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Some aspects of the phenology of rice-field weeds

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Abstract

On the basis of their life-span, rice-field weeds may be classified as annuals and perennials; the latter forms a low percentage (24.7) and the former a high one (75.3). The largest number of perennials, however, are contributed by the *Gramineae*.

The maximum flowering of weeds (40.4 per cent) takes place in the period ranging from the monsoon to the post-monsoon. Though not as high as this value, significant proportions of flowering occur in the season from the pre-monsoon to monsoon (11.8 per cent), from the monsoon to the winter via the post-monsoon (9.9 per cent) and monsoon alone (9.3 per cent). In the seasonal category of flowering, the *Gramineae* also constitutes a great bulk of the weeds.

The highest fruiting percentage of weeds (31.0) is found in the seasonal phase extending from the monsoon to the winter through the post-monsoon. This is followed by the regime from the monsoon to the post-monsoon (26.1 per cent) and the time from the post-monsoon to the winter (11.2 per cent).

In the seasonal category of fruiting, the *Gramineae* too contain a high number of weeds.

Whether by single method (fruit and seed) or dual method of reproduction (rhizome, tuber, etc. in addition to fruit and seed), the *Gramineae* finds a prominent place in the list of perennial species and the *Cyperaceae* among the annuals.

The implications of the above findings are discussed.

INTRODUCTION

In studies involving weeds of rice-fields, autecological aspects have recived little or no attention in India. Though Majumder (1962) prepared a list of 38 common weeds of rice-fields during the rainy season, he made passing remarks on their occurrence on damp and wet rice-fields. Datta and Maity (1963) went a step further, comparing their records

of weeds flowering in different periods with meteorological data. Mahapatra et al. (1965) commented on the flowering and fruiting time as well as the propagation of the rice-field weeds, but did not look at their data from the stand-point of an ecologist.

The primary aim of studying crop-weed ecology should be to probe the true relationships of a crop and the associated weeds. Such an objective can be achieved by considering autecological view of the weeds in general and their phenological view in particular. While it is a stupendous task to gather complete phenological observations from seed to seed for all weedspecies, much valuable information can occure if one chose to (i) ascertain their life-span, (ii) determine their flowering and fruting time and (iii) know their methods of propagation. When all these facts are forthcoming and correlated with ecological factors, it will be possible to pin-point the vulnerable stages in the life-cycle of a weed. The present study is concerned with the relevant observations of phenology recorded from the weeds of rice-fields.

MATERIAL AND METHODS

During the floristic survey of weeds in the districts of Hooghly and Midnapore, West Bengal, a total of 158 angiospermic weed species were collected from the alluvial soils of rice-fields in 10 different centres of the two districts. Collections were made twice every month throughout the year from 1968 to 1970. In the first year, specimens were brought to the laboratory where they were identified by matching with herbarium sheets kept at the Herbarium of the University of Calcutta and the Central National Herbarium, Howrah, by referring to the work of Hooker (1872—1897) and Prain (1963) and the keys prepared by the present authors. After identification, the names were entered in a bulky note-book along with their date of collection. This information was checked all through the succeeding two years by going to the spots where from the specimens were collected. The number of weeds that flowered and fruited every month was noted; seasonal categories, such as winter (A), summer or pre-monsoon (B), monsoon (C) and post-monsoon (D) and those extending from one season to the other denoted by plus (+) sign after the initial season, were indicated and respective percentages calculated. At the same time, the longevity of the weeds was designated by finding out when they completed their life-cycles and the types of reproduction by sexual (i.e. seed and fruit) or vegetative (i.e. rhizome, stolon, runner, etc.) methods were located.

RESULTS

Among the weeds studied, 119 species were annuals and 39 perennials which made up 75.3 per cent and 24.7 per cent respectively. While the annuals were found in almost all the angiospermous families, the perennials were restricted to a few families (Table 1). The *Gramineae* had the largest number of perennials (12) and 2 species each were contributed by the *Cyperaceae, Amaranthaceae, Malvaceae, Haloragaceae, Convolvulaceae, Scrophulariaceae* and *Acanthaceae*. The *Aponogetonaceae, Hydrocharitaceae, Araceae, Pontederiaceae, Polygonaceae, Nymphaeaceae, Leguminosae, Euphorbiaceae, Onagraceae, Umbelliferae, Gentianaceae, Rubiaceae* and *Compositae* each contributed 1 species of perennials.

