CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted during *rabi* 2005-06 and 2006-07 to study the interactive effects of weed management practices and seed rate in direct seeded rice under wet condition. The details of materials used and methods adopted during the course of this investigation are presented below.

3.1.1 Location

The field experiments were conducted in four locations two in Tamilnadu and two in Kerala.

1. Pulavarnatham, Tanjore, Tamilnadu
2. Vippedu, Kanchipuram, Tamilnadu
3. Alappad, Thrissur, Kerala

3.1.2 Climate and weather condition

Tanjore has a tropical climatic condition. During summers the average temperature of Tanjore rises to 36.6° C, while during the winter season, the average temperature goes down to 22° C. The city of Tanjore experiences heavy rain of about 111.37 cm during the rainy season. Tanjore experiences summer season during the months from March till the middle of July. The months of July, August and September are considered to be rainy season and experiences heavy rainfall. Winter season begins from the middle of October and lasts till the middle of February.

Kanchipuram district generally experiences hot and humid climatic conditions. The minimum and maximum temperature are 20°C and 37°C, respectively. The district receives the rain under the influence of both southeast and northeast monsoons. Most of the precipitation occurs in the form of cyclonic storm caused due to the depressions in Bay of Bengal chiefly during northeast monsoon period. The southwest monsoon rainfall is highly
erratic and summer rains are negligible. The normal annual rainfall over the district varies from 1105 mm to 1214 mm.

Trichur district has a tropical humid climate with an oppressive hot season and plentiful and seasonal rainfall. The maximum temperature ranges from 29.3°C to 36.2°C whereas, the minimum temperature ranges from 22.1°C to 24.9°C. The average annual maximum temperature is 30.7°C and the average annual minimum temperature is 23.9°C. The hot season from March to May is followed by the South West Monsoon season from June to September. The period from December to February is the North East Monsoon season, although the rain stop by the end of December and the rest of the period is generally dry. The average annual rainfall ranges between 2180 and 3484 mm in the district and the mean annual rainfall for the district is 2924.4 mm. The hole land where the rice is being cultivated has the elevation in the range of 1-2 m below, mean sea level and water logged for 5-6 months in a year due to tidal effects.

Alleppy district has a tropical humid climate. The period from March to end of May is the hot season. The summer season varies between March to May. The maximum temperature ranges from 28.8°C to 32.7°C whereas, the minimum temperature ranges from 22.6°C to 25.5°C. The average annual maximum temperature is 30.7°C and the average annual minimum temperature is 23.9°C. The percentage of humidity is very high during this period. This is followed by south west monsoon season, which continues till end of September. The district receives and average of 2965.4 mm as the normal rainfall. Out of this south west monsoon contributes major part of rainfall, which contributes 60.3 per cent. The rice fields are located at 0.6 to 2 m below mean sea level. The rice bowl of Kerala, kuttanad in Alleppy district is one of the very few places in the world where farming is done below mean sea level.

3.1.3. Soil characteristics

The soils of the experimental fields were sandy loam at Kanchipuram and clay loam at Tanjore, Trichur and Alleppy. The available nitrogen - phosphorous - potassium of the soils were classified as low - high - low at Tanjore, low - high - medium at Kanchipuram, medium - medium - medium at Trichur and Alleppy. The physico chemical properties of the soils are given in Table 1.
Table 1. Soil characteristics of experimental field

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Tanjore</th>
<th>Kanchipuram</th>
<th>Trichur</th>
<th>Alleppy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Physical properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay (%)</td>
<td>33.2</td>
<td>16.3</td>
<td>33.1</td>
<td>34.3</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>32.3</td>
<td>40.8</td>
<td>20.3</td>
<td>35.2</td>
</tr>
<tr>
<td>Coarse sand (%)</td>
<td>26.4</td>
<td>4.4</td>
<td>20.4</td>
<td>20.2</td>
</tr>
<tr>
<td>Fine sand (%)</td>
<td>8.1</td>
<td>38.5</td>
<td>26.2</td>
<td>10.3</td>
</tr>
<tr>
<td>B. Physico chemical properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil reaction pH</td>
<td>6.87</td>
<td>6.83</td>
<td>4.58</td>
<td>4.62</td>
</tr>
<tr>
<td>Electrical conductivity (EC) (d Sm⁻¹)</td>
<td>0.50</td>
<td>0.53</td>
<td>0.21</td>
<td>0.46</td>
</tr>
<tr>
<td>Cation Exchange capacity (CEC) (Cmol(P+) kg)</td>
<td>25.4</td>
<td>24.6</td>
<td>27.0</td>
<td>34.4</td>
</tr>
<tr>
<td>C. Chemical properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic carbon (%)</td>
<td>1.93</td>
<td>0.93</td>
<td>3.86</td>
<td>3.03</td>
</tr>
<tr>
<td>Available nitrogen (kg ha⁻¹)</td>
<td>272</td>
<td>159</td>
<td>423</td>
<td>381</td>
</tr>
<tr>
<td>Available phosphorous (kg ha⁻¹)</td>
<td>38.1</td>
<td>33.5</td>
<td>35.2</td>
<td>37.2</td>
</tr>
<tr>
<td>Available potassium (kg ha⁻¹)</td>
<td>117</td>
<td>272</td>
<td>178</td>
<td>198</td>
</tr>
</tbody>
</table>

