III. MATERIALS AND METHODS

Weeds form an integral part of the biotic environment at each and every agro-ecosystem and become competitor with the crop format of the natural resources. Hence, weeds are gaining importance as an increasingly predominant and troublesome in many of the irrigated upland crops of South India. Enormous seed production potential, tuber production and the adaptation to disperse with the help of various agents *viz.*, animals and water help the weeds to evade several of the control options when attempted independently. Hence, a comprehensive study was taken up to bring out the distribution pattern of nutsedge, competitive ability and the efficiency of integrated weed management practices to tackle the weed menace. The study includes

1) Weed survey in different gardenland crops to trace out the predominant weed flora.

2) One preliminary field experiment to find out the best herbicide to control *Cyperus rotundus* in maize crop.

3) Two main field experiments to explore the possibility of integrating off-season land management practices and cropping season weed management practices.

4) One laboratory experiment to find out the continuous effect of off-season land management practices on microbial population.
The materials and methods used in various experiments during the investigation are presented in this chapter.

3.1. MATERIALS

3.1.1. Location of the experimental site

3.1.1.1. Preliminary field experiment

The experiment was conducted in the field No. GL13A in the gardenland block of Annamalai University Experimental Farm, Annamalainagar during 2009. The farm is located at 11°24' North latitude and 79°41' East longitude at an altitude of 5.79 meters above mean sea level.

3.1.1.2. Main field experiment

Two main field experiments were carried out in farmer’s field. B.Mutlur, Chidambaram Taluk, Tamil Nadu during 2010 and 2011. The farm is located at 11°24'N as latitude and 74°41'E longitude at an altitude of 5.79 m above mean sea level.

3.1.2. Weather and climate

The weather at Annamalainagar is moderately warm with hot summer months. The maximum temperature ranges from 27.1°C to 38.1°C and the mean minimum temperature ranges from 18.5°C to 26.3°C. The highest mean relative humidity is 95 per cent during December-January and the lowest 75 per cent during May-June. The mean annual relative humidity is 88.3 per cent. The mean annual rainfall received is 1500 mm with a mean distribution of
1000 mm during North-east monsoon, 400 mm during South-west and 100 mm as summer showers and spread over 60 rainy days. The meteorological data recording during the crop period are given in Appendix I.

The weather at B.Mutlur is warm hot summer months. The maximum temperature ranges from 27.0°C to 38.5°C with a mean of 32.5°C while the minimum temperature fluctuates between 20.9°C to 26.8°C with a mean of 23.5°C. The mean relative humidity is 73.3 per cent.

The mean annual rainfall received is 1500 mm with a distribution of 1000 mm during North east monsoon, 400 mm during Southwest and 100 mm of summer showers. The weekly weather data during the cropping periods are presented in Appendix 2 and 3.

**Table 3.1. Location of the field experiments and years**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiments</th>
<th>Location of experimental field</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Preliminary study to choose the best herbicide with supplemental control measure for <em>Cyperus rotundus</em> in maize</td>
<td>Annamalai University Experimental Farm, Annamalainagar</td>
<td>2009</td>
</tr>
<tr>
<td>2.</td>
<td>Studies on integrated management practice for control of <em>Cyperus rotundus</em> in maize</td>
<td>Farmer’s field B.Mutlur</td>
<td>2010 &amp; 2011</td>
</tr>
</tbody>
</table>

**3.1.3. Soil**

The soil of both the experimental fields GL13A and farmer’s field were clayey loam in texture. The soil is low in available nitrogen, medium in
available phosphorus and high in available potassium content. The physico-chemical properties of the soil in the experimental sites are illustrated in Table 3.2.

3.1.4. Crop characters

The morphological characters of the maize variety CP 818 and intercrop blackgram Cv. ADT 3 are presented in Table 3.3 and Table 3.4.

3.1.5. Polythene sheets used for off-season solarization

Transparent white polythene (TPE) sheets of thickness 0.05 mm was used or solarise the surface of soil in the preceding off-season in the field experiments conducted with the objective of including soil solarization as one of the suitable off-season land management practice for managing *Cyperus rotundus* in maize crop.

3.2. METHODS

3.2.1. Experimental details

3.2.1.1. Weed survey in different gardenland crops

A survey was taken up during June 2008 in different gardenland crops *viz.*, maize, sorghum, cotton, sugarcane and gingelly in order to get a comprehensive idea about the associated weed flora located in and around Annamalainagar (within a radius of 15 km). Care was taken while selecting the fields to see that the crops were raised under normal care without any weed control measures until the completion of the survey.
Table 3.2. Physico-chemical properties of soil in the experimental sites