Flowering and fruting time for the various weeds are also given in Table 1.

Out of a total of 158 species investigated, 91 species were propagated generatively by either (i) seed or fruit and (ii) 67 species by organs like stoloniferous rootstock, stem, rhizome, tuber, runner, stolon, sucker and turion in addition to the seed or fruit. In the first category, i.e. single method of reproduction there were 25 monocot species and 66 dicot species; the corresponding number was 37 and 30 respectively in the second category, i.e. dual method of reproduction (Tables 2 and 3). The first category of reproduction was carried out by 21 species of the *Gramineae* and 4 species of the *Cyperaceae* among monocots as well as 8 species of the *Euphorbiaceae*, 5 each of the *Leguminosae* and the *Compositae* and 3 each by the *Amaranthaceae, Scrophulariaceae, Acanthaceae* and *Rubiaceae*. In the second category, there were 18 species of the *Gramineae* and 17 species of the *Cyperaceae;* here the rest of the families of angiosperms contributed either 2 or less than 2 species each.

DISCUSSION

It is seen that the weed flora of rice-fields consist of both annuals and perennials (Table 1). The annuals, forming a high percentage (75.3), are obviously prone to sexual propagation by the formation of fruits and seeds. On the other hand, the perennials, which constitute a mere 24.7 per cent, spreads rapidly by producing rhizomes, stolons, tubers, etc. in addition to the reproduction from seeds or fruits. Acording to Salisbury (1942, p. 212), vegetative propagation is of advantage in an unchanged environment where there will be no production of less suitable types. If the environment is changing, multiplication by seedlings gives greater chance of survival particularly when the environment is less congenial to the growth of the parent stock. Moreover, external conditions can induce more vegetative growth or active seed production in those species

Table 1

Some phenological observations on rice-field weeds

Species	Life-span	Flowering time	Fruiting time	Method of propagation
APONOGETONACEAE				
Aponogeton natans (L.) Engl. & Krause	Perennial	July—Spt. C	Aug.—Jan. C+D+A	Stoloniferous rootstock and seeds
HYDROCHARITACEAE				
Hydrilla verticillata (L.f.) Royle	Perennial	July—Sept. C	Oct.—Feb. D+A	Runner, turion and seeds
Ottelia alismoides (L.) Pers.	Annual	Sept.—Jan. C+D+A	Sept.—March. C+D+A+B	Seeds
GRAMINEAE				
Alloteropsis cimicina (L.) Stapf	Annual	July.—Aug. C	Aug.—Oct. C+D	Rhizome and seeds
Apluda mutica L.	Perennial	Sept.—Nov. C+D	Oct.—Dec. D+A	Creeping stem, rhizome and seeds
Brachiaria reptans (L.) Gard. & C. E. Hubb.	Annual	July—Nov. C+D	Aug.—Dec. C+D+A	Seeds
Chloris inflata Link.	Annual	June—Oct. C+D	Aug.—Dec. C+D+A	Seeds
Chrysopogon aciculatus (Retz.) Trin.	Perennial	June—Oct. C+D	Aug.—Nov. C+D	Creeping rhizome and seeds
Coix lachryma-jobi L.	Annual	Sept.—Dec. C+D+A	Oct.—Feb. D+A	Seeds
Cynodon dactylon (L.) Pers.	Perennial	June—Sept. C	July.—Dec. C+D+A	Creeping stem, rhizome and seeds
Dactyloctenium aegypticum (L.) Beauv.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Creeping rhizome and seeds
Dichanthium annulatum (Forsk.) Stapf		Aug.—Dec. C+D+A	Sept.—Jan. C+D+A	Seeds
Digitaria sanguinalis (L.) Scop.	Annual	July—Oct. C+D	Sept.—Nov. D	Seeds
D. stricta Roth ex Roem & Schult.	Annual	Sept.—Nov. C+D	Oct.—Dec. D+A	Seeds
Echinochloa colonum (L.) Link.	Annual	July—Oct. C+D	Aug.—Jan. C+D+A	Seeds
Eleusine inidca (L.) Gaertn.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Creeping rhizome and seeds
Eragrostis coarctata Stapf. apud Hook. f.	Perennial	July—Sep. C	Sept.—Feb. C+D+A	Creeping stem, rhizome and seeds
E. diarrhena (Schult.) Steud.	Perennial	July—Oct. C+D	Aug.—Nov. C+D	Creeping stem, rhizome and seeds
E. gangetica (Roxb.) Steud.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Creeping stem, rhizome and seeds