3.1.4. Season and crop variety

The two field experiments were conducted during *rabi* seasons of 2005-06 and 2006-07 using short duration rice Cv ADT-43 at Tanjore and Kanchipuram, and Jyothi as at Trichur and Alleppy. The details of the rice varieties grown were given in Table 2.

Table 2. Varietal characters of rice

<table>
<thead>
<tr>
<th>Character</th>
<th>ADT-43</th>
<th>Jyothi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of release</td>
<td>1999</td>
<td>1977</td>
</tr>
<tr>
<td>Duration</td>
<td>110 days</td>
<td>110 days</td>
</tr>
<tr>
<td>Habit</td>
<td>Semi dwarf</td>
<td>Semi dwarf</td>
</tr>
<tr>
<td>Average yield (kg ha⁻¹)</td>
<td>5900</td>
<td>4500</td>
</tr>
<tr>
<td>Source of seed</td>
<td>TFL seeds</td>
<td>TFL seeds</td>
</tr>
<tr>
<td>Parentage</td>
<td>IR 50 x white ponni</td>
<td>PTB-10 x IR8</td>
</tr>
<tr>
<td>Grain type</td>
<td>Medium slender</td>
<td>Bold</td>
</tr>
</tbody>
</table>

Based on the two season trials the recommended findings were validated under farmers condition in two fields each at Tanjore, Kanchipuram, Trichur and Alleppy during *rabi* 2007-08. To find out the residual toxicity of the herbicides green gram variety Co-4 was used.
Plate 1. Layout and view of the experimental field

a. Tanjore

b. Kancheepuram

c. Trichur

d. Alleppy
3.2.1 Experimental details

3.2.1.1 Design, layout and treatments

The experiment was laid out in split plot design with three replications. The main plot treatments consisted of three different seed rates and eight different weed management practices formed subplot treatments. The following are the treatments details.

Main Plot - Seed rate
M1 – 80 kg ha\(^{-1}\)
M2 – 100 kg ha\(^{-1}\)
M3 – 120 kg ha\(^{-1}\)

Sub Plot – Weed management practices
S1 – Unweeded check up to 45 DAS
S2 – Hand weeding twice at 25 DAS and 45 DAS
S3 – Cyhalofop butyl 10EC @ 100 g a.i. ha\(^{-1}\) at 15 DAS
S4 – Bensulfuron methyl 60DF @ 60 g a.i. ha\(^{-1}\) at 20DAS
S5 - Cyhalofop butyl 10EC @ 100 g a.i. ha\(^{-1}\) at 15 DAS / Bensulfuron methyl 60DF @ 60 g a.i. ha\(^{-1}\) at 20DAS
S6 - Cyhalofop butyl 10EC @ 100 g a.i. ha\(^{-1}\) at 15 DAS / hand weeding at 45DAS
S7 - Bensulfuron methyl 60DF @ 60 g a.i. ha\(^{-1}\) at 20DAS / hand weeding at 45DAS
S8 - Cyhalofop butyl 10EC @ 100 g a.i. ha\(^{-1}\) at 15 DAS / Bensulfuron methyl 60DF @ 60 g a.i. ha\(^{-1}\) at 20DAS / hand weeding at 45DAS

3.2.2 Crop husbandry

All the cultural practices and plant protection measures for rice other than the treatments (seed rate and weed management practices) were followed as per the recommendations of crop production guide of Tamilnadu Agricultural University and Kerala Agricultural University.