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Particulars</th>
<th>GL 13A</th>
<th>Farmer’s field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Physical properties (Piper, 1966)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coarse sand (%)</td>
<td>23.10</td>
<td>38.00</td>
</tr>
<tr>
<td></td>
<td>Fine sand (%)</td>
<td>19.10</td>
<td>11.80</td>
</tr>
<tr>
<td></td>
<td>Silt (%)</td>
<td>9.00</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td>Clay</td>
<td>48.50</td>
<td>35.00</td>
</tr>
<tr>
<td><strong>B.</strong></td>
<td><strong>Chemical properties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Available N (kg ha(^{-1}))</td>
<td>240</td>
<td>200 (low)</td>
</tr>
<tr>
<td></td>
<td>(Subbiah and Asija, 1956)</td>
<td>(low)</td>
<td>(low)</td>
</tr>
<tr>
<td></td>
<td>Available P(_2)O(_5) (kg ha(^{-1}))</td>
<td>21.40</td>
<td>20.5 (medium)</td>
</tr>
<tr>
<td></td>
<td>(Olsen <em>et al.</em>, 1954)</td>
<td>(medium)</td>
<td>(medium)</td>
</tr>
<tr>
<td></td>
<td>Available K(_2)O (kg ha(^{-1}))</td>
<td>336.20</td>
<td>310.00 (high)</td>
</tr>
<tr>
<td></td>
<td>(Stanford and English, 1949)</td>
<td>(high)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organic carbon (%)</td>
<td>0.52</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>(Walkley and Black, 1934)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH (1:2 soil and water extract)</td>
<td>7.90</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>EC (mmhos cm(^{-1}))</td>
<td>0.31</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>(Jackson, 1973)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3.3. Morphological characters of CP 818

<table>
<thead>
<tr>
<th>Character</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (days)</td>
<td>100-110</td>
</tr>
<tr>
<td>Area under cultivation</td>
<td>Entire state</td>
</tr>
<tr>
<td>Cultivation</td>
<td>Both rainfed and irrigated</td>
</tr>
<tr>
<td>Sheath colour</td>
<td>Green</td>
</tr>
<tr>
<td>Node colour</td>
<td>White</td>
</tr>
<tr>
<td>Cob size</td>
<td>Big</td>
</tr>
<tr>
<td>Grain colour</td>
<td>Yellow</td>
</tr>
<tr>
<td>Nature of kernels</td>
<td>Semi dent</td>
</tr>
<tr>
<td>Cob diameter (cm)</td>
<td>27.5</td>
</tr>
<tr>
<td>Number of grains (cob(^{-1}))</td>
<td>453.6</td>
</tr>
<tr>
<td>Cob length (cm)</td>
<td>21.6</td>
</tr>
<tr>
<td>Test weight (g)</td>
<td>28.3</td>
</tr>
</tbody>
</table>
Table 3.4. Morphological characters of Cv. ADT 3

<table>
<thead>
<tr>
<th>Particulars</th>
<th>ADT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parentage</td>
<td>Pureline selection from Tirunelveli</td>
</tr>
<tr>
<td>50% flowering (days)</td>
<td>30-35</td>
</tr>
<tr>
<td>Maturity duration (days)</td>
<td>70-75</td>
</tr>
<tr>
<td>Average grain yield (kg ha(^{-1}))</td>
<td>750-850</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>50</td>
</tr>
<tr>
<td>Clusters</td>
<td>10-15</td>
</tr>
<tr>
<td>Hairiness of pods</td>
<td>Hairs</td>
</tr>
<tr>
<td>Colour of grains</td>
<td>Black and dull</td>
</tr>
<tr>
<td>100 grain weight (g)</td>
<td>3.6</td>
</tr>
</tbody>
</table>
To determine the dominance of a particular species, the quantitative ecological characters viz., relative dominance, relative density, relative frequency and importance value index were calculated by using the following formulae suggested by Misra (1968).

Relative dominance (R.Do)\% = \frac{\text{Dominance of a particular species}}{\text{Sum total of dominance of all species}} \times 100

Relative density (R.De)\% = \frac{\text{Density of a particular species}}{\text{Sum total of density of all species}} \times 100

Relative frequency (R.F)\% = \frac{\text{Frequency of a particular species}}{\text{Sum total of frequency of all species}} \times 100

Importance value index (IVI) = \frac{R.Do + R.De + R.F}{3}

3.2.1.2. Preliminary study to choose the best herbicide with supplemental weed control measures for managing *Cyperus rotundus* in maize during cropping period

One preliminary field experiment was conducted to choose the best herbicide during cropping season for managing *Cyperus rotundus* L. in maize. The experiment was laid out in randomized block design with three replication. The treatment layout plan of the experiment is shown in Fig. 3.1.