Species	Life-span	Flowering time	Fruiting time	Method of propagation
E. tenella (L.) Beauv. ex Roem. & Schult	Annual	June—Oct. C+D	July—Dec. C+D+A	Sedes
E. unioloides (Retz.) Nees ex Steud.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Seeds
Eriochloa procera (Retz.) C.E. Hubb.	Annual	June—Oct. C+D+A	July—Dec. C+D+A	Seeds
Hemarthria compressa (L.f.) R. Br.	Perennial	July—Oct. C+D	Aug.—Nov. C+D	Creeping stem, rhizome and seeds
Imperata cylindrica (L.) Beauv.	Perennial	April—May B	June—July C	Creeping rhizome and seeds
Ischaemum rugosum Salisb.	Annual	Aug.—Dec. C+D+A	Sept.—Jan. C+D+A	Seeds
Leersia hexandra Sw.	Annual	Oct.—Jan. D+A	Nov.—Feb. D+A	Seeds
Leptochloa chinensis (L.) Nees	Annual	July—Oct. C+D	Aug.—Nov. C+D	Seeds
Oplismenus burmannii (Retz.) Beauv.	Annual	Sept.—Oct. C+D	Oct.—Dec. D+A	Seeds
Oryza sativa L. var. *fatua* Prain	Annual	Oct.—Nov. D	Nov.—Ddc. D+A	Seeds
Panicum austroasiaticum Ohwi	Annual	July—Sep. C	Aug.—Oct. C+D	Seeds
P. psilopodium Trin.	Annual	June—Oct. C+D	July—Dec. C+D+A	Seeds
P. repens L.	Perennial	July—Dec. C+D+A	Sept.—Jan. C+D+A	Underground stem and seeds
Panicum trypheron Schult.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Seeds
Paspalidium flavidum (Retz.) A. Camus	Annual	June—Oct. C+D	Aug.—Dec. C+D+A	Seeds
P. punctatum (Burm.) A. Camus	Perennial	Sept.—Dec. C+D	Oct.—Jan. D+A	Underground stem and seeds
Paspalum scrobiculatum L.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Creeping rhizome and seeds
Perotis indica (L.) Ktze.	Annual	Aug.—Oct. C+D	Sept.—Dec. C+D	Rhizome and seeds
Saccharum spontaneum L.	Perennial	Aug.—Nov. C+D	Oct.—Dec. D	Rhizome and seeds
Setaria glauca (L.) Beauv.	Annual	July—Oct. C+D	Sept.—Dec. C+D+A	Seeds
Sporobolus diander (Retz.) Beauv.	Perennial	July—Oct. C+D	Aug. Dec. C+D+A	Creeping rhizo- and seeds
Urochloa helopus (Trin.) (Irin.) Stapf	Annual	July—Oct. C+D	Aug.—Nov. C+D	Seeds
Vetiveria zizanioides (L.) Nash	Perennial	July—Nov. C+D	Aug.—Jan. C+D+A	Rhizome and seeds

