SOIL SEED BANK DYNAMICS OF WEED FLORA IN UPLAND AND LOWLAND PADDY CULTIVATION AREAS OF FAR WESTERN NEPAL

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Abstract: For the analysis of composition of individuals of weed flora, soil samples were taken with diameter of 8cm and depth of 10cm. Soil seed bank dynamics of weed flora experiments were carried out 2004 and 2005 by incubating soil samples collected from the upland and lowland sites. Soil seed bank dynamics of weed flora were recorded by incubating soil samples collected from the two study sites. A total of 46 weed species germinated of which 18 families and 34 genera in soil samples of upland site. From lowland site soil samples, the species were just marginally lower, 43 belonging to 32 genera and 17 families. The mean total number of individuals of weeds that germinated in soil samples of upland site was 517 compared to 503 at lowland site. The highest number of weeds (186) was of the family Cyperaceae (37% of the species). The proportion of this family was 35.6% at the upland site. The dominant families were Cyperaceae, Scrophulariaceae and Poaceae in both the study sites. Of the total germinated weed species, the highest number of individuals of broad-leaved followed by sedges and grasses in both the study sites.

Key words: Paddy; Weeds; Seed bank; Upland; Lowland.

INTRODUCTION

In Himalayan mountain region people are among the poorest in Nepal with lowest per capita income. Approximately 2.32 million ha of land is cultivated of which 1.7 million ha of agricultural land is rainfed. Nepal being a mountainous country, only 17% of the total surface area can be termed as plain. The remaining 83% of the country is the hilly or mountainous. The rainfed paddy is the most important staple crop in hilly belt of Nepal but the productivity is affected due to climate, edaphic and economic factors in foothills of Nepal. In hills and mountains, agriculture is still practiced in its traditional style. The traditional way of agriculture as practiced by majority of farmers is supposed to be one of the important factors for the poor performance of the agriculture sector in the country.

Weed management is as old as agriculture itself. Weeds are those plants, which are harmful, interfere with the agricultural operations, increase labours, add input to the cultivation and reduce the crop yields (Sen, 2000). Weeds compete with crop plants for light, water, nutrients and space. They are self-grown which appear simultaneously with crop plants and result in intense crop weed competition during early stage of crop growth and cause reduction in grain yield. Weed problem varies from one crop to another, from one season to other, from one farm to other and even one section of a farm to the other (Rao, 1983). Many weed species have almost identical growth and requirements as paddy. The practices that benefit rice also benefit weeds, while the practices that harm rice also harm weeds (De Datta and Baltazar, 1996).

Weeds are major problems specially limiting the growth and yield in paddy cultivation. They usually emerge faster than the rice plant, absorb available water and nutrients earlier, establish their growth earlier and suppress crop growth. The problem of weeds in upland rainfed rice during *kharif* season is extremely severe and causes substantial 45-85% reduction in yield (Moody, 1982). The low agricultural production because of limited suitable area for cultivation is further affected by weeds, which abound along with paddy crops. There is a need to assess the loss in paddy crop production because of these unwanted useless and persistent weed species. Further to restrict the loss in paddy biomass and develop reliable methods by which the poor farmers can control the most common and abundant weeds.

Seeds are the principal means by which weeds species spread and invade new areas. A single weed plant commonly produces vast number of seeds and these seeds easily escape detection when scattered on or in the soil making their presence known only as they germinate and become seedling plants. Weed seeds usually infest the soil of cropland in the amount of million per acre. Soil seed banks can be either transient, with seeds that germinate within a year of dispersal, with seeds that remain in the soil more than one year (Simpson *et al*., 1989). Soil seed banks partially reflect history of plant species and can play important role in its regeneration or restoration after disturbances. In this paper, the present study was made to examine the soil seed bank dynamics of weed flora, due to which strategies of spread and reproduction of paddy field weeds, and its impact on high yield of paddy.

