## CONTENT

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PARTICULAR</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>INTRODUCTION</td>
<td>1-10</td>
</tr>
<tr>
<td>II</td>
<td>REVIEW OF LITERATURE</td>
<td>11-37</td>
</tr>
<tr>
<td>2.1</td>
<td>Urdbean-Wheat cropping system</td>
<td>12</td>
</tr>
<tr>
<td>2.2</td>
<td>Planting method in urdbean</td>
<td>14</td>
</tr>
<tr>
<td>2.2.1</td>
<td>Effect on crop productivity</td>
<td>15</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Effect on nutrient content and uptake in plant</td>
<td>18</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Effect on soil physico-chemical properties</td>
<td>18</td>
</tr>
<tr>
<td>2.3</td>
<td>Nutrient management in urdbean</td>
<td>19</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Effect on crop productivity</td>
<td>19</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Effect on nutrient content and uptake in plant</td>
<td>27</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Effect on soil physico-chemical properties</td>
<td>28</td>
</tr>
<tr>
<td>2.4</td>
<td>Direct and residual effect of nutrient on wheat</td>
<td>29</td>
</tr>
<tr>
<td>2.4.1</td>
<td>Direct effect of nutrient</td>
<td>29</td>
</tr>
<tr>
<td>2.4.2</td>
<td>Residual effect of nutrient</td>
<td>31</td>
</tr>
<tr>
<td>2.5</td>
<td>Energy studies</td>
<td>35</td>
</tr>
<tr>
<td>2.6</td>
<td>Economics</td>
<td>36</td>
</tr>
<tr>
<td>III</td>
<td>MATERIALS AND METHODS</td>
<td>38-61</td>
</tr>
<tr>
<td>3.1</td>
<td>Experimental site</td>
<td>38</td>
</tr>
<tr>
<td>3.2</td>
<td>Climate and weather</td>
<td>39</td>
</tr>
<tr>
<td>3.3</td>
<td>Physico-chemical characteristics of the soil</td>
<td>40</td>
</tr>
<tr>
<td>3.4</td>
<td>Cropping history of the experimental site</td>
<td>41</td>
</tr>
</tbody>
</table>

Contd...
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PARTICULAR</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>Experimental details</td>
<td>42</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Experimental design, treatments and layout</td>
<td>42</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Treatment application to urdbean</td>
<td>43</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Treatment application to wheat</td>
<td>44</td>
</tr>
<tr>
<td>3.6</td>
<td>Cropping system under test: Urdbean-wheat</td>
<td>44</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Test cultivar of urdbean: TAU-2</td>
<td>44</td>
</tr>
<tr>
<td>3.6.2</td>
<td>Test cultivar of wheat: Sujata</td>
<td>45</td>
</tr>
<tr>
<td>3.7</td>
<td>Cultural operation in urdbean-wheat-cropping system</td>
<td>45</td>
</tr>
<tr>
<td>3.7.1</td>
<td>Urdbean</td>
<td>45</td>
</tr>
<tr>
<td>3.7.1.1</td>
<td>Field Preparation</td>
<td>45</td>
</tr>
<tr>
<td>3.7.1.2</td>
<td>Seed rate and spacing</td>
<td>45</td>
</tr>
<tr>
<td>3.7.1.3</td>
<td>Seed treatment and sowing</td>
<td>46</td>
</tr>
<tr>
<td>3.7.1.4</td>
<td>Nutrient management</td>
<td>46</td>
</tr>
<tr>
<td>3.7.1.5</td>
<td>Weed management</td>
<td>46</td>
</tr>
<tr>
<td>3.7.1.6</td>
<td>Water management</td>
<td>47</td>
</tr>
<tr>
<td>3.7.1.7</td>
<td>After care</td>
<td>47</td>
</tr>
<tr>
<td>3.7.1.8</td>
<td>Harvesting and Threshing</td>
<td>47</td>
</tr>
<tr>
<td>3.7.2</td>
<td>Wheat</td>
<td>47</td>
</tr>
<tr>
<td>3.7.2.1</td>
<td>Field preparation</td>
<td>47</td>
</tr>
<tr>
<td>3.7.2.2</td>
<td>Sowing</td>
<td>48</td>
</tr>
<tr>
<td>3.7.2.3</td>
<td>Nutrient management</td>
<td>48</td>
</tr>
<tr>
<td>3.7.2.4</td>
<td>Water management</td>
<td>48</td>
</tr>
<tr>
<td>3.7.2.5</td>
<td>Weed management</td>
<td>48</td>
</tr>
<tr>
<td>3.7.2.6</td>
<td>After care</td>
<td>49</td>
</tr>
<tr>
<td>3.7.2.7</td>
<td>Harvesting and Threshing</td>
<td>49</td>
</tr>
<tr>
<td>3.8</td>
<td>Studies performed in urdbean-wheat cropping system</td>
<td>49</td>
</tr>
<tr>
<td>3.8.1</td>
<td>Studies on urdbean</td>
<td>49</td>
</tr>
</tbody>
</table>