Species	Life-span	Llowering time	Fruiting time	Method of propagation
CYPERACEAE				
Cyperus diformis L.	Annual	Aug.—Nov. C+D	Aug.—Nov. C+D	Rhizome and seeds
C. haspan L.	Annual	July—Nov. C+D	Aug.—Dec. C+D+A	Rhizome and seeds
C. iria L.	Annual	July—Sept. C	Aug.—Oct. C+D	Rhizome and seeds
C. kyllinga Endle	Annual	April—Oct. B+C+D	June—Oct. C+D	Rhizome and seeds
C. niveus Retz.	Annual	July—Oct. C+D	July—Nov. C+D	Seeds
C. rotundus L.	Perennial	June—Nov. C+D	July—Nov. C+D	Tuber, rhizome and seeds
C. squarrosus L.	Annual	Aug.—Oct. C+D	Sept.—Dec. C+D	Seeds
C. triceps Rottb.	Annual	July—Nov. C+D	July—Dec. C+D+A	Rhizome and seeds
Cyperus umbellatus Miq.	Annual	Aug.—Oct. C+D	Aug.—Oct. C+D	Rhizome and seeds
Eleocharis caribaea (Rottb.) Blake	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Rhizome and seeds
Fimbristylis annua (All.) Roem. & Schult.	Annual	May—Oct. B+C+D	June—Nov. C+D	Rootstock and seeds
F. barbata Benth	Annual	July—Dec. C+D+A	July—Jan C+D+A	Rootstock and seeds
F. dichotoma Vahl	Annual	Sept.—Jan. C+D+A	Sept.—Jan C+D+A	Rootstock and seeds
F. dipsacea Benth.	Annual	May—Sept. B+C	June—Oct. C	Rootstock and seeds
F. falcata (Vahl) Kunth.	Annual	May—Oct. B+C+D	May—Oct. B+C+D	Rhizome, root-stock and seeds
F. ferruginea Vahl	Annual	May—Oct. B+C+D	June—Oct C+D	Rhizome, root-stock and seeds
F. littoralis Gand.	Annual	July—Oct. C+D	July—Oct. C+D	Rootstock and seeds
Scripus atticulatus L.	Perennial	Jan.—May A+B	Sept.—Dec. C+D	Stoloniferous rootstock and seeds
S. grossus L.f.	Perennial	Aug.—Dec. C+D+A	Sept.—Dec. C+D	Stoloniferous rootstock and seeds
S. pauciflorus Lightf.	Annual	Oct.—Nov. D	Oct.—Dec. D+A	Seeds
S. supinus L.	Annual	Oct.—Jan. D+A	Nov.—March D+A+B	Seeds
ARACAE				
Pistia stratiotes L. var. *cuneata* Engl.	Perennial	Aprl.—Dec. B+C+D+A	April.—Dec. B+C+D+A	Stolon and seeds

Species	Life-span	Flowering time	Fruiting time	Method of propagation
ERIOCAULACEAE				
Eriocaulon odoratum Dalz.	Annual	Oct.—Dec. D+A	Nov.—Jan. D+A	Seeds
E. sieboldianum Sieb. & Zucc.	Annual	Oct.—Dec. D+A	Nov.—Jan. D+A	Seeds
COMMELINACEAE				
Amischophacelus axillaris Rao et Kamathy	Annual	Aug.—Dec. C+D+A	Oct.—Feb. D+A	Creeping stem and seeds
Commelina diffusa Burm. f.	Annual	July—Oct. C+D	Aug.—Oct C+D	Creeping stem and seeds
Murdannia malabarica (L.) Brueckner	Annual	Aug.—Oct. C+D	Sept.—Dec. C+D+A	Seeds
PONTEDERIACEAE				
Eichhornia crassipes (Mart.) Solms	Perennial	April—June B+C & Sept.—Nov. C+D	Sept.—Dec. C+D+A	Offset and seeds
POLYGONACEAE				
Polygonum hydropiper L.	Perennial	May.—Oct. B+C+D	June—Dec. C+D+A	Underground stem and seeds
P. plebejum R. Br.	Annual	Feb.—July A+B+C	March—July B+C	Seeds
AMARANTHACEAE				
Achyranthes aspera L.	Perenntial	Throughout the year A+B+C+D	Throughout the year A+B+C+D	Creeping stem and seeds
Alternanthera sessilis (L.) DC.	Perennial	Throught out the year A+B+C+D	Throughout the year A+B+C+D	Creeping stem and seeds
Amaranthus gracilis Desf.	Annual	March—Oct. B+C+D	April—Dec. B+C+D+A	Seeds
Celosia argentea L.	Annual	Aug.—Nov. C+D	Sept.—Dec. C+D+A	Seeds
Digera alternifolia (L.) Asch.	Annual	May—Aug. B+C	June—Sept. C	Seeds
AIZOACEAE				
Glinus lotoides L.	Annual	Feb.—July A+B+C	March—Aug. B+C	Seeds
G. oppositifolius (L.) A. DC.	Annual	May—July B+C	May—Aug. B+C	Seeds
Trianthema portulacastrum L.	Annual	March.—Aug. B+C	April—Sept. B+C	Creeping stem and seeds
PORTULACACEAE				
Portulaca oleracea L.	Annual	May—Oct. B+C+D	July—Dec. C+D+A	Seeds
CARYOPHYLLACEAE				
Polycarpon prostratum (Forsk.) Asch. & Schewin. f.	Annual	March—Nov. B+C+D	Aug.—Nov. C+D	Seeds