**Treatment schedule**

\[ T_1 \] – Unweeded control

\[ T_2 \] – Twice handweeding (20 and 40 DAS)

\[ T_3 \] – Alachlor 1.5 kg ha\(^{-1}\) + 2,4-D Na salt 0.8 kg ha\(^{-1}\)
Fig. 3.1. Layout of the preliminary field experiment

|   | R₁  | T₂  | T₃  | T₁  | T₆  | T₄  | T₉  | T₇  | T₅  | T₈  | T₁₀ | T₁₂ | T₁₃ | T₁₁ | T₄  | T₁₆ | T₁₅ |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| ← Outs → |

|   | R₂  | T₃  | T₄  | T₂  | T₅  | T₇  | T₁  | T₆  | T₉  | T₁₃ | T₈  | T₁₀ | T₁₄ | T₁₂ | T₁₆ | T₁₅ | T₁₁ |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| ↑ Irrigation channel ↓ |

|   | R₃  | T₁  | T₂  | T₃  | T₄  | T₅  | T₈  | T₉  | T₇  | T₆  | T₁₁ | T₁₃ | T₁₂ | T₁₄ | T₁₅ | T₁₆ | T₁₀ |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| ← Outs → |

Plot size

4 m

5 m
T₄ – Fluchloralin 1.5 kg ha⁻¹ + 2,4-D Na salt 0.8 kg ha⁻¹
T₅ – Imazethapyr 0.05 kg ha⁻¹ + 2,4-D Na salt 0.8 kg ha⁻¹
T₆ – Alachlor 1.5 kg ha⁻¹ + Intercropping (blackgram)
T₇ – Fluchloralin 1.5 kg ha⁻¹ + Intercropping (blackgram)
T₈ – Imazethapyr 0.05 kg ha⁻¹ + Intercropping (blackgram)
T₉ – Alachlor 1.5 kg ha⁻¹ + mulching
T₁₀ – Fluchloralin 1.5 kg ha⁻¹ + mulching
T₁₁ – Imazethapyr 0.05 kg ha⁻¹ + mulching
T₁₂ – Intercrop alone
T₁₃ – Mulching alone

Gross plot = 5.0 x 4.0 m
Net plot = 3.8 x 3.6 m

**Treatment details**

In the unweeded control treatments, the weed flora was allowed to grow without any control measure. In twice handweeding treatments, the handweeding were taken up one at 20 DAS and again at 40 DAS. In herbicide treatments, the herbicides were applied through knapsack sprayer fitted with flat fan nozzle using 600 liters of water. Required quantities of formulated product of alachlor and imazethapyr were taken and sprayed as pre-emergence at 3 DAS on soil with optimum moisture. Whereas the required quantity of fluchloralin was applied as pre-sowing soil incorporation and irrigation was
given to incorporate the herbicide in the soil as well as to avoid volatilization loss. Alachlor 1.5 kg ha$^{-1}$ and Imazethapyr 0.05 kg ha$^{-1}$ each were sprayed separately and also followed by intercropping with blackgram ADT 3 was sown in between two rows of maize crop herbicides were sprayed as per the treatment schedule followed by mulching was done with sugarcane trash (12 t ha$^{-1}$) on 25 DAS. Intercropping blackgram was sown at 3 DAS of maize. The experiments were conducted in randomized block design and replicated thrice. For conducting main field experiments, the best treatments were selected from the preliminary field experiment.

3.2.1.3. Mainfield experiments on integrated management of *Cyperus rotundus* in maize

Field experiments were conducted during 2010 and 2011 at farmers field to evolve a suitable integrated management practice for *C. rotundus* in maize in split plot design with four main plot treatments (off-season land management practices) and five sub-plot treatment (cropping season weed control practices) and the treatments were replicated thrice. The layout plan of the experiment is shown in Fig. 3.2.

**Treatment schedule**

**Main plot treatment (off-season land management practices)**

- $M_1$ - Fallow
- $M_2$ - Summer ploughing
- $M_3$ - Soil solarization for 40 days with 0.05 mm TPE
- $M_4$ - Glyphosate spray (twice @ 1.5 kg ha$^{-1}$)
Fig. 3.2. Layout of the mainfield experiment

<table>
<thead>
<tr>
<th>R1M1S1</th>
<th>R1M2S5</th>
<th>R1M3S1</th>
<th>R1M4S2</th>
<th>R2M2S2</th>
<th>R2M3S3</th>
<th>R2M4S4</th>
<th>R2M5S5</th>
<th>R3M3S4</th>
<th>R3M4S3</th>
<th>R3M1S2</th>
<th>R3M5S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1M1S2</td>
<td>R1M2S4</td>
<td>R1M3S5</td>
<td>R1M4S3</td>
<td>R2M2S3</td>
<td>R2M3S4</td>
<td>R2M4S5</td>
<td>R2M5S5</td>
<td>R3M3S3</td>
<td>R3M4S2</td>
<td>R3M1S3</td>
<td>R3M2S3</td>
</tr>
<tr>
<td>R1M1S3</td>
<td>R1M2S2</td>
<td>R1M3S4</td>
<td>R1M4S1</td>
<td>R2M2S4</td>
<td>R2M3S5</td>
<td>R2M4S1</td>
<td>R2M5S2</td>
<td>R3M3S1</td>
<td>R3M4S2</td>
<td>R3M1S2</td>
<td>R3M2S4</td>
</tr>
<tr>
<td>R1M1S4</td>
<td>R1M2S3</td>
<td>R1M3S2</td>
<td>R1M4S5</td>
<td>R2M2S6</td>
<td>R2M3S1</td>
<td>R2M4S2</td>
<td>R2M5S3</td>
<td>R3M3S2</td>
<td>R3M4S3</td>
<td>R3M1S4</td>
<td>R3M2S2</td>
</tr>
<tr>
<td>R1M1S5</td>
<td>R1M2S1</td>
<td>R1M3S3</td>
<td>R1M4S4</td>
<td>R2M2S1</td>
<td>R2M3S2</td>
<td>R2M4S3</td>
<td>R2M5S5</td>
<td>R3M3S3</td>
<td>R3M4S1</td>
<td>R3M1S2</td>
<td>R3M2S1</td>
</tr>
</tbody>
</table>

