WEEDS OF PADDY FIELD AT KIRTIPUR, KATHMANDU

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Abstract: Paddy (*Oryza sativa* L. var. Taiching-127) fields of Kirtipur, central Nepal, were studied to evaluate the effects of weeds on crop yield during June to October 2003. Weed community was recorded in permanently marked plots (2 x 2 m^2 each), and grain and straw yields were measured. The effect of aqueous extracts (2 to 10%) of leaf, stem and root of dominant weeds (*Echinochloa colona, E. crusgalli, Cyperus iria* and *Ageratum conyzoides*) on germination and seedling growth of the paddy (Taiching-127) was examined in the laboratory. Altogether 52 weed species (27 dicot and 25 monocot) belonging to 32 genera and 15 families infested the paddy. The maximum weed density was observed in September (105 pl/m^2). There was significant reduction in straw and grain yield of paddy in weedy plots and negative correlation between weed species richness and straw yield. Crop weed competition reduced straw yield by 13% to 38% and grain yield by 25% to 47%. Weed growth changed pH and reduced soil nitrogen and phosphorus content. Aqueous extracts of root, stem and leaf of dominant weeds (*Echinochloa colona, E. crus-galli, Cyperus iria* and *Ageratum conyzoides*) showed a weak effect on seeds germination however most of them had inhibitory effect on root and shoot elongation of paddy seedlings. Root elongation was more sensitive to allelopathic inhibition than shoot elongation. Stem extract of these weeds showed higher inhibition on seedling growth of paddy than leaf and root extract except in *Ageratum conyzoides* in which root extract showed highest inhibition.

Keywords: Allelopathy; Crop-weed competition; Soil nutrients; Germination; Grain yield.

INTRODUCTION

Paddy is the most important cereal crop in Nepal which contributes nearly 20% to the gross domestic agricultural product and provides more than 50% of the total calorie requirement to the Nepalese people (Basnet 2004). About 80 % of the total production of paddy is produced in Terai and 20% in hills (NARC 2004). Paddy has been cultivated within wide ecological range in Nepal; from Terai plain (60 m asl) to high mountains (Jumla, 3078 m asl), which can harbour a diversity of weeds in the paddy field. Significant variation in weed diversity and crop-weed competition from Terai to high mountains is one of the major constraints of paddy cultivation.

Nearly 12% of the total loss of crop yields has been attributed to the weeds alone (Anaya 1999). The similarity of some weeds to paddy, such as *Echinochloa* spp. at early growth stages, makes it very difficult for farmers to distinguish them while hand weeding. The graminoid weeds compete more with cereals because of their similar growth behavior, rooting profile and nutrient requirements. Weeds remove nutrients more efficiently than crop. Weeds mostly being C_4 plants interfere with sunlight utilization and adversely affect plant productivity through reduction in photosynthesis.

In transplanted paddy, the young paddy plants have an advantage over germinating weeds and immediate flooding after transplanting limits the establishment of many weeds, hence yield losses due to weed competition tend to be less than those in direct seeded paddy. In Asia, yield losses due to uncontrolled weed growth in direct seeded lowland paddy was 45-75%, and for transplanted lowland paddy approximately 50% (Johnson 1996).

All weeds on crop field may not be harmful. At low density, weeds do not affect yield and certain weeds can even stimulate the crop growth (Thijssen 1991). The best way of weed management is to make use of it, to promote it to a level of wanted plants. The basic approach of allelopathic research in agroecosystem has been to screen both crops and natural vegetation for their capacity to suppress weeds. Allelochemistry may provide basic structures or templates for developing new synthetic herbicides. Incorporation of allelopathic traits from wild or cultivated plants into crops through traditional breeding or genetic engineering could also enhance the biosynthesis and release of allelochemicals (Anaya 1999). An allelopathic crop can potentially be used to control weeds by planting a variety with allelopathic qualities, either as a smother crop, in a rotational sequence, or when left as a residue or mulch, especially in low-till systems, to control subsequent weed growth (Weston, 1996).