Species	Life-span	Flowering tjma	Fruiting time	Method of propagation
NYMPHAEACEAE				
Nymphaea stellata Willd.	Perennial	July—Oct. C+D	Aug.—Dec. C+D+A	Rhizome and seeds
PAPAVERACEAE				
Argemone mexicana L.	Annual	Feb.—July A+B+C	April—Aug. B+C	Seeds
CAPPARIDACEAE				
Polanisia viscosa (L.) DC.	Annual	June—Sept. C	Aug.—Jan. C+D+A	Seeds
DROSERACEAE				
Drosera burmannii Vahl	Annual	Nov.—Jan. D+A	Nov.—Jan. D+A	Seeds
LEGUMINOSAE				
Aeschynomene aspera L.	Perennial	June-Sept. C	Sept. —Nov. C+D	Underground stem and seeds
A. indica L.	Annual	June—Sept. C	Sept.—Nov. C+D	Seeds
Alysicarpus vaginalis DC.	Annual	March—June B+C	April—July B+C	Seeds
Desmodium triflorum (L.) DC.	Annual	Aug.—Dec. C+D+A	Sept.—Jan. C+D+A	Seeds
Sesbania cannabina (Retz.) Pers.	Annual	Aug.—Oct. C+D	Sept.—Nov. C+D	Seeds
Smithia sensitiva Ait.	Annual	Aug.—Oct. C+D	Sept.—Nov. C+D	Seeds
OXALIDACEAE				
Biophytum sensitivum DC.	Annual	July—Oct. C+D	July—Oct. C+D	Seeds
EUPHORBIACEAE				
Chrozophora rottleri (Geis) Juss. ex Spreng	Annual	April—Aug. B+C	May—Oct. B+C+D	Seeds
Croton bonplandianum Baill	Perennial	Throughout the year A+B+C+D	Throughout the year A+B+C+D	Seeds
Euphorbia hirta L.	Annual	Throughout the year A+B+C+D	Throughout the year A+B+C+D	Seeds
E. parviflora L.	Annual	Thorughout the year A+B+C+D	Throughout the year A+B+C+D	Seeds
E. thymifolia Burm.	Annual	July—Nov. C+D	Aug. Dec. C+D+A	Seeds
Phyllanthus fraternus Webster	Annual	July—Nov. C+D	Aug. —Dec. C+D+A	Seeds
P. simplex Retz.	Annual	July—Nov. C+D	Aug.—Dec. C+D+A	Seeds
P. urinaria L.	Annual	June—Nov. C+D	July—Dec. C+D+A	Seeds

Species	Life-span	Flowering time	Fruiting time	Method of propagation
TILIACEAE				
Corchorus aestuans L.	Annual	July—Sept. C+D	Sept. Oct. C+D+A	Seeds
MALVACEAE				
Sida acuta Burm	Perennial	July—Oct. C+D	Aug. —Oct. C+D	Rootstock and seeds
S. rhomboidea Roxb.	Perennial	July—Oct. C+D	Aug—Oct C+D	Rootstock and seeds
STERCULIACEAE				
Melochia corchorifolia L. L.	Annual	June—Sept. C	Sept.—Nov. C+D	Seeds
ELATINACEAE				
Bergia ammanoides Roxb.	Annual	March—Sept. B+C	May—Nov. B+C+D	Seeds
LYTHRACEAE				
Ammania baccifera L.	Annual	July—Oct. C+D	Aug.—Dec. C+D+A	Seeds
A. multiflora Roxb.	Annual	July—Oct, C+D	Aug. —Nov C+D	Seeds
Rotala densiflora (Roth.) Koehne	Annual	July—Nov. C+D	Aug.—Dec. C+D	Seeds
R. indica Koehne	Annual	Oct.—Dec. D	Nov.—Dec. D+A	Seeds
ONAGRCEAE				
Ludwigia adscendens (L.) Hara	Perennial	July—Oct. C+D	Oct.—June D+A+B+C	Seeds
L. perennis L.	Annual	Sept.—Nov. C+D & May—June B+C	Oct.—Dec. D+B & June—July C	Seeds
HALORAGACEAE				
Myriophyllum indicum Willd.	Perennial	Throughout the year A+B+C+D	Throughout the year A+B+C+D	Submerged stem turion and seeds
M. tuberculatum Roxb.	Perennial	Throughout the year A+B+C+D	Throughout the year A+B+C+D	Submerged stem turion and seeds
UMBELLIFERAE				
Centella asiatica (L.) Urban	Perennial	March—Dec. B+C+D+A	April—Jan. B+C+D+A	Runner and seeds
Seseli diffusum (Roxb. ex Sm.) Santapau & Wagh	Annual	Feb.—April A+B	March—May B	Seeds
LOGANIACEAE				
Mitrasacme alsimoides R.Br.	Annual	Sept.—Nov. C+D	Oct.—Dec. D+A	Seeds
GENTIANACEAE				
Centaurium roxburghii (Don) Druce	Annual	March—June B+C	April—July B+C	Seeds