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MATERIALS AND METHODS

Experiments were conducted during the rainy seasons of 2004-2005 at two different study sites in Mahendranagar *i.e.* upland and lowland (28^0 32' N 80^0 33' E and 185-300 m amsl). The soil is silty clay in texture with p^H 6.2-6.5. Climate is humid tropical with three distinct seasons in a year *viz.* monsoon, winter and summer. Total annual rainfall during the study period was 1642.8 mm of which 90% was recorded during the monsoon months of the year.

For the analysis of composition of individual species of weed flora in soil seed bank, soil samples were collected from both the experimental sites of paddy fields in Mahendranagar. Twenty soil samples were collected randomly using a metal cylinder with a diameter of 8 cm and depth of 10 cm in the last week of May 2004. The collected soil samples were stored in labelled paper bags and transported to a green house. All the collected soil samples were mixed with each other carefully. The soil was spread on thin layer of calcium 3 mm over a siliceous sand substrate of 2 cm thick, on plastic trays. The experimental plastic trays were incubated for seed germination in the green house and watered to keep moist on alternate days with fixed amount of water. The emerging seedlings were observed daily, identified, counted and removed from the trays.

After eight month, i.e. in late spring of the following year, watering was interrupted and the soil left to dry. In the following autumn, watering was restarted, the soil samples were stirred to stimulate new germination, and seedlings were identified, counted and discarded during another eight months. The calculated seed bank is the number of seedlings counted in soil sample during the two years. Soil seed bank experiment was conducted according to the procedure given by Maranon (1998).

RESULTS

Seeds are the basic demographic unit of most annual plants. Soil seed banks refer to all viable seeds and fruits present on or in the soil and associated with litter or humus. Soil seed banks partially reflect history of plant species and can play important roles in its regeneration or restoration after disturbances. Seeds of weed species are very small, so in the present study they were observed by the seedling germination trails.

By incubating soil samples collected from the two study sites we recorded the germination of 46 weed species, which belonged to 18 families, 34 genera in soil samples of upland site. From lowland site soil samples the species were just marginally lower, 43 belonging to 32 genera and 17 families (Table 1). The mean total number of weeds that germinated in soil samples of upland site was 517 compared to 503 at lowland site (Table 1). The highest number of weeds (186) was of the family Cyperaceae (37% of the species). The proportion of this family was 35.6% at the upland site.

Family Cyperaceae was followed by Scrophulariaceae, 120 (23.2%) at upland site and 88 seedlings (17.5%) emerged at lowland site. Poaceae was third in ranking in both the study

Table 1: Total number of emerged weed species in individuals from soil samples (soil seed bank) collected from the upland site and lowland site in Mahendranagar during 2004-2005. The soil samples taken were 0-10 cm depth and 8 cm diameter. The values are mean of three soil samples (Mean±SE). Data are average of two years.

Weed species	Family	Upland Site						Lowland Site					
		Number of emerged individuals						Number of emerged individuals					
		June	July	Aug	Sept	Oct	Nov	June	July	Aug	Sept	Oct	Nov
*Ageratum conyzoides**	Asteraceae	12±2.89	11±1.25	4±1.25	2±0.47	-	-	9±1.63	-	4±0.94	2±0.47	-	-
Alternanthera sessilis	Amaranthaceae	4±0.47	4±0.94	3±0.47	-	-	-	2±0.47	1±0.47	-	-	-	-
*Amaranthus viridus**	Amaranthaceae	2±0.47	1±0.47	-	-	-	-	1±0.47	-	-	-	-	-
*Brachiaria ramosa**	Poaceae	4±1.25	1±0.0	-	-	-	-	3±0.94	-	-	-	-	-
*Chenopodium album**	Chenopodiaceae	1±0.47	-	-	-	-	5±1.25	-	-	-	-	-	3±0.49
Commelina benghalensis	Commenlinaceae	1±0.0	2±0.47	-	-	-	-	1±0.47	3±0.47	-	-	-	-
Commelina paludosa	Commenlinaceae	4±1.25	1±0.47	-	-	-	-	7±0.58	-	-	-	-	-

