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# Biology and phenology of predominant weed species in lowland rice ecosystems

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**ABSTRACT**

A field survey was taken up in Coimbatore, Tamil Nadu state to know the dominant weed species competing in the lowland rice ecosystems to identify the major weeds and study the biology and phenology of the weed species. Barnyard grass *(Echinochloa crus-galli)*, blistering ammannia *(Ammania baccifera)*, false daisy *(Eclipta alba)* and Viper grass *(Dinebra retroflexa)* were found predominant in lowland and were selected for the study. The seeds of selected weeds were collected along with the inflorescence from the field pot culture and field studies. It was found that among the four lowland weeds, *Echinochloa crus-galli* and *Eclipta alba* germinated 6 days after sowing both in the pot as well as field study. *Ammania baccifera* was germinated earlier in pot culture (7 days) and *Dinebra retroflexa* germinated earlier (7 days) in field condition. Weeds grown in field condition came to 50% flowering earlier than grown in pot culture. Total dry weight per plant at flowering was higher in *Dinebra retroflexa* both in field and pot culture and at maturity, it was higher with *Echinochloa crusgalli*. Total dry weight at maturity was 8-12 times more than at flowering for all the weeds. The numbers of seeds/plant was higher with *Echinochloa crus-galli* in both in pot culture and field study with 650 and 850 seeds/ plant respectively.

Rice is one of the most important food crops of India in terms of area, production and consumer preference. India is the second largest producer and consumer of rice in the world. In India, rice is grown in an area of 43.8 million hectares in different agro-climatic regions with a production of 112.91 million tonnes during 2017-2018 (MoA 2019). In Tamil Nadu, 7.28 million tonnes of rice has been produced with a productivity of 3923 kg/ha during 2017-18. This will not be sufficient to meet the needs of the growing population and the demand will increase by 69% by 2025 A.D. However, production and productivity are restricted because of infestation by biotic stress *i.e.* weeds, insects and diseases.

Among the yield limiting biotic factors, weeds play a major role. Uncontrolled growth of weeds in rice reduced the grain yield by 75.8, 70.6 and 62.6% in dry-seeded rice, wet-seeded rice and transplanted rice, respectively (Singh *et al.* 2005). Gharde *et al.* (2018) estimated that the total economic loss due to weeds in 10 major crops in India is around USD 11 billion. Although the number of species recorded in the lowlands were lower and more stable over time, there was an increase in problem grass weeds, such as *Echinochloa crus-pavonis* (Kunth.) Schult in the irrigated lowlands and *Leersia hexandra* Sw. in the rain-fed lowlands (Johnson and Kent 2002). So, it is necessary to manage the weeds to the level that it may not cause economic yield loss. Weed biology relates to the plant attributes such as morphology, seed dormancy and germination, physiology of growth, competitive ability and reproductive biology. Knowledge of weed biology is essential for the development of both economically and environmentally acceptable weed management systems. However, the growth of weeds varies in field conditions and controlled conditions. Taking this into consideration a pot culture and field study was taken up with the objective of studying the biology of predominant weed species in wetland ecosystems.

A field survey was conducted to study biology and phenology of predominant weed species in

lowland rice ecosystems in wet land farm of Tamil Nadu Agricultural University, Coimbatore and sorrounding villages. Lowland rice fields in surrounding villages located in the region were surveyed during 2015. Major weed species in the rice fields were identified according to Harada *et al.* (1996). Weed species selection was done by a field survey to know the dominant weed species occupying the wet land and the major weeds were identified. The seeds of selected weed species were collected along with the inflorescence from the field in advance and were cleaned to get the seeds. Then the seeds were shade-dried to the optimum moisture level. The seeds thus collected were used for both pot culture experiment and field study.

For the pot culture study, the pots were filled with wet land soil up to ¾th level. Then 30 seeds were sown for each pot and soil was sprinkled for uniform coverage of seeds. This was irrigated by sprinkling water. For field study, one square metre were selected in the wetland 30 seeds were sown for each plot and this was replicated thrice. Folloaing biological and phenological parameters, were take by adopting the standard procedures: days to emergence, germination percentage, seedling fresh weight (g/plant) at 10 days after sowing (DAS), Seedling dry weight (g/plant) at 10 DAS, seedling fresh weight (g/plant) at 15 DAS, seedling dry weight (g/plant) at 15 DAS, days for initiation of flowering, days to 50% flowering, number of tillers/branch, total fresh weight at flowering (g/plant), total dry weight at flowering (g/plant), leaf area at flowering ($cm^2$/ plant), total fresh weight at maturity (g/plant), total dry weight at maturity (g/plant), leaf area at maturity (cm/plant), number of seeds or fruits per plant, thousand seed weight (g).

The experimental data were subjected to statistical scrutiny as per methods suggested by Gomez and Gomez (1984) and executed with the software AGRES by Tamil Nadu Agricultural University. Wherever the results were significant, critical differences were worked out at probability level p d" 0.05 / 0.01 using the ANOVA.