Plot size

- 5 m
- 4 m

← Outs →

← Outs →
Sub plot treatment (cropping season weed management practices)

S₁ – Unweeded control
S₂ – Twice handweeding on 20 and 40 DAS
S₃ – Fluchloralin 1.5 kg ha⁻¹ + one hand weeding
S₄ – Fluchloralin 1.5 kg ha⁻¹ + Intercropping with Blackgram
S₅ – Fluchloralin 1.5 kg ha⁻¹ + Mulching (Sugarcane trash)

Plot size = 5.0 x 4.0 m
Net plot = 3.8 x 3.6 m

Treatment details

Field experiments were conducted to compare the efficiency of different management practices. The field was divided into four strips during off-season (April-June). One strip was left as a fallow without any soil disturbance, another strip was ploughed twice with an interval of 15 days after the receipt of summer showers. Soil solarization was done by spreading with white transparent polyethylene sheet of thickness 0.05 mm over the strip of land for 40 days and securing them air tight by folding and inserting the edges underneath the bunds, after initial wetting of the soil at 70 per cent ASM. Glyphosate 41% SL was sprayed @ 1.5 kg ha⁻¹ with ammonium sulphate @ 2.5 kg ha⁻¹ (as an additive) using 600 l of water ha⁻¹ in another strip. Spraying was repeated once again after a fortnight. The best weed control measure chosen from the preliminary experiment was superimposed during cropping season over this off-season land management practices and compared.
In sub plots, unweeded control was maintained as without any intercultural operations throughout the crop period. Two handweeding was done on 20 DAS and 40 DAS. Fluchlolarin 1.5 kg ha\(^{-1}\) was applied as pre-sowing soil incorporation. Field was irrigated lightly immediately after herbicide application to avoid volatilization loss. Fluchlolarin 1.5 kg ha\(^{-1}\) followed by mulching was done with sugarcane trash (12 t ha\(^{-1}\)) on 25 DAS. Fluchlolarin (1.5 t ha\(^{-1}\)) + intercropping with blackgram ADT 3 was sown in between two rows of maize crop and fluchlolarin 1.5 kg ha\(^{-1}\) followed by one hand weeding on 40 DAS was included.

<table>
<thead>
<tr>
<th>Duration of off-season solarization</th>
<th>Period of off-season solarization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>Started</td>
</tr>
<tr>
<td>40 days</td>
<td>21.4.2010</td>
</tr>
</tbody>
</table>
Details of Alachlor

Common name : Alachlor
Chemical name : 2-Chloro,2,6-diethyl-N-(methoxy methyl) acetanilide (IUPAC)
Trade name : Lasso
Structural formula :

\[
\begin{array}{c}
\text{CH}_3 \\
\text{O} \\
\text{C}_2\text{H}_5\text{CH}_2 \\
\text{O} \\
\text{N} - \text{C} - \text{C} - \text{Cl} \\
\text{C}_2\text{H}_4 \\
\text{H}
\end{array}
\]

Molecular formula : C_{14}H_2O ClNO_2
Molecular weight : 269.77
Chemical formula : Acetamide
Physical form : Colourless to yellow crystals
Melting point : 39.5 to 41.5°C
Vapour pressure : 3x10^{-5} to 25°C
Specific gravity : -1.133 at 25°C
Stability : Hydrolyzed by strong acid and alkalis stable to UV light decomposes at 105°C
Corrosiveness : Corrosive to steel and black iron non-corrosive to aluminium and stainless steel.
Solubility : In water at 25 to 242 mg litre, soluble in diethyl ether acetone, benzene, chloroform, ethanol and ethyl acetate sparingly soluble in heptane.
| **Mode of action** | Selective systemic herbicide, absorbed principally by germinating shoots, but also by roots with translocation throughout the plant and accumulation than reproductive parts. Acts by inhibiting protein synthesis and root elongation. |
| **Toxicity to mammals** | Acute and LD50 for rats 930-1200 mg kg$^{-1}$ |
| **Manufacturer** | Monsanto India Ltd., |
| **Formulation** | 50% EC |
| **Time of application** | 3 DAS |
| **Cost** | Rs. 350 l$^{-1}$. |
Details of Fluchloralin