Contd...
### 3.8.3 Computation
- Leaf area index (LAI) (56)
- Leaf area duration (LAD) (56)
- Crop growth rate (CGR) (56)
- Relative growth rate (RGR) (57)
- Harvest index (HI) (57)
- Productivity rating index (PRI) (58)
- Production efficiency (PE) (58)

### 3.8.4 Chemical studies in urdbean-wheat cropping system
- Plant analysis (58)
  - **3.8.4.1** Urdbean (58)
    - **3.8.4.1.1** N, P, K content in seed and stover (%) (58)
    - **3.8.4.1.2** N, P and K Uptake (59)
    - **3.8.4.1.3** Protein content (%) and protein yield (q ha⁻¹) (59)
  - **3.8.4.1.2** Wheat (59)
    - **3.8.4.1.2.1** N, P, K content and their uptake (59)
  - **3.8.4.2** Soil Analysis (59)
    - **3.8.4.2.1** N, P and K availability in soil (59)
  - **3.8.5** Energy studies in urdbean-wheat (60)
  - **3.8.6** Economic analysis of urdbean-wheat (61)
  - **3.8.7** Statistical analysis (61)

### IV RESULTS
- **4.1** Studies on urdbean (62)
  - **4.1.1** Growth characters (62)
    - **4.1.1.1** Plant population (no. m⁻¹ row length) (62)
    - **4.1.1.2** Plant height (cm) (63)
    - **4.1.1.3** Number of branches plant⁻¹ (64)
    - **4.1.1.4** Root length (cm) (65)

