/3rd of recommended NPK fertilizers.

Net returns per rupee invested from absolute control treatment were found to be lower as compared to all other treatments during both the years of study.
Pooled analysis (Table 4.20) shows that application of vermicompost @ 6 t/ha resulted in lowest net returns per rupee invested, however, it was found to be at par with application of vermicompost @ 4 t/ha. No application of vermicompost resulted in highest net returns per rupee invested. Application of recommended NPK fertilizer, remaining at par with 2/3rd of recommended NPK application resulted in highest net returns per rupee invested.

Absolute control treatment resulted in significantly lower net returns than all other treatments.

**Wheat**

Data on grain yield, straw yield and harvest index has been given in Table 4.21 and has been depicted graphically in Fig. 4.12.

**Grain yield**

A perusal of data in Table 4.21 reveals that plot which received vermicompost @ 6 t/ha in paddy crop, resulted in significantly higher grain yield as compared to that of all other treatments (*Rabi* 2003-2004), whereas, without vermicompost applications treatments resulted in lower grain yield of wheat i.e. plots which received vermicompost @ 6 t/ha in paddy season (*Kharif* 2003) resulted in higher grains yield of wheat. Increase in grain yield was 15.3, 22.5 and 30.6%, respectively as compared to plots which received vermicompost @ 4 t/ha, 2 t/ha and no vermicompost.

In *Rabi* 2004-2005 season, similar trends were also observed with an increase in wheat yield upto 11.1, 21.6 and 25.8% respectively as compared to plots which received vermicompost @ 4 t/ha, 2 t/ha and no vermicompost in previous paddy crop.
Absolute control treatment proved to be inferiormost as compared to all other treatments, during both the years.

Different fertilizer treatments applied to previous paddy crop (Kharif 2003, Kharif 2004) did not significantly influence the wheat grain yield during both the years of study.

A perusal of pooled data (Table 4.21) shows that application of vermicompost @ 6 t/ha resulted in significantly higher wheat grain yield than all other levels of vermicompost, whereas, application of vermicompost @ 4 t/ha and 2 t/ha were found to be at par with each other. No vermicompost resulted in lowest grain yield of wheat crop.

Different fertilizer treatments applied to previous paddy crop (Kharif 2003, Kharif 2004) did not significantly influence the wheat grain yield.

Absolute control treatment resulted in lowest grain yield of wheat than all other treatments.

**Straw yield**

It is evident from Table 4.21 that vermicompost @ 6 t/ha application treatment applied to paddy crop (Kharif 2003) resulted in significantly higher straw yield of wheat (Rabi 2003-2004), and no vermicompost application to paddy crop resulted in lowest straw yield of wheat crop. Similar trend were also observed during Rabi 2004-2005 wheat season.

Absolute control treatment resulted in lowest straw yield of wheat as compared to all other treatments.
Different fertilizer treatments applied to previous paddy crop (Kharif 2003, 2004) did not significantly influence the wheat grain yield during both the years of study.

A perusal of pooled data in Table 4.21 shows that vermicompost @ 6 t/ha application applied to paddy crop resulted in significantly higher wheat straw yield than all other levels of vermicompost, whereas, application of vermicompost @ 4 t/ha and 2 t/ha were found to be at par with each other. No vermicompost resulted in lowest straw yield of wheat crop, however, it was found to be at par with vermicompost @ 2 t/ha.

Different fertilizer treatments applied to previous paddy crop (Kharif 2003, Kharif 2004) did not significantly influence the wheat straw yield.

Absolute control treatment resulted in lowest straw yield of wheat than all other treatments.

**Harvest index**

A perusal of data in Table 4.21 reveals that no significant difference in harvest index were recorded due to the application of vermicompost or NPK fertilizer to paddy crop (Kharif 2003 and 2004).

Similar results were obtained after pooling of the data and no significant differences in harvest index were recorded.

**Nutrient uptake**

Data on nutrient uptake viz. N, P and K uptake has been given in Table 4.22 and depicted graphically in Fig. 4.14. Analysis of variance table has been given in Appendix V.
Nitrogen uptake

A perusal of data in Table 4.22 reveals that during both the years of study i.e. Rabi 2003-2004 and Rabi 2004-2005, application of vermicompost @ 6 t/ha to paddy crop in previous season resulted in significantly higher uptake of nitrogen by wheat crop, without vermicompost lowest nitrogen uptake was recorded by wheat crop, during both the years of study viz. Rabi 2003-2004 and 2004-2005.