Paddy farming in Nepal is a major agricultural sector that employs >75% of total population but its yield is not satisfactory (Thapa & Jha 1999). New varieties, improved

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paddy production practices and proper weed management at farm level can attribute to increase yield. In this paper we present community structure of paddy field weeds, reduction in paddy yield due to crop-weed competition and allelopathic interaction between major weeds and paddy. These data will be valuable to implement proper weed management strategies and increase productivity.

MATERIALS AND METHODS

Study Area

This work was carried out during June 2003 to October 2003 in Kirtipur (27° 40' N, 85° 17' E, 1300 m asl). It lies in subtropical region with characteristic monsoon rainfall and three distinct seasons: hot and dry summer (February to May), hot and moist rainy season (June to September) and cold and dry winter (October to January). Maximum temperature ranges from 30° to 33°C in summer and 13° to 22° in winter and minimum temperature from 20° to 23°C in summer and -3° to 0°C in winter (Figure 1). Soil in this area is silty loam and very suitable for paddy growing.

Weed sampling and paddy harvest

Six square plots (2 m x 2 m) were marked in paddy fields of Kirtipur using stick and plastic rope in June 2003, representing both water logged lowland and relatively dry upland. They were designated as 'weedy plots' and weeds were not removed from these plots. Near each marked plot, another 'control' plot was fixed which was maintained weed free throughout the growing season by hand-weeding at regular intervals. Weeds in their flowering stage were collected from June to October 2003 to prepare herbarium. Herbarium specimens were identified with the help of experts. The nomenclature follows Press et al (2000). Algae and bryophytes found in the field were not considered in present study.

Weed diversity was recorded two times: last week of August and September in each of the marked plots. Each plot was divided into four sub plots (1 m x 1 m). Density, frequency, coverage and importance value index (IVI) were determined following Misra (1968) and Zobel et al. (1987). During harvesting period, fresh biomass (above ground) of paddy was recorded from each plot. Air dried mass of straw and grain were measured using spring balance. Similarly biomass of paddy from the adjoining control plot (regularly weeded, 2 m x 2 m plot) was also measured for comparison.

Soil analysis

After paddy harvest, 1 kg soil sample (15 cm depth) was collected from each plot and used to determine soil pH, organic matter content, nitrogen (N), phosphorus (P) and potassium (K). Soil analysis was done at Soil Analysis Department, Harihar Bhawan, Lalitpur.

The soil pH was determined by using Fischor's Digital meter as well as pH paper. During the process 5 ml of distilled water was poured into 5g of sieved soil sample. It was allowed to dissolve for 25 minutes and the electrode was dipped to record pH. Organic matter content was determined by Walkey and Black's method. Nitrogen in soil was determined by micro-Kjeldahl method in which the organic matter was oxidized by sulphuric acid and the nitrogen converted to ammonia which was determined by titration with hydrochloric acid. Olsen's method was used to determine phosphorus. Potassium was determined by atomic absorption spectrophotometer. All these methods of soil analysis have been described in Gupta (2000).

Allelopathic study

The allelopathic effect of aqueous extracts of leaf, stem and root of four dominant weeds of paddy field (*Echinochloa colona, E. crus-galli, Ageratum conyzoides* and *Cyperus iria*) were examined for germination and seedling growth of the same variety of paddy (Taiching-127). The seeds were collected from the experimental plots when the farmers harvest paddy. Ten gram of air dried and crushed plant parts of the weeds was mixed with 100 mL distilled water and allowed to decay for 24 h at room temperature (mid day maximum: 28°C). Aqueous extract was obtained as filtrate of the mixture and final volume was adjusted to 100 mL; this gave 10% aqueous extract. The extract was considered as stock solution and a series of solution with different strengths (2, 4, 6 and 8%) were prepared by dilution. Seeds were surface sterilized (1% sodium hypochlorite for 15 minutes) and allowed to germinate in petri-dishes (10 seeds in each) with double layer of blotting paper soaked by 10 mL aqueous extracts of different concentrations (2 - 10%). An experiment using distilled water was also performed as control. Each treatment had three replicas. The petri-dishes with seeds were maintained at room temperature (maximum temperature during mid day: 28°C - 32°C) and natural photoperiod for seven days. On 8th day germination percentage was determined and root and shoot length measured.