3.2.2.1 Field preparation

The selected experimental field was initially dry ploughed with tractor drawn disc harrow and then puddle with tractor drawn cage wheel. The field was leveled with wooden
plank before lay out. The main and sub plots were laid out with irrigation and drainage channels all around the experimental field.

3.2.2.2 Sowing

Pre-germinated rice seeds (seeds soaked in water overnight and incubated for 24 hours) were sown as broadcasting. The different seed rate was followed in main plots viz., 80 kg ha\(^{-1}\), 100 kg ha\(^{-1}\) and 120 kg ha\(^{-1}\).

3.2.2.3 Weed management practices

All the herbicide applications were done using flat fan nozzle fitted in knapsack sprayer using 300 l ha\(^{-1}\) of water. As per treatment schedule cyhalofop butyl 10EC @ 100 g a.i. ha\(^{-1}\) was applied at 15 DAS in S3, S5, S6 and S8, and bensulforon methyl 60DF @ 60 g a.i. ha\(^{-1}\) at 20 DAS in S4, S5, S7 and S8. Non-ionic surfactant @ 0.2 per cent was used with bensulforon methyl. Hand weeding operations as per treatment schedule were done on 25 DAS in S2 and on 45 DAS in S1, S2, S6, S7 and S8.

3.2.2.4 Fertilizer application

A recommended dose of 150:50:50 kg ha\(^{-1}\) and 110:45:45 kg ha\(^{-1}\) of nitrogen, phosphorous and potassium at TamilNadu and Kerala, respectively in the form of urea (46%N), single super phosphate (16% P\(_2\)O\(_5\)) and muriate of potash (60% K\(_2\)O). Split application of N was done as per treatment and an entire dose of phosphorous and potassium was applied basally before sowing. At active tillering stage, nitrogen was applied after completion of weeding operation (as per the treatments).

3.2.2.5 Water management

A thin film of water was maintained at the time of sowing. Subsequently for the next 8-10 days, irrigation and drainage of water were alternated to facilitate aeration and adequate moisture for germination of seeds and establishment of seedlings. Thereafter, the crop was irrigated to 5 cm depth at required interval when the water completely drained and irrigation was withheld 10 days prior to harvest.
Table 3. Calendar of operations

<table>
<thead>
<tr>
<th>No.</th>
<th>Particulars</th>
<th>Tanjore</th>
<th>Kanchipuram</th>
<th>Trichur</th>
<th>Alleppy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Date of harvest</td>
<td>20.02.2006</td>
<td>11.03.2006</td>
<td>15.03.2006</td>
<td>06.03.2006</td>
</tr>
</tbody>
</table>

II year (*rabi* 2006-07)

<table>
<thead>
<tr>
<th>No.</th>
<th>Particulars</th>
<th>Tanjore</th>
<th>Kanchipuram</th>
<th>Trichur</th>
<th>Alleppy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Date of sowing</td>
<td>10.11.2006</td>
<td>24.11.2006</td>
<td>22.11.2006</td>
<td>29.11.2006</td>
</tr>
<tr>
<td>2</td>
<td>Date of harvest</td>
<td>01.03.2007</td>
<td>15.03.2007</td>
<td>12.03.2007</td>
<td>21.03.2007</td>
</tr>
</tbody>
</table>

3.3 Sampling technique

Samples were taken from the pre-designed sample zones on either side of the plot excluding the border rows. Crop and weed samples were collected from these sample zones. Every time samples were taken from an area of 0.5 m² (0.25 m² at two locations)

3.4 Studies on weeds

3.4.1 Weed density and dry weight

In each plot weeds were counted at 30, 45 and 60 DAS of the crop from an area of 0.5 m², and sampled at 45 DAS and dried to constant weights at 70°C in an oven and expressed as g m⁻².

3.4.2 Weed control efficiency

Weed control efficiency was worked out on the basis of weed dry matter recorded in each treatment at 45 DAS using the formula suggested by Sankaran and Mani (1974).

\[
WCE = \frac{DWC - DWT}{DWC} \times 100
\]

where,

\[WCE\] - weed control efficiency (%)  
\[DWC\] – dry weight of weeds in unweeded control  
\[DWT\] – dry weight of weeds in weed control treatments
3.4.3 Relative density

Relative density (RD) of grass, sedges and broad leaved weeds were calculated using the formula suggested by Kim and Moody (1983)

\[
RD = \frac{\text{Absolute density of given species}}{\text{Total absolute density of all species}} \times 100
\]

3.4.4 Weed Index

Weed index was worked out on the basis of the economic produce recorded in each treatment as outlined by Gill and Vijayakumar (1966).

\[
WI = \frac{X - Y}{X} \times 100
\]

Where,
- \( WI \) - weed index
- \( X \) - Yield from minimum weed competition plot
- \( Y \) - Yield from the treatment for which WI is to be worked out.