Weed species	Family	Upland Site						Lowland Site					
		Number of emerged individuals						Number of emerged individuals					
		June	July	Aug	Sept	Oct	Nov	June	July	Aug	Sept	Oct	Nov
Commelina paludosa	Commenlinaceae	4±1.25	1±0.47	-	-	-	-	7±0.58	-	-	-	-	-
Cynodon dactylon	Poaceae	7±1.25	-	-	-	-	-	4±0.47	-	-	-	-	1±0.47
Cyperus corymbosus	Cyperaceae	15±3.68	-	-	-	-	-	9±3.93	-	-	-	-	-
Cyperus difformis	Cyperaceae	2±0.47	3±0.49	1±0.0	-	-	-	8±1.66	6±0.47	-	-	-	-
Cyperus esculentus	Cyperaceae	4±1.41	2±0.47	-	-	-	-	3±1.25	3±1.63	-	-	-	-
*Cyperus iria**	Cyperaceae	46±6.13	6±1.63	3±0.47	5±0.82	-	-	20±4.03	3±0.47	2±0.47	3±0.47	-	-
Cyperus rotundus	Cyperaceae	4±1.25	4±0.94	2±0.47	-	-	-	6±0.47	2±0.47	1±0.47	-	-	-
Dactyloctenium aegypticum	Poaceae	2±0.47	2±0.47	-	-	-	-	1±0.0	1±0.47	-	-	-	-
Dactyloctenium indica	Poaceae	2±0.47	1±0.47	-	-	-	-	1±0.47	-	-	-	-	-
*eria sanguinalis**	Poaceae	1±0.47	3±0.94	-	-	-	-	-	2±0.47	-	-	-	-
*Echinochloa colona**	Poaceae	11±1.19	1±0.0	-	-	-	-	8±1.25	6±0.94	6±1.25	-	-	-
Echinochloa crus-galli	Poaceae	20±3.77	-	-	-	-	-	17±3.95	-	-	-	-	-
Eclipta prostrata	Asteraceae	-	4±0.49	-	-	-	-	-	2±0.47	-	-	-	-
*Eleocharis atropurpurea**	Cyperaceae	24±3.77	8±0.94	4±0.94	3±0.94	4±0.47	2±0.47	24±2.94	17±2.94	10±1.25	11±3.3	2±0.47	-
*Elusine indica**	Poaceae	1±0.47	-	-	-	-	-	-	-	-	-	-	-
*Euphorbia hirta**	Euphorbiaceae	3±0.94	1±0.0	-	-	-	-	2±0.47	-	-	-	-	-
*Fimbristylis miliacea**	Cyperaceae	28±2.36	3±0.94	3±0.47	3±0.82	1±0.47	-	22±2.36	8±0.94	8±1.25	4±0.94	-	-
Gnaphalium pensylvanisum	Asteraceae	-	-	-	-	-	2±0.82	-	-	-	-	-	2±0.47
Hedyotis corymbosa	Rubiaceae	2±0.94	-	-	-	-	-	1±0.47	-	-	-	-	-
*Ischaemum rugomum**	Poaceae	10±2.51	1±0.47	2±0.82	-	-	-	8±0.94	4±0.47	4±0.47	-	-	-
*Lindernia antipoda**	Scrophulariaceae	-	2±0.47	1±0.47	-	-	1±0.47	-	5±1.25	4±0.94	-	1±0.47	-