Statistical Analysis

Correlation coefficients were determined among soil parameters, paddy yield and weed characters. Significance of the difference in soil characters and paddy yield were tested using Student's t-test. Least Significant Difference (LSD) in root and shoot length of paddy seedlings was determined between control and different concentrations of the extracts. Significance of the difference in shoot and root length of paddy seedlings which germinated at 10% aqueous extracts of different weeds was tested by Duncan Homogeneity Test. Decline in root and shoot length of paddy seedlings with increasing concentration of extracts was examined by regression analysis. For this analysis data of all treatments were pooled separately for root and shoot length and their relative response to increasing concentration was examined. All statistical analyses were done using Statistical Program for Social Sciences (SPSS, Version 11.5, 2003).

RESULTS AND DISCUSSION

Altogether 52 weed species (27 dicots and 25 monocots) belonging to 32 genera and 15 families were recorded in transplanted paddy field of Kirtipur (Figure 2). Dicot species were more prominent than monocot in weed flora of the study

Table 1: Density and Importance Value Index (IVI) of weed species recorded in the paddy fields of Kirtipur in August.

S.N.	Species	Local Name	Density (plants/m^2)	IVI
1	*Cyperus difformis* L.	Mothe Jhar	7.13	68.87
2	*Echinochloa colona* (L.) Link.	Sama	10.75	49.21
3	*Cyperus iria* L.	Thulo mothe Jhar	3.5	41.92
4	*Ageratum conyzoides* L.	Gandhe jhar	2.58	38.52
5	*Spilanthes iabadicensis* A.H Moore	Chimke jhar	2.54	35.60
6	*Drymaria diandra* Blume	-	8.38	15.15
7	*Galinsoga parviflora* Cab.	Chitlange jhar	0.38	11.00
8	*Cynodon dactylon* (L.) Pers.	Dubo	0.63	8.82
9	*Rumex nepalensis* Spreng.	Hal-Hale	0.67	5.94
10	*Polygonum barbatum* L.	Pire jhar	0.25	5.60
11	*Ammania baccifera* L.	-	0.17	4.42
12	*Eclipta prostrata* (L.) L.	Kanike ghans	0.21	3.89
13	*Mazus pumilus* (Burm. f.) Steen	Baghmukhe jhar	0.17	4.40
14	*Alternanthera philoxeroides* (Mart.) Griseb.	-	0.08	2.93
15	*Alternanthera sessiles* (L.) DC.	Bhiringi jhar	0.13	2.44
16	*Cuphea procumbens*	Sulpa phul	0.13	2.04
Total			**38**	**300**

area. Weed did not appear until seven days after transplantation. Total weed density and number of weed species were higher in September (Table 2), when the cropland was becoming dry and the crop was finally ready for harvest, than in August (Table 1). It appears that sufficient accumulation of surface water in paddy fields can prevent germination and growth of many weeds.

On the basis of IVI, the dominant weed species were *Cyperus difformis*, *Echinochloa colona*, *Cyperus iria*, *Ageratum conyzoides*, *Spilanthes iabadicensis* and *Echinochloa crus-galli*. The Poaceae and Cyperaceae were represented by fifteen and nine species respectively and were dominant families in paddy fields. *Cynodon dactylon*, *Echinochloa colona*, *E. crusgalli*, *Ageratum conyzoides*, *Fimbristylis* sp. etc were reported as the major troublesome weeds in paddy field of Pokhara (Thapa and Kayastha 1998). Paddy weeds such as *Eleusine indica*, *Fimbristylis miliacea* and *Ischaemum rugosum* are of global importance (Holm et al. 1977). *Echinochloa crus-galli* is an abundant weed of paddy field in warm temperate regions of the world (Michael 1983, Yabuno 1983). Since the number of sample and the sampling area of present study were small and post harvest weed flora was not recorded, the present list of weed species may not be complete. However, it covers all the important paddy weeds and can provide background information for more detailed study of species composition of the weeds in paddy fields of this area.