**Weed flora**

Weed count observation indicated more than 14 number of weed species belonging to 10 families were identified from the plots (Data not shown). According to the weed species identified, the top three largest families were found to be Poaceae (21%), Lythraceae (16%) and Asteraceae (8%). Of these four predominant weeds from lowland were selected for the current study. The predominant weeds were: *Echinochloa crus-galli, Ammania bacciffera, Eclipta alba, Dinebra retroflexa.* The specifications with full details about the weeds were given in **Table 1.**

**Biology and phenology of weeds**

**Barnyard grass *(Echinochloa crus-galli)***

Seedling emergence of *Echinochloa crus-galli* was at 6 DAS in both pot culture and the field condition (**Tables 1** and **2)**. However, the germination percentage was higher in the field than pot culture condition. Dry matter accumulation of seedlings at 10 DAS, 15 DAS, flowering and at maturity was higher in the field than pot culture condition. The rate of dry matter accumulation was slow in early growth stages and it was higher at later stages. It accumulated to an extent of 6.41 g/plant and 4.50 g/plant in field and pot culture conditions, respectively at the maturity stage. Days for initiation of flowering were 46 days and 48 days in the field and pot culture conditions, respectively showed that field sown weeds initiated flowering early. However, 50% flowering was earlier in pot culture condition. Leaf area was higher in the field (431.7 $cm^2$/plant) at flowering and at maturity (485.6 $cm^2$ /plant). The number of seeds/plant was higher in field conditions than pot culture. It produced to the maximum extent of 650 to 850 seeds/plant. However, there was no significant difference in 1000-seed weight between pot culture and field condition (Ann *et al.* 2001).

**False daisy *(Eclipta alba)***

*Eclipta alba* seedlings emerged within 6 DAS in both conditions. Germination percentage was higher in the field (87%) than pot culture (74%). Seedlings grown under the field produced higher dry matter than pot culture at 10 DAS, 15 DAS and at flowering. The dry matter accumulation at maturity was however higher in pot culture than field condition which was to the tune of 4.187 g/plant in pot culture. Flower initiation started at 41 DAS and 42 DAS in field and pot culture conditions, respectively. The same trend was followed in 50% flowering also, which were 45 DAS and 46 DAS in field and pot culture conditions, respectively. The number of branches and leaf area was higher in the field than pot culture. The maximum leaf area/plant was 163.74 $cm^2$ in the field condition. The number of seeds/plant was higher in the field (735) compared to pot culture (576). However, 1000-seed weight have no significant difference in field and pot conditions.

**Blistering ammannia (*Ammania bacciffera*)**

*Ammania bacciffera* germinated at 7 DAS in pot culture and one day later in field condition. Germination percentage was higher in the field (54.4%) than pot culture. Dry matter accumulation in 10 DAS, 15 DAS, flowering and maturity was higher in the field than pot culture. The maximum dry matter accumulation was 5.47 g/plant at maturity in field condition. A similar trend was followed for leaf area at flowering and at maturity. A higher leaf area of 146.16 $cm^2$/plant was recorded in the field at maturity. However, there was no variation in days for initiation of flowering (35 DAS) and 50% flowering (42 DAS) occurred in both conditions. The number of capsules was 118 in field and 102 in pot culture. Since the seeds are very small, it was not possible to estimate 1000-seed weight (Ann *et al.* 2001, Shibayama 2001).

**Table 1. Phenological characteristics (mean values) of major wet land weeds (pot culture experiment)**

| Parameter | Weed species(mean values) | | | |
|---|---|---|---|---|
| | *Echinochloa crusgalli* | *Eclipta alba* | *Ammania bacciffera* | *Dinebra retroflexa* |
| Days to emergence | 6 | 6 | 7 | 8 |
| Germination % | 66.700 | 74.400 | 33.300 | 71.100 |
| Seedling fresh wt (g/pt) at 10DAS | 0.055 | 0.084 | 0.044 | 0.016 |
| Seedling dry wt (g/pt) at 10 DAS | 0.007 | 0.010 | 0.005 | 0.004 |
| Seedling fresh wt (g/pt) at 15 DAS | 0.082 | 0.159 | 0.073 | 0.029 |
| Seedling dry wt (g/pt) at 15DAS | 0.013 | 0.016 | 0.007 | 0.006 |
| Days for initiation of flowering | 48.000 | 42.000 | 35.000 | 38.000 |
| Days to 50% flowering | 53.000 | 46.000 | 42.000 | 44.000 |
| No of tillers /branches | 2.330 | 3.330 | 1.660 | 4.330 |
| Total fresh wt at flowering (g/plant) | 2.399 | 3.604 | 3.953 | 3.341 |
| Total dry wt at flowering (g/plant) | 0.449 | 0.497 | 0.345 | 0.819 |
| Leaf area at flowering $cm^2$/plant | 398.310 | 42.150 | 4.960 | 105.480 |
| Total fresh wt at maturity (g/plant) | 6.210 | 17.330 | 20.060 | 3.320 |
| Total dry wt at maturity (g/plant) | 4.503 | 4.187 | 2.407 | 1.633 |
| Leaf area at maturity $cm^2$/plant | 412.850 | 112.324 | 98.130 | 168.340 |
| Seeds / fruits / plant | 650.000 | 576.000 | 102.000 | 4.100 |
| 1000 seed wt (g) | 1.640 | 0.71 | - | 0.130 |
| LSD (p=0.05) | 34.700 | 23.730 | 6.240 | 8.720 |