Contd...
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PARTICULAR</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.1.5</td>
<td>Root weight (g plant⁻¹)</td>
<td>66</td>
</tr>
<tr>
<td>4.1.1.6</td>
<td>Leaf area index (LAI)</td>
<td>67</td>
</tr>
<tr>
<td>4.1.1.7</td>
<td>Leaf area duration (LAD)</td>
<td>67</td>
</tr>
<tr>
<td>4.1.1.8</td>
<td>Dry matter accumulation (DMA), g plant⁻¹</td>
<td>68</td>
</tr>
<tr>
<td>4.1.1.9</td>
<td>Crop growth rate (CGR), g day⁻¹ plant⁻¹</td>
<td>69</td>
</tr>
<tr>
<td>4.1.1.10</td>
<td>Relative crop growth rate (RGR), g g⁻¹ day⁻¹ plant⁻¹</td>
<td>70</td>
</tr>
<tr>
<td>4.1.1.11</td>
<td>Nodule number plant⁻¹</td>
<td>70</td>
</tr>
<tr>
<td>4.1.1.12</td>
<td>Nodule dry weight (mg plant⁻¹)</td>
<td>71</td>
</tr>
<tr>
<td>4.1.1.13</td>
<td>Number of flowers plant⁻¹ (at 35, 45 and 55 DAS)</td>
<td>72</td>
</tr>
<tr>
<td>4.1.1.14</td>
<td>Number of pods plant⁻¹ (at 45, 55 and 65 DAS)</td>
<td>73</td>
</tr>
<tr>
<td>4.1.2</td>
<td><strong>Yield and yield attributes</strong></td>
<td>74</td>
</tr>
<tr>
<td>4.1.2.1</td>
<td>Pods plant⁻¹ (at harvest)</td>
<td>74</td>
</tr>
<tr>
<td>4.1.2.2</td>
<td>Seeds pod⁻¹ (no.)</td>
<td>75</td>
</tr>
<tr>
<td>4.1.2.3</td>
<td>Seeds plant⁻¹ (no.)</td>
<td>75</td>
</tr>
<tr>
<td>4.1.2.4</td>
<td>Length of pod (cm)</td>
<td>76</td>
</tr>
<tr>
<td>4.1.2.5</td>
<td>Pod weight plant⁻¹ (g)</td>
<td>76</td>
</tr>
<tr>
<td>4.1.2.6</td>
<td>Seed weight plant⁻¹ (g)</td>
<td>77</td>
</tr>
<tr>
<td>4.1.2.7</td>
<td>100-seed weight (g)</td>
<td>78</td>
</tr>
<tr>
<td>4.1.2.8</td>
<td>Seed and stover yields (q ha⁻¹)</td>
<td>78</td>
</tr>
<tr>
<td>4.1.2.9</td>
<td>Harvest index (HI), %</td>
<td>79</td>
</tr>
<tr>
<td>4.1.3</td>
<td><strong>Chemical studies</strong></td>
<td>79</td>
</tr>
<tr>
<td>4.1.3.1</td>
<td><strong>Plant</strong></td>
<td>79</td>
</tr>
<tr>
<td>4.1.3.1.1</td>
<td>Nitrogen content (%)</td>
<td>79</td>
</tr>
<tr>
<td>4.1.3.1.2</td>
<td>Nitrogen uptake (kg ha⁻¹)</td>
<td>80</td>
</tr>
<tr>
<td>4.1.3.1.3</td>
<td>Phosphorus content (%)</td>
<td>81</td>
</tr>
<tr>
<td>4.1.3.1.4</td>
<td>Phosphorus uptake (kg ha⁻¹)</td>
<td>81</td>
</tr>
<tr>
<td>4.1.3.1.5</td>
<td>Potassium content (%)</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Contd.</td>
<td></td>
</tr>
<tr>
<td>CHAPTER</td>
<td>PARTICULAR</td>
<td>PAGE NO.</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td>4.1.3.1.6</td>
<td>Potassium uptake (kg ha(^{-1}))</td>
<td>83</td>
</tr>
<tr>
<td>4.1.3.1.7</td>
<td>Protein content (%)</td>
<td>83</td>
</tr>
<tr>
<td>4.1.3.1.8</td>
<td>Protein yield (kg ha(^{-1}))</td>
<td>84</td>
</tr>
<tr>
<td>4.1.3.2</td>
<td>Soil</td>
<td>85</td>
</tr>
<tr>
<td>4.1.3.2.1</td>
<td>Available N (kg ha(^{-1}))</td>
<td>85</td>
</tr>
<tr>
<td>4.1.3.2.2</td>
<td>Available P (kg ha(^{-1}))</td>
<td>85</td>
</tr>
<tr>
<td>4.1.3.2.3</td>
<td>Available K (kg ha(^{-1}))</td>
<td>86</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Productivity rating index (PRI), %</td>
<td>86</td>
</tr>
<tr>
<td>4.1.5</td>
<td>Production efficiency (PE), kg ha(^{-1}) day(^{-1})</td>
<td>87</td>
</tr>
<tr>
<td>4.1.6</td>
<td>Energetics of production</td>
<td>87</td>
</tr>
<tr>
<td>4.1.7</td>
<td>Economics</td>
<td>88</td>
</tr>
<tr>
<td>4.2</td>
<td>Studies on wheat</td>
<td>89</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Growth characters</td>
<td>89</td>
</tr>
<tr>
<td>4.2.1.1</td>
<td>Plant population (no. m(^{-1}) row length)</td>
<td>89</td>
</tr>
<tr>