There was significant reduction in straw (t-test, $p<0.001$, d.f = 5) and grain yield (t-test, $p = 0.013$, d.f = 5) of paddy in weedy plots. Straw yield was reduced by 13 to 38% whereas

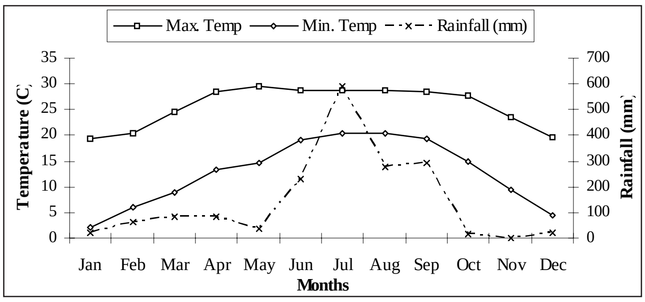

Figure 1: Climatic data of 2003 for Kathmandu.

(*Source:* Dept. of Hydrology and Meteorology, Kathmandu, Nepal). The data were recorded at Tribhuvan International Airport (27^0 42' N, 85^0 22' E, alt. 1336m), which is about 5 km east of study site.)

Figure 2: Distribution of weed species in different genera and families.

Table 2: Density and Importance Value Index (IVI) of weed species recorded in the paddy fields of Kirtipur in September.

S.N.	Species	Local Name	Density (plants/m^2)	IVI
1	*Echinochloa crus-galli* (L.) P. Beauv.	Sama	18.83	67.40
2	*Ageratum conyzoides* L.	Gandhe jhar	17.00	42.89
3	*Spilanthes iabadicensis* A.H. Moore	Chimke jhar	6.67	29.67
4	*Cyperus iria* L.	Thulo mothe Jhar	8.00	29.21
5	*Echinochloa colona* (L.) Link.	Sama	4.17	18.01
6	*Drymaria diandra* Blume	-	17.67	14.09
7	*Alternanthera sessiles* (L.) DC.	Bhiringi jhar	2.04	9.75
8	*Lobelia chinensis* Lour.	-	2.50	8.99
9	*Fimbristylis ovata* (Brum. F.) Kern.	-	3.04	8.09
10	*Cyperus difformis* L.	Mothe Jhar	1.46	7.52
11	*Bidens pilosa* L.	Kuro	2.08	6.91
12	*Paspalum distichum* L.	Banso	1.46	6.60
13	*Linderina oppositifolia* (L.) Mukerje	-	8.00	6.52
14	*Ischaemum rugosum* Salisb.	Madilo	1.04	5.97
15	*Cynodon dactylon* (L.) Pers.	Dubo	1.13	5.21
16	*Digitaria ciliaris* (Retz.) Koeler	Chitre banso	2.17	5.10
17	*Rotalla indica* (Willd.) Koehne	Belaute	0.83	3.81
18	*Polygonum barbatum* L.	Pire jhar	0.71	3.59
19	*Galinsoga parviflora* Cab.	Chitlange jhar	0.50	3.50
20	*Fimbristylis astivalis* (Retz.) Vahl.	Mothe jhar	0.96	2.98
21	*Linderina antipoda* (L.) Alston	-	1.67	2.43
22	*Eleusine indica* (L.) Gaertn.	Kode ghans	0.21	2.08
23	*Pycreus sanguinolentus* (Vahl.) Nees ex C.B.Clarke		1.33	1.92
24	*Digitaria setigera* Schult. apud Roem. & Schult.	Banso	0.17	1.54
25	*Digitaria* sp. 1	Banso	0.21	1.25
26	*Spilanthes paniculata* Wall. ex. DC.	-	0.08	1.00
27	*Amischophacelus axillaris* (L.) Rao &	Kane jhar	0.17	0.87

grain yield by 25 to 47% when compared with weed free (control) plots. This indicates that paddy faced severe competition with weeds for resource acquisition. Statistically there was significant negative correlation (r – "0.91, p – 0.05) between weed species richness and straw yield of paddy. Potential reduction in paddy yield due to uncontrolled weed growth during cropping season has been estimated to range from 45 to 95% depending on ecological and climatic conditions (Ampong - Nyarko and De Datta 1991, Moody 1991). Therefore, weed management should be a key element of agricultural system. In Nepal, though the importance of weed in crop yield reduction has been realized yet the intensive research on ecophysiological aspects of weed in agro-ecosystem are very few.