Common name : Fluchloralin
Chemical name : N-(2-chloroethyl)-2,6-dinitro-N-propyl-4(trifluoromethyl)-aniline (CA)
Trade name : Basalin

Structural formula :

\[
\begin{align*}
\text{C}_3\text{H}_7 & \quad \text{C}_2\text{H}_4\text{Cl} \\
\text{N} & \\
\text{NO}_2 & \quad \text{NO}_2 \\
\text{CF}_3 &
\end{align*}
\]

Molecular formula : C_{12}H_{13}ClF_3N_3O_4
Molecular weight : 355.7
Chemical formula : Dinitroanilines
Physical form : Orange-yellow crystals
Melting point : 42-43°C (pure)
Vapour pressure : 4x10^{-5} m bar at 20°C
Stability : Very stable decomposed by UV light
Solubility : In water at 20°C, 1 mg l^{-1}. In acetone, 100 ethyl acetate, 100 cyclohexane 25.1 (all in g).
Mode of action : The primary mechanism of action is by inhibiting oxidation, phosphorylation and ATP formation.
Uses : Herbicide applied as pre-plant or pre-emergence.
LD50 : 1550 mg kg^{-1}
Manufacturer : BASF
Formulation : 45% EC
Time of application : Pre-sowing soil incorporation
Cost : Rs. 400 l^{-1}
### Details of Imazethapyr

<table>
<thead>
<tr>
<th><strong>Common name</strong></th>
<th>Imazethapyr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical name</strong></td>
<td>5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid</td>
</tr>
<tr>
<td><strong>Trade name</strong></td>
<td>Pursit</td>
</tr>
<tr>
<td><strong>Structural formula</strong></td>
<td><img src="image" alt="Structural formula" /></td>
</tr>
<tr>
<td><strong>Molecular formula</strong></td>
<td>C₁₅H₁₉N₃O</td>
</tr>
<tr>
<td><strong>Molecular weight</strong></td>
<td>289.3</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td>Very stable decomposed by UV light</td>
</tr>
<tr>
<td><strong>Solubility</strong></td>
<td>In water at 20°C, 1 mg l⁻¹. In acetone, 100 ethyl acetate, 100 cyclohexane 25.1 (all in g).</td>
</tr>
<tr>
<td><strong>Mode of action</strong></td>
<td>It is a systemic herbicide, absorbed by the roots and foliage, with translocation in the xylem and phloem, and accumulations in the meristematic region.</td>
</tr>
<tr>
<td><strong>Uses</strong></td>
<td>It controls major, annual and perennial grass and broad leaved weeds in soybeans, groundnuts and other leguminous crops. It is applied as pre-plant incorporation, pre-emergence and or post-emergence.</td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>Bayer Crop Science</td>
</tr>
<tr>
<td><strong>Formulation</strong></td>
<td>5%SL, 10%SL, 70%SP, 70%WP, 70%WDG</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Rs. 500</td>
</tr>
</tbody>
</table>
Details of 2,4-D Na salt

Common name : 2,4-D Sodium salt
Chemical name : (2, 4-dichlorophenoxy) acetic acid
Trade name : Fernoxone
Structural formula :

\[
\text{Cl} \quad \text{OCHCOH}_2 \\
\text{Cl}
\]

Mode of action : 2, 4-D sodium salt once it has contacted the plant, it is readily absorbed and translocated within the phloem through the tissues and causes disruption of its phloem tissues and consequent dislocation of photosynthesis symptoms and kills even perennial weeds efficiently. It accumulates in the meristematic regions. Principally and normal cell division ceases, affects respiration rate, increases turgor pressure of cells, causes abnormal growth and close of stomata resulting in death of plants.

Uses : Post-emergence control of annual and perennial broad-leaved weeds in cereals, maize, sorghum, grassland, established turf, grass seed crops, orchards (Pome fruit and stone fruit), cranberries, asparagus, sugar cane, rice, forestry, and on non-crop land (including areas adjacent to water) at 0.28-2.3 kg ha\(^{-1}\).