Species	Life-span	Flowering time	Fruiting time	Method of propagation
Nymphoides cristatum (Roxb.) O. Ktze.	Perennial	June—Oct. C+D	July—Nov. C+D	Stolon and seeds
APOCYNACEAE				
Lochnera pusilla K. Schum.	Annual	July—Sept. C	Aug.—Dec. C+D	Seeds
CONVOLVULACEAE				
Evolvulus nummularius L.	Annual	April—Aug. B+C	May—Sept. B+C	Seeds
Ipomoea aquatica Forsk.	Perennial	Nov.—April. C+D+A	Dec.—May A+B	Creeping stem and seeds
Merremia emarginata (Burm. f.) Hall. f.	Perennial	Sept.—Nov. C+D	Oct.—Dec. D	Creeping stem and seeds
HYDROPHYLLACEAE				
Hydrolea zeylanica (L.) Vahl	Annual	Nov.—Jan. D+A	Dec.—March A+B	Seeds
BORAGINACEAE				
Coldenia procumbens L.	Annual	Oct.—Jan. D+A	Jan.—July D+A	Seeds
Heliotropium indicum L.	Annual	Feb.—June A+B+C	March. Aug. B+C	Seeds
H. ovalifolium Forsk.	Annual	March—July B+C	June—Aug. C	Seeds
Phyla nodiflora (L.) Greene	Annual	March—July B+C	July—Sept. C	Seeds
LABIATAE				
Leucas cephalotes Spreng.	Annual	July—Oct. C+D	Sept.—Nov. C+D	Seeds
SCROPHULARIACEAE				
Bacopa monnieri (L.) Pennell	Perennial	June—Sept. C	July—Dec. C+D+A	Creeping stem and seeds
Centranthera tranquebarica (Spreng.) Merr.	Annual	July—Oct. C+D	Aug.—Nov. C+D	Seeds
Limnophila indica (L.) Druce	Annual	Sept.—Jan. C+D+A	Oct.—Feb. C+D+A	Creeping stem and seeds
L. sessiliflora Bl.	Annual	Sept.—Dec. C+D+A	Oct.—Jan. C+D+A	Creeping stem and seeds
Lindernia ciliata (Colsm.) Pennell	Annual	July—Oct. C+D	Aug.—Nov. C+D	Seeds
L. cordifolia (Colsm.) Merr.	Annual	May—Oct. B+C+D	June—Nov. C+D	Seeds
L. crustacea (L.) F. Muell.	Annual	July—Nov. C+D	Aug.—Dec. C+D+A	Creeping stem and seeds
Scoparia dulcis L.	Perennial	Throughout the year A+B+C+D	Throughout the year A+B+C+D	Seeds
LENTIBULARIACEAE				
Utricularia flexuosa Vahl	Annual	Oct.—Feb. D+A	Nov.—March D+A+B	Turion and seeds