<td>4.2.1.2</td>
<td>Plant height (cm)</td>
<td>90</td>
</tr>
<tr>
<td>4.2.1.3</td>
<td>Tillers plant(^{-1}) (no.)</td>
<td>91</td>
</tr>
<tr>
<td>4.2.1.4</td>
<td>Dry matter accumulation (g plant(^{-1}))</td>
<td>92</td>
</tr>
<tr>
<td>4.2.1.5</td>
<td>Root volume (cm(^{3}))</td>
<td>93</td>
</tr>
<tr>
<td>4.2.1.6</td>
<td>Root dry weight (g plant(^{-1}))</td>
<td>94</td>
</tr>
<tr>
<td>4.2.1.7</td>
<td>Leaf area index (LAI)</td>
<td>95</td>
</tr>
<tr>
<td>4.2.1.8</td>
<td>Leaf area duration (LAD)</td>
<td>96</td>
</tr>
<tr>
<td>4.2.1.9</td>
<td>Crop growth rate (CGR), g day(^{-1}) plant(^{-1})</td>
<td>96</td>
</tr>
<tr>
<td>4.2.1.10</td>
<td>Relative growth rate (RGR), g g(^{-1}) day(^{-1}) plant(^{-1})</td>
<td>97</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Yield and yield attributes</td>
<td>97</td>
</tr>
<tr>
<td>4.2.2.1</td>
<td>Ears m(^{-1}) row length (no.)</td>
<td>97</td>
</tr>
<tr>
<td>4.2.2.2</td>
<td>Length of ears (cm)</td>
<td>98</td>
</tr>
<tr>
<td>4.2.2.3</td>
<td>Weight of ears (g)</td>
<td>99</td>
</tr>
<tr>
<td>4.2.2.4</td>
<td>Grains earhead(^{-1}) (no.)</td>
<td>99</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>PARTICULAR</td>
<td>PAGE NO.</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td>4.2.2.5</td>
<td>Grain weight earhead(^{-1}) (g)</td>
<td>100</td>
</tr>
<tr>
<td>4.2.2.6</td>
<td>1000-grain weight (g)</td>
<td>101</td>
</tr>
<tr>
<td>4.2.2.7</td>
<td>Grain yield (q ha(^{-1}))</td>
<td>102</td>
</tr>
<tr>
<td>4.2.2.8</td>
<td>Straw yield (q ha(^{-1}))</td>
<td>103</td>
</tr>
<tr>
<td>4.2.2.9</td>
<td>Harvest index (%)</td>
<td>103</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Chemical studies</td>
<td>104</td>
</tr>
<tr>
<td>4.2.3.1</td>
<td>Nitrogen content (%)</td>
<td>104</td>
</tr>
<tr>
<td>4.2.3.2</td>
<td>Nitrogen uptake (kg ha(^{-1}))</td>
<td>104</td>
</tr>
<tr>
<td>4.2.3.3</td>
<td>Phosphorus content (%)</td>
<td>106</td>
</tr>
<tr>
<td>4.2.3.4</td>
<td>Phosphorus uptake (kg ha(^{-1}))</td>
<td>106</td>
</tr>
<tr>
<td>4.2.3.5</td>
<td>Potassium content (%)</td>
<td>107</td>
</tr>
<tr>
<td>4.2.3.6</td>
<td>Potassium uptake (kg ha(^{-1}))</td>
<td>108</td>
</tr>
<tr>
<td>4.2.3.7</td>
<td>Available N, P and K in soil (kg ha(^{-1}))</td>
<td>109</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Productivity rating index (PRI), %</td>
<td>110</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Production efficiency (PE), kg ha(^{-1}) day(^{-1})</td>
<td>110</td>
</tr>
<tr>
<td>4.2.6</td>
<td>Energetics of production</td>
<td>111</td>
</tr>
<tr>
<td>4.2.7</td>
<td>Economics</td>
<td>112</td>
</tr>
<tr>
<td>4.3</td>
<td>Studies on urdbean-wheat cropping system</td>
<td>113</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Total productivity and net income</td>
<td>113</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Balance sheet of N, P and K</td>
<td>114</td>
</tr>
<tr>
<td>V</td>
<td>DISCUSSION</td>
<td>116-131</td>
</tr>
<tr>
<td>5.1</td>
<td>Weather effect</td>
<td>116</td>
</tr>
<tr>
<td>5.2</td>
<td>Effect on urdbean</td>
<td>118</td>
</tr>
<tr>
<td>5.2.1</td>
<td>Growth, yield attributes and yield</td>
<td>118</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Content and uptake of N, P, K and content and yield of protein</td>
<td>122</td>
</tr>
<tr>
<td>5.2.3</td>
<td>Available soil nutrients</td>
<td>123</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Productivity rating index, energy and economics</td>
<td>124</td>
</tr>
</tbody>
</table>