Similarly, during both the years, application of recommended dose of NPK to previous paddy crop, resulted in higher uptake of nitrogen by wheat crop, however, it was at par with application of 2/3rd of recommended NPK fertilization to paddy crop. 1/3rd of recommended NPK fertilizers resulted in lower uptake of nitrogen than other two treatments i.e. application of 2/3rd of recommended NPK and 1/3rd of recommended NPK fertilizer.

Absolute control treatment resulted in lower uptake of N than other all other treatments during both the years.

A perusal of pooled data (Table 4.22) reveals that application of vermicompost @ 6 t/ha to previous paddy crop resulted in significantly highest nitrogen uptake by wheat crop than all other levels of vermicompost, whereas, no vermicompost application resulted in lowest nitrogen uptake by wheat crop.

Application of recommended dose of NPK fertilizers to previous paddy crop resulted in higher nitrogen uptake by wheat crop, however, it was found to be at par with 2/3rd of recommended NPK fertilizer application, whereas, 1/3rd of recommended NPK application resulted in lowest nitrogen uptake by wheat crop.
Absolute control treatment resulted in lower nitrogen uptake than all other treatments.

**Phosphorus uptake**

A perusal of data in Table 4.22 reveals that during both the years of study i.e. *Rabi* 2003-2004 and *Rabi* 2004-2005, application of vermicompost @ 6 t/ha to previous paddy crop, resulted in significantly higher phosphorus uptake by wheat crop, whereas, without vermicompost treatment, lowest phosphorus uptake was recorded by wheat crop.

Application of recommended dose of NPK fertilizers to previous paddy crop, remaining at par with 2/3rd of recommended NPK fertilizer application resulted in significantly higher uptake of phosphorus than 1/3rd of recommended NPK fertilizer application to paddy in the previous season. Similar trend was recorded during both the years.

Absolute control treatment resulted in lower phosphorus uptake than all other treatments during both the years of study.

A perusal of pooled data (Table 4.22) reveals that application of vermicompost @ 6 t/ha to previous paddy crop resulted in significantly highest phosphorus uptake by wheat crop than all other levels of vermicompost. No vermicompost application remaining at par with vermicompost @ 2 t/ha resulted in significantly lower phosphorus uptake by wheat crop.
Application of recommended dose of NPK fertilizers to previous paddy crop resulted in higher P-uptake by wheat crop, however, it was found to be at par with 2/3\textsuperscript{rd} of recommended NPK fertilizers application, whereas, 1/3\textsuperscript{rd} of recommended NPK fertilizer application resulted in lowest phosphorus uptake by wheat crop.

Absolute control treatment resulted in lower nitrogen uptake than all other treatments.

**Potassium uptake**

A perusal of data in Table 4.22 reveals that during both the years of study i.e. *Rabi* 2003-2004 and *Rabi* 2004-2005, application of vermicompost @ 6 t/ha to previous paddy crop, resulted in significantly higher potassium uptake by wheat crop, whereas, without vermicompost treatment, lowest potassium uptake was recorded by wheat crop.

Application of recommended dose of NPK fertilizer to previous paddy crop resulted in significantly higher potassium uptake than other treatments \textit{viz.} 2/3\textsuperscript{rd} of recommended NPK and 1/3\textsuperscript{rd} of recommended NPK, however, during *Rabi* 2004-2005, it was at par with 2/3\textsuperscript{rd} of recommended NPK application. Application of 1/3\textsuperscript{rd} of recommended NPK fertilizers to paddy crop in previous season, resulted in significantly lowest uptake of potassium by wheat during both the years of study.

Absolute control treatment resulted in lower potassium uptake than all other treatments during both the years of study.
A perusal of pooled data (Table 4.22) reveals that application of vermicompost @ 6 t/ha to previous paddy crop resulted in significantly highest potassium uptake by wheat crop than all other levels of vermicompost, whereas, no vermicompost application resulted in lowest potassium uptake by wheat crop.

Application of recommended dose of NPK fertilizers to previous paddy crop resulted in higher potassium uptake by wheat crop, however, it was found to be at par with 2/3rd of recommended NPK fertilizer application, whereas 1/3rd of recommended NPK fertilizers application resulted in lowest potassium uptake by wheat crop.