Weed species	Family	Upland Site						Lowland Site					
		Number of emerged individuals						Number of emerged individuals					
		June	July	Aug	Sept	Oct	Nov	June	July	Aug	Sept	Oct	Nov
*Lindernia oppositifolia**	Scrophulariaceae	6±0.47	9±1.25	2±0.47	1±0.0	-	-	-	10±0.84	8±0.84	-	-	-
*Lindernia procumbens**	Scrophulariaceae	62±4.48	6±1.25	6±0.47	4±0.47	2±0.47	1±0.47	20±2.36	9±1.63	4±0.84	1±0.47	3±0.94	4±1.41
Lindernia viscosa	Scrophulariaceae	-	3±0.94	4±0.47	-	-	-	-	2±0.47	3±0.84	-	-	-
Lippia nudiflora	Verbenaceae	5±0.47	-	-	-	-	-	3±1.10	-	-	-	-	-
*Ludwigia Perennis**	Onagraceae	-	-	1±0.47	1±0.0	-	-	2±0.94	-	2±0.47	2±0.94	3±0.47	-
Mecardonia procumbens	Scrophulariaceae	5±0.94	2±0.94	1±0.47	2±0.47	-	-	2±0.47	4±0.47	4±0.94	3±.94	1±0.47	-
Murdania nudiflora	Commenlinaceae	13±2.36	2±0.94	1±0.47	-	-	-	6±0.94	6±0.47	-	-	-	-
*Oplismenus burmanii**	Poaceae	2±0.47	-	-	-	-	1±0.47	1±0.47	-	-	-	-	1±0.47
Oxalis corniculata	Oxalidaceae	2±0.47	-	-	-	-	3±0.94	-	-	-	-	-	-
*Phyllanthus urinaria**	Euphorbiaceae	4±1.63	-	-	-	-	-	5±1.41	-	-	-	-	-
*Phyllanthus varigatus**	Euphorbiaceae	2±0.94	-	-	-	-	-	2±0.82	-	-	-	-	-
*Polygonium plebejum**	Polygonaceae	-	-	2±0.94	2±0.47	2±0.47	5±1.63	-	1±0.47	-	2±0.47	15±2.36	51±2.36
Portulica oleracea	Portulaceae	4±1.63	2±0.94	-	-	-	-	3±0.92	-	-	-	-	-
Sagittaria guayensis	Alismataceae	-	-	-	-	-	-	-	3±0.82	2±0.47	2±0.47	-	-
*Schoenoplectus juncoides**	Cyperaceae	3±0.82	-	-	-	-	1±0.47	2±0.47	2±0.94	3±0.82	4±1.41	3±1.41	-
Sida acuta	Malvaceae	-	1±0.47	-	-	-	-	-	1±0.47	-	-	-	-
Solanum nigrum	Solanaceae	-	-	-	-	-	1±0.47	-	-	-	-	-	-
*Vicia hirsuta**	Leguminosae	-	-	-	-	2±0.47	2±0.94	-	-	-	-	-	-
Vicia tetrasperma	Leguminosae	-	-	-	-	-	12±1.41	-	-	-	-	-	9±1.25
Wahlenbergia mariginata	Campanulaceae	-	-	-	-	-	3±0.47	-	-	-	-	-	1±0.47

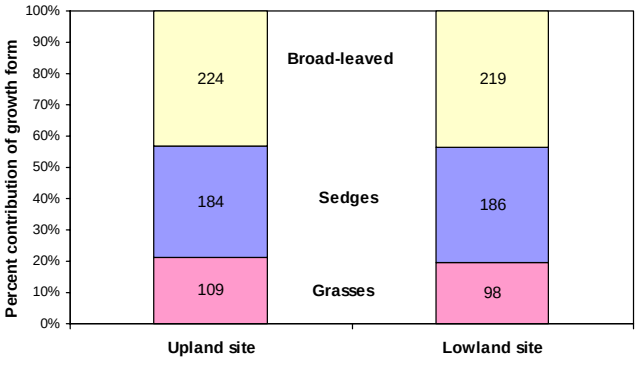
* Weed species that also emerged in the second year soil seed bank experiment between June to November 2005.

sites the number of emerged weeds being 72 at upland site and 68 at lowland site. The number of emerged weeds of family Poaceae represented 13.9% and 13.5% of the total species, respectively. Species of the above families produce large number of seeds, which remain dormant for long period because of which they appear in next cropping season (Table 1).

Of the emerged weed individuals 109 were grasses, 184 sedges and 224 broad-leaved weeds at upland site and 98 grasses, 186 sedges and 219 broad-leaved weeds at lowland site. The soil samples of experimental upland site showed highest number of broad-leaved (43.3%) weeds followed by sedges (35.6%) and grasses (21.1%). The soil samples of experimental lowland site showed highest number of broad-leaved (43.5%) followed by sedges (37%) and grasses (19.5%). The number of weeds of grasses, sedges and broad-leaved species that emerged in both the study sites (Figure 1).