Manufacturer : Sygenta Pvt. Ltd.,
Formulation : 80% WP
Cost : Rs. 250 kg\(^{-1}\)
Details of glyphosate

Common name : Glyphosate
Chemical name : N-(phosphonomethyl) glycine
Trade name : ROUNDUP
Structural formula : \[
\begin{align*}
\text{O} & \quad \text{O} \\
\text{OH} - \text{C} - \text{CH}_2 - \text{N} - \text{CH}_2 - \text{P} - \text{OH} \\
\text{N} & \quad \text{OH}
\end{align*}
\]
Formulation : 41% Soluble liquid (SL)
Molecular weight : 169.10
Chemical formula : Organo phosphate
Physical form solubility : White, crystals 1.2% at 25°C
Mode of action : Glyphosate is translocated in the plant by downward movement to the roots and rhizomes and also upward movement to the meristem, once the glyphosate arrives in the meristematic region. It attacks EPSP synthase, an enzyme of the Shikimate pathway, which is involved in the synthesis of aminoacids such as tyrosine, phenylalanine and tryptophan. These amino acids are essential to protein synthesis, cell wall formation, defense against pathogens and production of hormones. This enzyme blockage might have lead to massive, phytotoxic buildup of Shikmic acid and benzoic acid which inhibits respiration, bud development, chlorophyll synthesis and transpiration, leading to eventual death of plants.
<table>
<thead>
<tr>
<th>Spectrum activity</th>
<th>Glyphosate is a broad spectrum non-selective post emergence herbicide used for effective control of rhizomates and develop rooted perennial weeds besides annual and biennials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Monsanto India Ltd.,</td>
</tr>
<tr>
<td>Cost</td>
<td>Rs. 350 l$^{-1}$</td>
</tr>
</tbody>
</table>
3.2.1.4. Studies on continuous effect of off-season land management practices on microbial population

For this study, composite soil samples were taken from plots of the mainfield experiments as explained below.

Soil samples were collected from all the plots in all the three replication. They were pooled together treatment wise. The soil samples were collected from different plots of off-season land management practices viz., before and after imposing treatments and 15 days after sowing maize. With three samples, a laboratory experiments was conducted in randomized block design with four treatments and five replications at Agricultural Microbiology Department Laboratory, Annamalai University.

**Treatment schedule – Off-season land management practices**

- $T_1$ - Fallow
- $T_2$ - Summer ploughing (twice)
- $T_3$ - Soil solarization for 40 days
- $T_4$ - Glyphosate spray (twice @ 1.5 kg ha$^{-1}$)

**Treatment details**

From each samples, 10 g soil was taken, suspensions made and cultured with different media following the dilution plate technique as suggested by Allen (1953). The number of fungal colonies developing on rose bengal agar, bactericidal colonies on soil extract agar and actinomycetes on kenster agar were counted after four, seven and ten days of incubation, respectively. The
number of colonies noted was multiplied by the dilution factor of the concerned group of microorganisms and expressed as the number of fungal, bacteria and actinomycetes per gram of dry soil.

3.3. CROP MANAGEMENT

3.3.1. Field preparation

The fields were ploughed twice with tractor drawn cultivator in a criss-cross manner so as to obtain a desirable tilth. The clods were broken by spade.

In field experiments, involving off-season land management practices, the field was divided into four strips after ploughing and leveling. One strip was left without any disturbance after land preparation (fallow). The remaining strips were subjected to as per treatment. One strip was saturated by about 70 per cent of field capacity level in the upper layers and moistened to depth of 60 cm. Then the white transparent polyethylene sheets (thickness 0.05 mm) were spread over the strip of land and securing them air tight by folding and inserting the edges underneath the bunds.

3.3.2. Seeds and sowing

The seed treatment with carbendazim 2 g kg\(^{-1}\) of seeds 24 h before sowing. Then seed treatment with Azospirillum @ 3 packets ha\(^{-1}\). The seeds were sown by dibbling the seeds at the rate of one seed per hole to a depth of four cm in lines in one side of the ridges adopting a spacing of 60 cm between the rows and 20 cm between the plants within the row. The date of experiment starting, sowing and harvesting for different experiments are furnished below:
<table>
<thead>
<tr>
<th>Experiments</th>
<th>Date of sowing</th>
<th>Date of harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary experiment</td>
<td>05.04.2009</td>
<td>20.07.2009</td>
</tr>
<tr>
<td>Mainfield experiment-I</td>
<td>01.06.2010</td>
<td>18.09.2010</td>
</tr>
<tr>
<td>Mainfield experiment-II</td>
<td>01.06.2011</td>
<td>16.09.2011</td>
</tr>
</tbody>
</table>

One row of intercrop blackgram (ADT 3) was sown in between the maize rows by adopting spacing 10 cm between plants as per the treatment.

The planting pattern of sole crop and smother intercrop were given below:

**The planting pattern of sole crop and smother intercrop**

\[
\begin{array}{ccccccc}
X & X & X & X & X & X & X \\
X & X & X & X & X & X & X \\
X & X & X & X & X & X & X \\
X & X & X & X & X & X & X \\
X & X & X & X & X & X & X \\
\end{array}
\]

Maize with smother intercrop (blackgram)

\[
\begin{array}{ccccccc}
X & . & X & . & X & . & X \\
. & . & . & . & . & . & . \\
X & . & X & . & X & . & X \\
. & . & . & . & . & . & . \\
X & . & X & . & X & . & X \\
. & . & . & . & . & . & . \\
X & . & X & . & X & . & X \\
\end{array}
\]

where

X – sole crop (maize); . – intercrop (blackgram)
3.3.3. Manures and manuring

For all the field experiments, uniform recommendation of 135:62.5:50 kg of NPK ha\(^{-1}\) was applied to maize crop in the form of urea, superphosphate and muriate of potash, respectively. A basal dressing of 67.5 kg N ha\(^{-1}\) was applied as band placement 5 cm away from the seed row and 5 cm below soil. The other nutrients P\(_2\)O\(_5\) and K\(_2\)O were applied each at 62.5 and 50 kg ha\(^{-1}\) as basal dose for all the plots. The balance dose of N was applied as top dressing at 25 and 45 DAS along with earthing up operation.