**Economic studies: WHEAT**

In the present study, the prices of input such as seed, fertilizers, labour and units of outputs (grain and straws) paid by CSK Himachal Pradesh Krishi Vishvavidyalaya during 2003-2004 and 2004-2005, formed the basis of working out the cost of production under various treatments (Appendix V). Using the total cost of cultivation, gross returns, net returns and net returns pr rupee invested for each treatment were worked out and has been presented in Table 4.19 and 4.20 and Fig. 4.15 and 4.16. The analysis of variance has been appended in Appendix V.

**Gross returns**

With the increase in the application of vermicompost from 0 to 6 t/ha to paddy crop in previous season resulted in a significant and consistent increase in gross returns of wheat crop, during both the years of study. Application of
vermicompost @ 6 t/ha to previous paddy crop, resulted in higher gross returns over other treatments i.e. vermicompost application @ 4 t/ha, 2 t/ha and no vermicompost application to previous paddy crop. Application of recommended dose of NPK fertilizers to previous paddy crop resulted in significantly higher gross returns of wheat crop, however, it was found to be at par with 2/3\textsuperscript{rd} of recommended NPK fertilizer application during \textit{Rabi} 2003-2004. Application of 1/3\textsuperscript{rd} of recommended dose of NPK fertilizers to paddy crop, resulted in lowest gross returns of wheat crop.

Absolute control treatments resulted in lower gross returns than all other treatments during both the years of study.

Pooled analysis of data (Table 4.20) revealed that application of vermicompost @ 6 t/ha to previous paddy crops, resulted in higher gross returns than all other treatments, whereas, vermicompost @ 4 t/ha and 2 t/ha were found to be at par with each other.

Application of recommended dose of NPK fertilizers remaining at par with 2/3\textsuperscript{rd} of recommended NPK fertilizers, resulted in higher gross returns of wheat crop than 1/3\textsuperscript{rd} of recommended NPK fertilizers.

Absolute control resulted in significantly lower gross returns than all other treatments.

\textbf{Net returns}

With the increase in the application of vermicompost from 0 to 6 t/ha to paddy crop in previous season resulted in a significant and consistent increase in net returns of wheat crop, during both the years of study. Application of
vermicompost @ 6 t/ha to previous paddy crop resulted in higher net returns over other treatments i.e. vermicompost application @ 4 t/ha, 2 t/ha and no vermicompost application to previous paddy crop. Application of recommended dose of NPK fertilizers to previous paddy crop resulted in significantly higher net returns of wheat crop, however, it was found to be at par with 2/3rd of recommended NPK fertilizers application during Rabi 2003-2004 and 2004-2005. Application of 1/3rd of recommended dose of NPK fertilizers to paddy crop, resulted in lowest net returns of wheat corp.

Absolute control treatment resulted in lower net returns than all other treatments during both the years of study.

Pooled analysis of data (Table 4.20) reveals that application of vermicompost @ 6 t/ha to previous paddy crop, resulted in higher net returns than all other treatments, whereas, vermicompost @ 4 t/ha and 2 t/ha were found to be at par with each other.

Application of recommended dose of NPK fertilizers remaining at par with 2/3rd of recommended NPK fertilizer resulted in higher net returns to wheat crop than 1/3rd of recommended NPK application.

Absolute control treatment resulted in significantly lower net returns than all other treatments.

**Net returns per rupee invested**

A perusal of data in Table 4.19 reveals that application of vermicompost @ 6 t/ha to previous paddy crop, resulted in significantly higher net returns per rupee invested in wheat during both the years of study viz. Rabi 2003-04 and Rabi 2004-05, whereas, net returns from no vermicompost application was found to be lowest among all levels of vermicompost.
Similarly, with the increase in levels of fertilizers from 1/3\textsuperscript{rd} of recommended to recommended NPK fertilizer to previous paddy crop resulted in an increase in net returns per rupee invested, with recommended NPK application resulted in significantly higher net returns per rupee invested, however, it was found to be at par with application of 2/3\textsuperscript{rd} of recommended NPK fertilizer application to previous paddy crop.

Absolute control treatment resulted in significantly lower net returns per rupee invested over all other treatments.