3.5 Studies on rice

3.5.1 Plant population

The plant population was counted from two spots in each plot from an area of 0.25 \( m^2 \) at 20DAS and expressed in number \( m^2 \)

3.5.2 Plant height

Plant height was measured from the ground level to the tip of the panicle at maturity stage from five randomly selected plants and the average was worked out and expressed in cm

3.5.3 Number of productive tillers

The number of productive tillers in 0.5 \( m^2 \) area counted at maturity stage and expressed as number \( m^2 \)
3.5.4 Dry matter production

Plant samples drawn at tillering, flowering and maturity stages from the sampling zone at two locations (0.25 m² each) in each plot were sun dried and then oven dried to a constant weight at 70°C and computed to kg ha⁻¹.

3.5.5 Crop growth rate

Crop growth rate for the period from seedling to tillering, tillering to flowering and flowering to maturity stages were calculated using the mathematical formula given by Watson (1958) and expressed in g m⁻² day⁻¹

\[
\text{CGR} = \frac{W_2 - W_1}{G (t_2 - t_1)} \text{ g m}^{-2} \text{ day}^{-1}
\]

where, \( W_1 \) and \( W_2 \) - plant dry weight recorded at \( t_1 \) and \( t_2 \) days, respectively
\( t_2 - t_1 \) - time interval in days
\( G \) - ground area in which \( W_1 \) and \( W_2 \) were estimated

3.6 Yield components

3.6.1 Panicle length

10 random panicles were collected from the trial plots and were measured for its length and the average was worked out and expressed in cm.

3.6.2 1000 grain weight

The weight of 1000 well filled grains, selected at random, in each net plot produce was recorded and expressed in grams.

3.6.3 Grain and straw yield

The grains from individual net plot were sundried, cleaned and weighed. The results were expressed on 14 per cent moisture basis suggested by Yoshida et al. (1976). Straw was sun dried for 4 days and weighed separately, grain and straw yield were expressed in kg ha⁻¹.

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3.6.4 Economic analysis

Economic evaluation of treatments was done by calculating gross return, net return and Benefit Cost Ratio (BCR) and expressed as Rs ha\(^{-1}\).

\[
\text{Benefit Cost Ratio} = \frac{\text{Gross return (Rs ha}\(^{-1}\))}{\text{Cost of cultivation (Rs ha}\(^{-1}\))}
\]

3.6.5. Statistical analysis

All the data were statistically analysed as per the methods suggested by Gomez and Gomez (1984). The data on weed density and dry weight of weeds showed high variance and hence they were subjected to log transformation (Log x + 1) before statistical analysis as suggested by Bartlett (1947). Wherever statistical significance was observed, critical difference (CD) at 0.05 level of probability was worked out for comparison.

3.7. Test verification of effective treatments in large plots

The effective treatments from the current study were verified under farmers growing condition in larger plots of 400 m\(^2\) during rabi 2007-08. The test verifications were conducted at Pulavarnatham and Vandayariruppu in Tanjore, at Vippedu and Vishar in Kanchipuram, at Alappad and Chenam in Trichur, and at Kidangara and Moncombu in Alleppy. The seed rate of 100 kg ha\(^{-1}\) (M2) and the weed management practices, untreated weedy check (S1), hand weeding twice at 25 and 45 DAS (S2), cyhalofop butyl fb bensulfuron methyl (S5) and cyhalofop butyl fb bensulfuron methyl fb hand weeding (S8) were practiced. The weed density and dry weight of total weeds at 60 DAS and the grain and straw yield of rice were taken as per the methodology explained previously.

3.8. Bioassay study on residual green gram

After the harvest of the main crop rice in rabi 2007-08, in the same field green gram were sown without disturbing treatment block to find out the residual safety of the herbicides on the succeeding green gram. On the residual green gram, germination per cent, plant height (cm) and plant bio mass (kg ha\(^{-1}\)) at 30 and 60 DAS and the final grain yield (kg ha\(^{-1}\)) were recorded.