In the second year soil seed bank experiment also, 20 species of weed emerged at upland site and 14 species at lowland site. The species which emerged in second year experiments were *Ageratum conizoides, Cyprus iria, Digiteria sanguinalis, Echniochloa colona, Eleocharis atropurpurea, Elusine indica, Fimbristylis miliacea, Ischaemum rugosum, Lindernia procumbens, Lindernia oppositifolia, Polygonium plebejum, Schoenoplectus juncoides* etc. This showed longer viability of the seeds of these species.

Fig. 1: Individuals of growth forms of weeds that emerged from soil seed bank in the upland and lowland sites. The percent share of different growth forms is given on the y-axis.



Growth form of weeds

DISCUSSION

Knowledge of soil seed bank dynamics of weed flora is an essential prerequisite for any planning of their control. Seeds are basic demographic units of most annual plants, are important with regard to understanding population dynamics of annual weeds. Soil seed bank partly reflects the history of plant species and can play an important role in its regeneration or restoration after disturbances. Densities of viable seeds in the soil seed banks are also useful initial parameters for bioeconomic weed management models. These models use seed bank estimates to predict potential seedling densities and crop-weed competition and to evaluate weather preplant or pre-emergence control strategies. This has resulted in substantial reduction in applied herbicides compared to conventional practices (Forcella, 1984).

In the seed bank experiment 517 and 503 plants of weed species were emerged from the seed bank of upland and lowland sites, respectively. They belonged to 18 families 34 genera and 46 species and 17 families 32 genera and 43 species from upland site and lowland site, respectively, during the two years experiments. The family Cyperaceae showed highest number of emerged plants, followed by Scrophulariaceae and Poaceae at each site. As for species number, it was highest for Poaceae (10 spp.), followed by Cyperaceae (8 spp.) and Scrophulariaceae (5 spp.) at upland site. The same pattern occurred at lowland site; Poaceae (9 spp.), Cyperaceae (8 spp.) and Scrophulariaceae (5 spp.). Out of the total recorded emerged individuals, 109 were grasses, 184 sedges and 224 of broad-leaved at upland site, and 98 grasses, 186 sedges and 219 broad-leaved in soil samples of lowland site. The proportional distribution of grasses, sedges and broad-leaved weeds (individuals %) in soil seed bank and crop field was similar as evident from Table 2.

Table 2: Proportional distributions of individuals of weeds growth form in soil seed bank and in paddy crop fields.

Soil seed bank	**Grasses**	**Sedges**	**Broad-leaved**
Upland site	21.1	35.6	43.3
Lowland site	19.5	37.0	43.5
In crop field	**Grasses**	**Sedges**	**Broad-leaved**
Upland site	20.7	36.2	43.1
Lowland site	18.7	38.3	43.0

Some weed species, like *Ageratum conyzoides, Amarantus viridus, Brachiaria ramosa, Cyperus iria, Digitaria sanguinalis, Echinochloa colona, Eleocharis atropurpurea, Elusine indica, Euphorbia hirta, Fimbristylis miliacea, Ischaemum rugosum, Lindernia oppositifolia, Lindernia procumbens, Ludwiga perennis, Oplismenus burmanii, Phyllanthus urinaria, Phyllanthus varigatus, Polygonium plebejum, Schoenoplectus juncoides*, which also emerged in the second year (between June and November 2005) of the soil seed bank experiments, proved to have a longer viability of their seeds.

The species composition of the soil seed bank was more or less similar between sites. The present investigated data indicates that family Cyperaceae, Scrophulariaceae and Poaceae were the dominant families, which produce a high number of seeds, mix well with the soil, and remain dormant for approximately 12 months so that they can reappear in next cropping season. Some of them may also remain dormant for longer period (2 years) and manifest themselves after two years. The identification and composition of weed flora in soil seed banks are useful to manage weed control practices for agricultural personals. These observed data are used to predict weed seedling densities on a unit area basis. In turn, weed seedling densities are used to estimate crop yield loss, need for herbicides, and weed seed production at the end of growing season.

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