Contd..
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PARTICULAR</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.3</td>
<td>Effect on wheat</td>
<td>125</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Growth, yield attributes and yield</td>
<td>125</td>
</tr>
<tr>
<td>5.3.2</td>
<td>N uptake and use efficiency</td>
<td>128</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Available soil nutrients</td>
<td>129</td>
</tr>
<tr>
<td>5.3.4</td>
<td>Productivity rating index, energy and economics</td>
<td>129</td>
</tr>
<tr>
<td>5.4</td>
<td>Effect of urdbean-wheat cropping system</td>
<td>130</td>
</tr>
</tbody>
</table>

### VI SUMMARY, CONCLUSION AND SUGGESTION FOR FUTURE RESEARCH WORK

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Studies on urdbean</td>
</tr>
<tr>
<td>6.2</td>
<td>Studies on wheat</td>
</tr>
<tr>
<td>6.3</td>
<td>Effect on urdbean-wheat cropping system</td>
</tr>
</tbody>
</table>

CONCLUSION 162

SUGGESTION FOR FUTURE RESEARCH 163

### BIBLIOGRAPHY

164-186

### ABSTRACT

187-188

### APENDICES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Weekly meteorological data during crop growth period of urdbean (from 15/07/2002 to 28/09/2002) and wheat (from 21/11/2002 to 18/03/2003)</td>
</tr>
<tr>
<td>III</td>
<td>Crop-wise details of cultural operations</td>
</tr>
<tr>
<td>IV</td>
<td>Cost of cultivation of urdbean</td>
</tr>
<tr>
<td>V</td>
<td>Cost of cultivation of wheat</td>
</tr>
<tr>
<td>VI</td>
<td>Standard values for calculation of energy relationship during the course of investigation</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>TITLE</th>
<th>PAGES IN BETWEEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Physico-chemical properties of the soil</td>
<td>40-41</td>
</tr>
<tr>
<td>3.2</td>
<td>Cropping history of the experimental site</td>
<td>41</td>
</tr>
<tr>
<td>3.3</td>
<td>Treatment details</td>
<td>43</td>
</tr>
<tr>
<td>4.1</td>
<td>Plant population and plant height of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>63-64</td>
</tr>
<tr>
<td>4.2</td>
<td>Number of branches plant(^{-1}) of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>64-65</td>
</tr>
<tr>
<td>4.3</td>
<td>Root length of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>65-66</td>
</tr>
<tr>
<td>4.4</td>
<td>Root weight of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>66-67</td>
</tr>
<tr>
<td>4.5</td>
<td>Leaf area index of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>67-68</td>
</tr>
<tr>
<td>4.6</td>
<td>Dry matter accumulation in urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>68-69</td>
</tr>
<tr>
<td>4.7</td>
<td>Number of nodule plant(^{-1}) in urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>70-71</td>
</tr>
<tr>
<td>4.8</td>
<td>Dry weight of nodules of urdbean at various stages as influenced by planting method and nutrient management</td>
<td>71-72</td>
</tr>
<tr>
<td>4.9</td>
<td>Number of flowers and pods at various stages as influenced by planting method and nutrient management</td>
<td>72-73</td>
</tr>
</tbody>
</table>