3.3.4. Gap filling

Gap filling was done at 5 DAS so as to maintain uniform plant population and maintain one healthy seedling per hole for main and intercrop.

3.3.5. Herbicide application

3.3.5.1. Spraying

The amount of water required to cover to be sprayed was calibrated. From this, the amount of water required to spray the gross plot area was calculated and the required herbicides were sprayed as per treatment. The spray fluid required was 600 l ha\(^{-1}\). Herbicide dosages were calculated and applied as pre-emergence at 3 DAS. For applying herbicide, knapsack sprayer was used. The sprayer was fitted with a flat fan nozzle.
3.3.6. Irrigation

First irrigation was given immediately after sowing. The life irrigation was given on third day after sowing to ensure proper germination. The subsequent irrigation were given as per requirements.

3.3.7. After cultivation

Earthing up was done on 20 DAS. The ridges were broken and loosen and soil was thrown on both sides of the plants in rows. This facilitates to control of weeds as well as in supporting the plants against heavy winds. Adequate prophylactic plant protection measures were taken up to control the sucking pest like aphids, jassids and thereby ensure a healthy crop.

3.3.8. Harvesting and threshing

The cobs were harvested from each treatment plots separately. The harvested cobs were sun dried, threshed, cleaned and grain yield was recorded at 12 per cent moisture level. It was expressed in kg ha$^{-1}$. After harvest of the cobs, the stover from each plot was cut close to the ground level. Then the dry stover from individual plot was weighed and expressed in kg ha$^{-1}$.

The pods of intercrop was harvested and sun dried and hand threshed treatment wise. The grains from each treatment were weighed and expressed in kg ha$^{-1}$. Dried haulm was cut and weight were recorded from each plot and expressed as dry weight of haulm in kg ha$^{-1}$. 
3.4. OBSERVATIONS

3.4.1. Observation on weeds

3.4.1.1. Individual weed count

For all the experiments, individual weed count was recorded at flowering from four m$^2$ frame area placed at random in each net plot. Later average weed counts m$^2$ was arrived and the data were computed to give the individual weed count m$^2$.

3.4.1.2. Total weed count

For all the experiments, total weed count was recorded at flowering from four m$^2$ frame area placed at random in each net plot (Rao, 1983). Later the average weed counts m$^2$ area was arrived and the data were computed to give the total weed count m$^2$.

3.4.1.3. Total weed biomass

Weeds from four m$^2$ frame area placed at random in each plot were collected at flowering. These weeds were dried after removing the roots in hot air oven at 80°C±5°C for 48 h and the biomass was recorded in kg ha$^{-1}$.

3.4.1.4. Weed control efficiency (per cent)

In the preliminary and mainfield experiments regarding the management of the weeds, weed control efficiency was calculated at flowering by using the formula suggested by Misra and Tosh (1979) and recorded in percentage.
\[
WCE (%) = \left( \frac{\text{Weed biomass in treated plot}}{\text{Weed biomass in unweeded control plot}} \right) \times 100
\]

### 3.4.1.5. Nutrient removal by weeds

Chemical analysis of weed samples for nitrogen, phosphorus and potassium content was carried out for the computation of nutrient removal by weeds in experiments regarding the management of the weeds. The values were expressed in kg ha\(^{-1}\). The analysis was carried out as per the standard procedure given below:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Nutrient</th>
<th>Method</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nitrogen</td>
<td>Microkjeldahl</td>
<td>Yoshida et al. (1976)</td>
</tr>
<tr>
<td>2.</td>
<td>Phosphorus</td>
<td>Colorimetry – Triple acid digestion</td>
<td>Jackson (1973)</td>
</tr>
<tr>
<td>3.</td>
<td>Potassium</td>
<td>Spectrophotometry – Triple acid digestion</td>
<td>Jackson (1973)</td>
</tr>
</tbody>
</table>

### 3.4.2. Observation on maize

#### 3.4.2.1. Growth characters

Five maize plants were selected at random in the net plot area of each plot were tagged for observation on growth characters.