Species	Life-span	Flowering time	Fruiting time	Method of propagation
U. inflexa Forsk. var. *stellaris* (L. f.) P. Taylor	Annual	July—Dec. C+D+A	Aug.—Dec. C+D+A	Turion and seeds
ACANTHACEAE				
Hemigraphis hirta (Vahl) T. And.	Perennial	March—July B+C	April—Aug. B+C	Creeping stem and seeds
Hygrophila auriculata (Schum.) Heine	Annual	Nov.—Jan. D+A	Feb.—April A+B	Seeds
H. difformis (L. f.) Bl.	Perennial	Sept.—March C+D+A+B	Oct.—April D+A+B	Underground stem and seeds
H. polysperma T. And.	Annual	March—July B+C	April—Aug. B+C	Creeping stem and seeds
Justicia quinqueanqularis Koen.	Annual	Aug.—Oct. C+D	Sept.—Nov. C+D	Seeds
Rungia pectinata (L.) Nees	Annual	Dec.—March A+B	Jan.—April A+B	Seeds
RUBIACEAE				
Borreria articularis (L.f.) F.N. Will.	Perennial	May—July B+C	July—Sept. C	Unerground stem and seeds
Dentella repens Forst.	Annual	May—Aug. B+C	May—Aug. B+C	Creeping stem and seeds
Oldenlandia corymbosa L.	Annual	May—Dec. B+C+D+A	Aug.—Jan. C+D+A	Seeds
O. heynei Br.	Annual	July—Oct. C+D	Aug.—Nov. C+D	Seeds
O. nudicaulis Roth	Annual	Aug.—Oct. C+D	Sept.—Nov. C+D	Seeds
CAMPANULACEAE				
Lobelia alsinoides Lam.	Annual	July—Nov. C	Aug.—Dec. C+D+A	Seeds
Sphenoclea zeylanica Gaertn.	Annual	Oct.—Dec. D+A	Oct.—Dec. D+A	Seeds
COMPOSITAE				
Eclipta prostrata (L.) L.	Perennial	June—Dec. C+D+A	July—Jan. C+D+A	Seeds
Enhydra fluctuans Lour.	Perennial	May—Dec. B+C	July—Jan. C+D+A	Floating stem and seeds
Gnaphalium indicum L.	Annual	Feb.—April A+B	March—April B	Seeds
G. pulvinatum DC.	Annual	Feb.—April A+B	March. /April B	Seeds
Grangea madraspatana (L.) Poir.	Annual	Feb.—July A+B+C	March—Aug. B+C	Seeds
Xanthium strumarium L.	Annual	April—Aug. B+C	May—Oct. B+C+D	Seeds

Table 2

Seasonal categories in the flowering of rice-field weeds

Seasons	Categories	No of weeds flowered	% of weeds flowered
Winter	A	0	0
Summer or pre-monsoon	B	1	0.6
Monsoon	C	15	9.3
Post-monsoon	D	3	1.9
Winter + summer	A + B	5	3.1
Winter + monsoon	A + C	0	0
Winter + post-monsoon	A + D	0	0
Pre-monsoon + monsoon	B + C	19	11.8
Pre-monsoon + post-monsoon	B + D	0	0
Monsoon + post-monsoon	C + C	65	40.4
Post-monsoon + winter	D + A	11	6.8
Winter + summer + monsoon	A + B + C	5	3.1
Summer + monsoon + post-monsoon	B + C + D	9	5.6
Monsoon + post-monsoon + winter	C + D + A	16	9.9
Post-monsoon + winter + summer	D + A + B	0	0
Winter + summer + monsoon + post-monsoon	A + B + C + D	8	5.0
Summer + monsoon + post-monsoon + winter	B + C + D + A	3	1.9
Monsoon + post-monsoon + winter + summer	C + D + A + B	1	0.6
Post-monsoon + winter + summer + monsoon	D + A + B + C	0	0

which are capable of either. While the seed production of annual species is high compared with that of perennials (cf. Salisbury, 1942, p. 77), the latter become more successful due to good adaptability and efficient method of vegatative propagation. It is these perennial weeds which turn pernicious and are difficult to eradicate.

It has been observed that the weeds belonging to the *Gramineae* and *Cyperaceae* predominate in rice-fields. Though these weeds produce fertile seeds, their spread is spectacular by means of creeping stems, underground stems, rootstocks, rhizomes and tubers. Except for tubers which give out aerial shoots, the other organs are capable of radial extension. While slender rhizomes or stems occupy superficial horizons of the soil, stout rhizomes or stems are more deeply permeating. The stout rhizomes or stems constitute an effective means of invasion and contribute to the success of the weedy species. Moreover, most of the species of the *Gramineae* and *Cyperaceae* come up in the monsoon when the rice-fields are wet and the mud is physiologically and physically favourable for them. The increase of these plants is also due, in part, to the suitability of the environment for volume increase and to the facility with which water currents can transport relatively bulky propagules during the rainy sea-