Contd...
<table>
<thead>
<tr>
<th>TABLE</th>
<th>TITLE</th>
<th>PAGES IN BETWEEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.10</td>
<td>Number of pods plant$^{-1}$, seeds pod$^{-1}$, and seeds plant$^{-1}$ of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>75-76</td>
</tr>
<tr>
<td>4.11</td>
<td>Length of pod, pod weight, seed weight plant$^{-1}$ and 100-seed weight of urdbean at various stages as influenced by planting method and nutrient management</td>
<td>77-78</td>
</tr>
<tr>
<td>4.12</td>
<td>Seed and stover yields and harvest index of urdbean at various growth stages as influenced by planting method and nutrient management</td>
<td>78-79</td>
</tr>
<tr>
<td>4.13</td>
<td>Nitrogen content and uptake in urdbean as influenced by planting method and nutrient management</td>
<td>80-81</td>
</tr>
<tr>
<td>4.14</td>
<td>Phosphorus content and uptake in urdbean as influenced by planting method and nutrient management</td>
<td>81-82</td>
</tr>
<tr>
<td>4.15</td>
<td>Potassium content and uptake in urdbean as influenced by planting method and nutrient management</td>
<td>83-84</td>
</tr>
<tr>
<td>4.16</td>
<td>Protein content and yield of urdbean as influenced by planting method and nutrient management</td>
<td>84-85</td>
</tr>
<tr>
<td>4.17</td>
<td>Available N, P and K in the soil at harvest as influenced by planting method and nutrient management</td>
<td>86-87</td>
</tr>
<tr>
<td>4.18</td>
<td>Energetic of urdbean as influenced by planting method and nutrient management</td>
<td>87-88</td>
</tr>
<tr>
<td>4.19</td>
<td>Economics of urdbean production as influenced by planting method and nutrient management</td>
<td>88-89</td>
</tr>
<tr>
<td>4.20</td>
<td>Plant population and plant height of wheat at various growth stages as influenced by residual effect of kharif treatments and directly applied nutrients in wheat</td>
<td>90-91</td>
</tr>
<tr>
<td>TABLE</td>
<td>TITLE</td>
<td>PAGES IN BETWEEN</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>------------------</td>
</tr>
<tr>
<td>4.21</td>
<td>Number of tillers plant(^1) of wheat at various growth stages as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>91-92</td>
</tr>
<tr>
<td>4.22</td>
<td>Dry matter accumulation in wheat at various growth stages as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>92-93</td>
</tr>
<tr>
<td>4.23</td>
<td>Root volume and root dry weight of wheat at various growth stages as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>94-95</td>
</tr>
<tr>
<td>4.24</td>
<td>Leaf area index of wheat at various growth stages as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>95-96</td>
</tr>
<tr>
<td>4.25</td>
<td>Ears m(^{-1}) row length, length of ears and weight of ears in wheat as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>98-99</td>
</tr>
<tr>
<td>4.26</td>
<td>Grains earhead(^{-1}) (no), grain weight earhead(^{-1}) (g) and 1000-grain weight of wheat as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>101-102</td>
</tr>
<tr>
<td>4.27</td>
<td>Grain and straw yields and harvest index of wheat as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>103-104</td>
</tr>
<tr>
<td>4.28</td>
<td>Nitrogen content and uptake by wheat as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>105-106</td>
</tr>
<tr>
<td>4.29</td>
<td>Phosphorus content and uptake by wheat as influenced by residual effect of <em>kharif</em> treatments and directly applied nutrients in wheat</td>
<td>107-108</td>
</tr>
</tbody>
</table>