Pooled analysis of data (Table 4.20) revealed that application of vermicompost @ 6 t/ha to previous paddy crop, resulted in higher net returns per rupee invested than all other treatments, whereas, vermicompost @ 4 t/ha and 2 t/ha were found to be at par with each other.

Application of recommended dose of NPK fertilizers, remaining at par with 2/3\textsuperscript{rd} of NPK fertilizer, resulted in higher net returns per rupee invested than 1/3\textsuperscript{rd} of recommended NPK fertilizer application.

Absolute control resulted in significantly lower net returns per rupee invested than all other treatments.

**Economics of rice-wheat cropping system**

Data on the economics of rice-wheat cropping system has been given in Table 4.23 and depicted in Fig. 4.11.

On the basis of average values of gross and net returns for direct seeded rice-wheat sequence, it was observed that application of vermicompost @ 6 t/ha to paddy crop resulted in highest gross and net returns than all the
levels of vermicompost. Similarly application of recommended dose of NPK fertilizers also resulted in highest gross and net returns in direct seeded rice-wheat sequence.

**Soil studies**

The data on various soil properties have been given in Table 4.24 and 4.25 and analysis of variance have been given in Appendix V.

1. **pH**

Different levels of vermicompost as well as different levels of NPK fertilizers did not significantly influence the pH of the soil at the end of experiment.

2. **Soil texture**

Different levels of vermicompost as well as different levels of NPK fertilizers did not influence the soil texture.

3. **Organic carbon**

The perusal of data in Table 4.24 reveals that plots receiving higher levels of vermicompost resulted in higher level of organic carbon content of soil and application of vermicompost @ 6 t/ha resulted in significantly higher organic carbon content in soil as compared to other treatments *viz.* 2 t/ha, 4 t/ha and no vermicompost.

With the increase in fertilizer levels, the organic carbon content of soil decreased to a significant level.

Control treatment resulted in lower value of organic carbon content as compared to other treatments.
4. **Bulk density**

With the increase in the levels of vermicompost the bulk density of soil decreased significantly with application of vermicompost @ 6 t/ha resulting in lowest bulk density value than all other three treatments. On the other hand, with the increase in levels of chemical fertilizers from 1/3\textsuperscript{rd} of recommended NPK to recommended NPK application, the bulk density slightly increased. Absolute control value gave higher value of bulk density over all other treatments.

5. **Particle density**

Different levels of vermicompost as well as different levels of NPK fertilizers did not significantly influence the particle density of soil.

6. **Available N, P and K status after harvest**

Data on available N, P and K at the end of experiment has been given in Table 4.25 and analysis of variance table has been given in Appendix V.

a) **Available nitrogen**

Application of vermicompost @ 2, 4 and 6 t/ha recorded substantial available N build-up after two years of experimentation with highest value of 489.30 kg in V\textsubscript{3} treatment. Different levels of vermicompost also exhibited significant differences in available N build up.

Application of fertilizers @ 1/3\textsuperscript{rd}, 2/3\textsuperscript{rd} and recommended dose of NPK fertilizer recorded substantial available N build up after two years of experimentation with highest value of 434.09 kg in F\textsubscript{3} treatment. Different levels of NPK fertilizers also exhibited significant differences in available N build up.

Absolute control treatment exhibited significantly lower N build up than all other treatments.
b) **Available phosphorus**

Application of vermicompost @ 2, 4 and 6 t/ha recorded significant available phosphorus build up after two years of experimentation with highest value of 24.21 in V3 treatment. Differences within treatments were also found significant.

Application of fertilizers @ 2/3rd and recommended doses of NPK fertilizers recorded available phosphorus value of 21.11 and 22.09 kg P/ha which were statistically higher over F1 (19.53 kg P/ha) treatment. Different levels of NPK fertilizers also exhibited significant differences in available P build up.

Absolute control treatment exhibited significantly lower P build up than all other treatments.

c) **Available potassium**

Application of vermicompost @ 2t, 4 t and 6 t/ha recorded significant increase in available potassium build up after two years of experimentation with highest value of 268.72 in V3 treatment. Different levels of vermicompost also exhibited significant differences in available K build up.

Application of fertilizers @ 1/3rd, 2/3rd and recommended NPK fertilizers also recorded substantial available potassium build up after two years of experimentation with highest value of 265.06 in F3 treatment. Different levels of NPK fertilizers also exhibited significant differences in available K build up.

Absolute control treatment exhibited significant reduction in available potassium status.