**Table 2. Phenological characteristics (mean values) of major wet land weeds (field experiment)**

| Parameter | Weed species (mean values) | | | |
|---|---|---|---|---|
| | *Echinochloa crusgalli* | *Eclipta alba* | *Ammania bacciffera* | *Dinebra retroflexa* |
| Days to emergence | 6 | 6 | 8 | 7 |
| Germination percentage | 78.900 | 86.700 | 54.400 | 77.800 |
| Seedling fresh wt (g/pt) at 10DAS | 0.076 | 0.095 | 0.045 | 0.016 |
| Seedling dry wt (g/pt) at 10DAS | 0.008 | 0.010 | 0.005 | 0.003 |
| Seedling fresh wt (g/pt) at 15DAS | 0.107 | 0.207 | 0.095 | 0.038 |
| Seedling dry wt (g/pt) at 15DAS | 0.018 | 0.023 | 0.010 | 0.008 |
| Days for initiation of flowering | 46.000 | 41.000 | 35.000 | 36.000 |
| Days to 50% flowering | 54.000 | 45.000 | 42.000 | 42.000 |
| No of tillers/branches | 3.300 | 4.000 | 2.300 | 5.300 |
| Total fresh wt at flowering (g/plant) | 3.487 | 3.766 | 4.103 | 5.513 |
| Total dry wt at flowering (g/plant) | 0.662 | 0.527 | 0.451 | 1.103 |
| Leaf area at flowering $cm^2$/plant | 431.700 | 49.920 | 6.730 | 123.950 |
| Total fresh wt at maturity g/plant | 34.600 | 16.530 | 29.770 | 10.990 |
| Total dry wt at maturity g/plant | 6.410 | 3.527 | 5.446 | 2.307 |
| Leaf area at maturity $cm^2$/plant | 485.620 | 163.740 | 146.160 | 138.240 |
| Seeds / fruits / plant | 850.000 | 735.000 | 118.000 | 4.300 |
| 1000 seed wt (g) | 1.658 | 0.718 | - | 0.136 |
| LSD (p=0.05) | 42.790 | 30.320 | 8.180 | 8.330 |

**Viper grass *(Dinebra retroflexa)***

*Dinebra retroflexa* seedling emergence was 7 DAS at the field and one day later in pot culture. The germination percentage was higher in the field than pot culture. Total dry matter accumulation was higher in the field than pot culture at all stages of plant growth. The maximum dry matter accumulation was 2.31 g/plant at maturity in field condition. Flowering initiation was at 36 DAS in field and 2 days later in pot culture. Similarly, 50% flowering was at 42 DAS in both conditions. The number of tillers was 5.3/plant in field than 4.3/plant in pot culture. Leaf area/plant was higher in the field at flowering and it was higher at maturity in pot culture which was 168.34 $cm^2$/ plant. Thousand seed weight was 0.136 g in field and it was 0.130 g in pot culture. Similar finding was also reported by Honek and Martinkova (2002).

Among all weeds, *Echinochloa crus-galli* germinates very early *i.e*. within 6 DAS which should to be taken into consideration in its management under field condition. It has also high dry matter accumulation potential among all weeds. From these observations, it was clear that weed growth occurs within 46 days after rice sowing/planting which may propagate by seeds and propagules or by both. The perennial weeds create the most serious problem in rice fields. Major weeds produce a large number of seeds, which may remain in the soil and serve as a soil seed bank for the next cropping season. It can be emphasized that major weeds should be controlled at the proper time to check reduction in rice yield, and they must be removed before flowering and fruiting to reduce the production of seeds that remain as a soil seed bank for the following years. The present results will be useful for setting the economic thresholds for weed control. The competition of 25 barnyard grass plants/$m^2$ caused approximately 50% yield loss in rice in Vietnam (Duong Van 2001). Moreover, from this study, it is suggested that weed control practices should be completed before rice tillering for could lead to improved yield in rice. Besides, if the perennial weeds are controlled well before flowering, then subsequent rice crop can be saved from weed infestation, which will ultimately result in higher productivity of rice.

From the present field study, it was concluded that weed seeds grown under field condition has a higher growth rate than pot culture condition. This may be due to the fact that field grown seedlings get higher solar insolation and more ground area per plant. Among all weeds, *Echinochloa crus-galli* germinated very early *i.e*. within 6 DAS which should be taken into consideration in its management under field condition. It has also high dry matter accumulation potential among all weeds.

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