Table 3

Seasonal categories in the fruiting of rice-field weeds

Seasons	Categories	No. of weeds fruited	% od weeds fruited
Winter	A	0	0
Summer or pre-monsoon	B	3	1.9
Monsoon	C	7	4.3
Post-monsoon	D	3	1.9
Winter + summer	A+B	4	2.5
Winter + monsoon	A+C	0	0
Winter + post-monsoon	A+D	0	0
Pre-monsoon + monsoon	B+C	13	8.1
Pre-monsoon + post-monsoon	B+D	0	0
Monsoon + post-monsoon	C+D	42	26.1
Post-monsoon + winter	D+A	18	11.2
Winter + summer + monsoon	A+B+C	1	0.6
Summer + monsoon + post-monsoon	B+C+D	4	2.5
Monsoon + post-monsoon + winter	C+D+A	50	31.0
Post-monsoon + winter + summer	D+A+B	3	1.9
Winter + summer + monsoon + post-monsson	A+B+C+D	8	4.9
Summer + monsoon + post-monsoon + winter	B+C+D+A	3	1.9
Post-monsoon + winter + summer + + summer	C+D+A+B	1	0.6
Monsoon + post-monsoon + winter + monsoon	D+A+B+C	1	0.6

son. Weeds of rice-fields do not complete their lifecycle during the rains, but persist in the post-rainy months when they flower and fruit. It has been stated by S a l i s b u r y (1942, p. 224) "that the possession by a species of the dual mode of reproduction not only enables it to flourish in a much wider range of habitats but also ensures success in a much wider range of climaitc codnitions". This remark holds good for the weedy species of the *Gramineae* and *Cyperaceae* which not only endure wet, marshy or dry conditions of soil, but also survive with the change of temperature, light and humidity conditions.

As to the flowering time, the number fo weed species is highest in the period extending from the monsoon to the post-monsoon and the *Gramineae* makes up a great proportion of these species (Table 2). Other seasonal categories in flowering have been noted, but strict correlations between flowering frequency and day-length have been obtained only in three cases. In the summer or pre-monsoon only one weed (*Imperata cylindrica*) flowered, whereas in the monsoon and post-monsoon 15 species (9.3 per cent) and 3 species (1.9 per cent) of weeds produced flowers.

As regards the fruiting time of weeds, the maximum number (31 per cent) is shown in the regime extending from the monsoon through the

post-monsoon to the winter (Table 3). Other significant figures for seasonal categories in fruiting include the time from the monsoon to post--monson (26.1 per cent) and from the post-monsoon to the winter (11.2 per cent). Like the flowering time, correlations are evident between the day-length and the fruiting frequency of weeds in three cases only. Whereas 7 specis produced fruits in the monsoon, only 3 species each did the same in the summer or pre-monsoon or post-monsoon period.

Since no weeds produced flowers or fruits exclusively in the winter, they are not likely to infest the rice-fields in a menacing way. Harmful weeds are those which carry on dual reproduction, sexual and vegetative, in other seasons and most of them appear to be monocotyledonous plants. Danger may come from those weeds (all dicots) which flower and fruit throughout the year. All these are a great handicap to the farmers and, therefore, their control measures should be fully worked out. The present investigation provides information about the growth and behaviour of rice-field weeds. Although hand-pulling is a primitive method, it may be recommended for the removal of weeds when they are just detected in the rice-fields and before they are allowed to form flowers and fruits. In this way, the aerial parts of weeds are eliminated, but the roots in case of perennials and rhizomes, creeping stems, etc. in case of grasses (*Gramineae*) and sedges (*Cyperaceae*) remain underground. Only digging or hoeing may aid in the extermination of this type of weeds. In western countries, the use of selective herbicides has proved very popular (Robbins et al. 1952). Effective concentrations of herbicides like 2, 4-D may kill or injure weeds and will not affect the rice crop. Even for such applications, it is important to know the life-span, flowering and fruiting time and the methods of propagation of the weeds.

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Fenologia chwastów pól ryżowych w Zachodnim Bengalu

Streszczenie

Chwasty pól ryżowych były badane pod względem:

a) cyklu życiowego — gatunki roczne (24,7%) i trwałe (75,3%);

b) okresu kwitnienia — w okresie od pro-monsunu do monsunu (11,8%), od monsunu do zimy przez post-monsun (9,9%) oraz tylko w czasie monsunu (9,3%);

c) wytwarzania nasionn — najwyższy procent owocujących chwastów jest w okresie od monsunu do zimy przez post-monsun (31,0%), w okresie od monsunu do post-monsunu (26,1%) i od post-monsunu do zimy (11,2%).

Wśród roślin trwałych pól ryżowych Zachodniego Bengalu najliczniej występują gatunki z rodziny *Gramineae* — zarówno o rozmnażaniu płciowym, jak i wegetatywnym, natomiast w grupie gatunków rocznych najliczniejsze są turzycowate.