#### 3.4.2.1.1. Plant height

The height of the main plants were taken on 30, 60 DAS and at harvest from the base of the plant to the tip of the last opened leaf and the average was expressed in cm.
3.4.2.1.2. Crop Dry Matter Production (CDMP)

In each plot, five plants were randomly chosen used for recording dry matter production at 30, 60 DAS and at harvest. Samples were oven dried at 80°C±5°C for 48 h and weights were recorded. Dry matter production ha⁻¹ was calculated by multiplying the mean weight of plant samples with population ha⁻¹. The crop dry matter production was expressed in kg ha⁻¹.

3.4.2.1.3. Leaf Area Index (LAI)

The leaf area index was calculated at flowering. The leaf area was measured for five numbers of maize leaves randomly chosen from the tagged plant. The mean value of the leaf area was calculated from the sample leaves by using the formulae by Iruthayaraj and Sivaraj (1979).

\[ \text{LA} = L \times W \times \text{Cf} \times \text{NL} \times \text{NP} \]

where

- \( \text{LA} \) = Leaf area (cm²)
- \( L \) = Length (cm)
- \( W \) = Width (cm)
- \( \text{Cf} \) = Correction factor (0.70)
- \( \text{NL} \) = Number of leaves plant⁻¹
- \( \text{NP} \) = Number of plants per unit area⁻¹

\[ \text{LAI} = \frac{\text{Leaf area}}{\text{Ground area}} \]
3.4.3. Yield components

3.4.3.1. Cob length

The length of the cob were measured from the randomly selected five tagged plants and mean was worked out cumulatively and expressed in cm.

3.4.3.2. Cob diameter

The diameter of the cob were measured from the randomly selected five tagged plants and mean was worked out cumulatively and expressed in cm.

3.4.3.3. Number of grains cob\(^{-1}\)

The number of grains cob\(^{-1}\) were counted from the randomly selected five tagged plants and mean was worked out cumulatively.

3.4.3.4. Test weight

The mean test weight of 100 grains plot\(^{-1}\) were recorded at 12 per cent moisture level and expressed in g.

3.4.4. Yield

3.4.4.1. Grain yield

The harvested cobs were sun dried, threshed, cleaned and grain yield was recorded at 12 per cent moisture level for each plots and expressed in kg ha\(^{-1}\).

3.4.4.2. Stover yield

The dry weight of stover obtained from each plot was recorded and expressed in kg ha\(^{-1}\).
3.4.4.3. Intercrop crop (Blackgram)

The matured blackgram plants were cut at ground level and transported to threshing yards where threshing was done manually. The grain yield was recorded at 10 per cent moisture level and expressed in kg ha⁻¹.

3.4.4.3.1. Maize-equivalent yield

In order to compare the relative yield potential of intercrop combination, yield of intercrop was converted into maize equivalent based on market price at the time of harvest and added to maize grain yield. Maize-equivalent yield was calculated by using the following formula

$$\text{Maize-equivalent yield (kg ha}^{-1}) = \frac{\text{Seed yield of intercrop (kg ha}^{-1}) \times \text{Price of intercrop (Rs. kg}^{-1})}{\text{Price of maize grain (Rs.kg}^{-1})}$$

3.4.4. Nutrient uptake by crop

3.4.4.1. Nitrogen uptake

The N content of the crop was estimated by microkjeldahl method suggested by Yoshida et al. (1976) and recorded in percentage. The total N uptake by crop was estimated by multiplying the crop biomass with percentage of N content respectively and recorded in kg ha⁻¹.

3.4.4.2. Phosphorus uptake

The P content of the crop was estimated by triple acid digestion method described by Jackson (1973) with photoelectric calorimeter. From the standard curve drawn, the P content of the crop was calculated and by multiplying the percentage value with crop biomass. P uptake was computed and recorded in kg ha⁻¹.
3.4.4.3. **Potassium uptake**

The K content of crop was estimated by triple acid digestion method described by Jackson (1973) using the flame photometer. From the standard curve drawn, the K content of the plants were calculated and the uptake was computed by multiplying with biomass and expressed in kg ha\(^{-1}\).

3.4.5. **Economic analysis**

The net return ha\(^{-1}\) was calculated for the treatments by subtracting the cost of cultivation from the gross return. For solarization experiment, the cost of polyethylene sheet was first apportioned over a period of five years which is the expected longevity of the sheet and then to three crops raised per year to be included in the cost of cultivation as fixed cost. The interest was also worked out 7 per cent per annum for this amount and included in the cost of cultivation.

The cost benefit ratio was calculated as follows:

\[
\text{Cost benefit ratio} = \frac{\text{Gross income (Rs.ha}^{-1})}{\text{Total cost of cultivation (Rs.ha}^{-1})}
\]

3.4.6. **Statistical analysis**

The data of weed count was transformed using the formula \((\sqrt{x} + 0.5)\). The data analysis using variance to draw the standard error of difference and ultimately the critical difference was worked out as suggested by Panse and Sukhatme (1978). Design analysis as stated under every experiment was performed using IRRISTAT system in a computer.