Contd...
<table>
<thead>
<tr>
<th>TABLE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.30</td>
<td>Potassium content and uptake by wheat as influenced by residual effect of kharif treatments and directly applied nutrients in wheat</td>
</tr>
<tr>
<td>4.31</td>
<td>Available N, P and K in the soil at harvest as influenced by residual effect of kharif treatments and directly applied nutrients in wheat</td>
</tr>
<tr>
<td>4.32</td>
<td>Energetic of wheat as influenced by residual effect of kharif treatments and directly applied nutrients in wheat</td>
</tr>
<tr>
<td>4.33</td>
<td>Economics of wheat production as influenced by residual effect of kharif treatments and directly applied nutrients in wheat</td>
</tr>
<tr>
<td>4.34</td>
<td>Total productivity and net return from urdbean-wheat cropping system under different treatment</td>
</tr>
<tr>
<td>4.35</td>
<td>Balance sheet of N after harvest of wheat under urdbean-wheat cropping system (Mean of two years data)</td>
</tr>
<tr>
<td>4.36</td>
<td>Balance sheet of P after harvest of wheat under urdbean-wheat cropping system (Mean of two years data)</td>
</tr>
<tr>
<td>4.37</td>
<td>Balance sheet of K after harvest of wheat under urdbean-wheat cropping system (Mean of two years data)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PAGES IN BETWEEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.30 108-109</td>
</tr>
<tr>
<td>4.31 109-110</td>
</tr>
<tr>
<td>4.32 111-112</td>
</tr>
<tr>
<td>4.33 112-113</td>
</tr>
<tr>
<td>4.34 113-114</td>
</tr>
<tr>
<td>4.35 114-115</td>
</tr>
<tr>
<td>4.36 114-115</td>
</tr>
<tr>
<td>4.37 114-115</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>TITLE</th>
<th>PAGES IN BETWEEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Weekly meteorological observations of <strong>kharif</strong> 2002 and <strong>rabi</strong> 2002-03 at I.G.A.U., Raipur</td>
<td>39-40</td>
</tr>
<tr>
<td>3.3</td>
<td>Layout plan of urdbean Experiment during <strong>Kharif</strong> 2002 and 2003</td>
<td>42-43</td>
</tr>
<tr>
<td>3.4</td>
<td>Layout plan of wheat Experiment during <strong>Rabi</strong> 2002-03 and 2003-04</td>
<td>42-43</td>
</tr>
<tr>
<td>4.1</td>
<td>Leaf area duration of urdbean as influenced by planting method and nutrient management</td>
<td>67-68</td>
</tr>
<tr>
<td>4.2</td>
<td>Crop growth rate at various growth stages of urdbean as influenced by planting method and nutrient management</td>
<td>69-70</td>
</tr>
<tr>
<td>4.3</td>
<td>Relative growth rate at various growth stages of urdbean as influenced by planting method and nutrient management</td>
<td>69-70</td>
</tr>
<tr>
<td>4.4</td>
<td>Productivity rating index (PRI) and production efficiency (PE) as influenced by planting method and nutrient management</td>
<td>86-87</td>
</tr>
<tr>
<td>4.5</td>
<td>Leaf area duration of wheat as influenced by residual effect of <strong>kharif</strong> treatments and directly applied nutrients in wheat</td>
<td>96-97</td>
</tr>
<tr>
<td>4.6</td>
<td>Crop growth rate of wheat at various growth stages as influenced by residual effect of <strong>kharif</strong> treatments and directly applied nutrients in wheat</td>
<td>96-97</td>
</tr>
<tr>
<td>4.7</td>
<td>Relative growth rate of wheat at various growth stages as influenced by residual effect of <strong>kharif</strong> treatments and directly applied nutrients in wheat</td>
<td>96-97</td>
</tr>
<tr>
<td>4.8</td>
<td>Productivity rating index (PRI) and production efficiency (PE) as influenced by residual effect of <strong>kharif</strong> treatments and directly applied nutrients in wheat</td>
<td>110-111</td>
</tr>
</tbody>
</table>
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Notations used</th>
<th>Description</th>
<th>Notations used</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>@</td>
<td>At the rate of</td>
<td>m</td>
<td>Metre</td>
</tr>
<tr>
<td>°C</td>
<td>Degree celsius</td>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>CD</td>
<td>Critical differences</td>
<td>ml</td>
<td>Millilitre</td>
</tr>
<tr>
<td>CEC</td>
<td>Cation exchange capacity</td>
<td>mm</td>
<td>Milimetre</td>
</tr>
<tr>
<td>CG</td>
<td>Chhattisgarh</td>
<td>min</td>
<td>Minimum</td>
</tr>
<tr>
<td>CGR</td>
<td>Crop growth rate</td>
<td>N</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetre</td>
<td>NS</td>
<td>Non-significant</td>
</tr>
<tr>
<td>DAS</td>
<td>Days after sowing</td>
<td>P</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>et al.</td>
<td>And co-worker/or others</td>
<td>pH</td>
<td>Logarithm of the reciprocal of H⁺ ion activity</td>
</tr>
<tr>
<td>Fig.</td>
<td>Figure</td>
<td>q</td>
<td>Quintal</td>
</tr>
<tr>
<td>FYM</td>
<td>Farm yard manure</td>
<td>RDF</td>
<td>Recommended dose of fertilizers</td>
</tr>
<tr>
<td>g</td>
<td>Gram</td>
<td>RGR</td>
<td>Relative growth rate</td>
</tr>
<tr>
<td>ha</td>
<td>Hectare</td>
<td>RH</td>
<td>Relative humidity</td>
</tr>
<tr>
<td>ha⁻¹</td>
<td>Per hectare</td>
<td>Rs</td>
<td>Rupees</td>
</tr>
<tr>
<td>HI</td>
<td>Harvest index</td>
<td>SEM±</td>
<td>Standard error of mean</td>
</tr>
<tr>
<td>hr⁻¹</td>
<td>Per hour</td>
<td>S.No.</td>
<td>Serial Number</td>
</tr>
<tr>
<td>i.e.</td>
<td>That is</td>
<td>SSP</td>
<td>Single super phosphate</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
<td>t</td>
<td>Tonne</td>
</tr>
<tr>
<td>kg</td>
<td>Kilogram</td>
<td>viz.</td>
<td>That is to say/in other words</td>
</tr>
<tr>
<td>LAD</td>
<td>Leaf area duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAI</td>
<td>Leaf area index</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>