It is obvious that crop - weed competition played an important role in the growth and yield of transplanted paddy. Weeds compete with crops mainly for nutrients, light, soil moisture, water and space. Due to excessive growth of weeds, there may be competition between weeds and paddy for space, light and nutrients, which decreases yield. Assessment of the losses due to weed is a difficult work because the extent of damage vary from year to year depending on the crop, weed species, soil condition and the climate (Moody 1982).

Table 3: Soil characters in weed control plots and weedy plots. The mean values were compared using Studenst's t – test.

* Significant at p = 0.05, ns – non significant

Weed management during the cropping season has been a serious problem for many years. Despite the use of huge amount of herbicides (three million tons per year) and integrated weed managements in many agricultural systems, 10% loss in agriculture production worldwide has been attributed to competitive effect of weed (Stephenson, 2000). Soil in weedy plot was less acidic than in weed free plots and their difference was significant (p = 0.01, Table 3). Nitrogen and phosphorus contents were lower in weedy plots than in control though the difference was not significant (Table 3). Thus weed growth changed soil chemistry and reduced soil nutrient content. Weeds can utilize plant nutrients more efficiently than crop plant due to their rapidly spreading and deeply penetrating root system. Crop-weed competition is more intense and crop yield reduction is large when nutrients are limited (Jordan and Shanter 1980).

Aqueous extracts of root, stem and leaf of dominant weeds (*Echinochloa colona, Ageratum conyzoides, Cyperus iria* and *Echinochloa crus-galli*) showed a weak effect on germination of paddy seeds because the seed germination was >90% in all the treatments. Only the concentrated extracts (8 - 10%) had weak inhibitory effect on seed germination of paddy. It appears that allelochemicals present in these weeds may prevent germination at very high concentration; but in agroecosystem such high concentration does not occur. Therefore, they do not have direct effect on seed germination of paddy. However, most of these aqueous extracts had inhibitory effect ($p<0.05$) on root and shoot elongation of paddy seedlings (Table 4). The inhibitory effect increased with increasing concentration of the extracts as evident from shorter length of root and shoot at higher extract concentrations (Figure 4). Since the slope of regression line between root length and concentration ($\tan^{-1}4 = 76°$, Figure 4A) was higher than shoot length and concentration ($\tan^{-1}1.2 = 50.2°$, Figure 4B), rate of decline in length should be higher for root than for shoot. Thus root elongation of paddy seedling was more sensitive to allelopathic inhibition of weeds than shoot elongation. Higher inhibition in root elongation of paddy and other two cereals (maize and wheat) than in

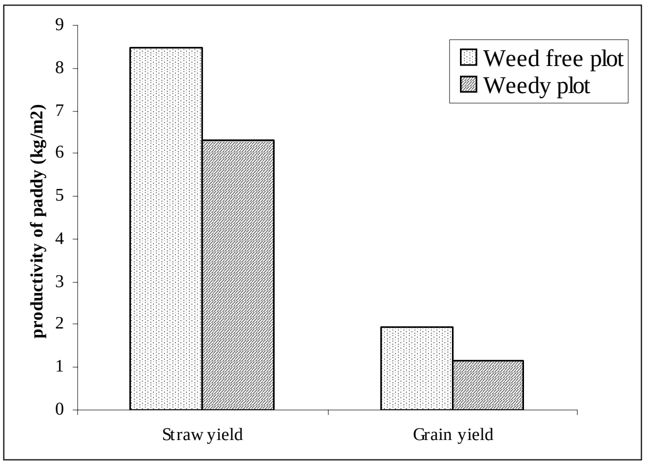

Figure 3: Mean value productivity of paddy crops in experimental plots of Kirtipur.

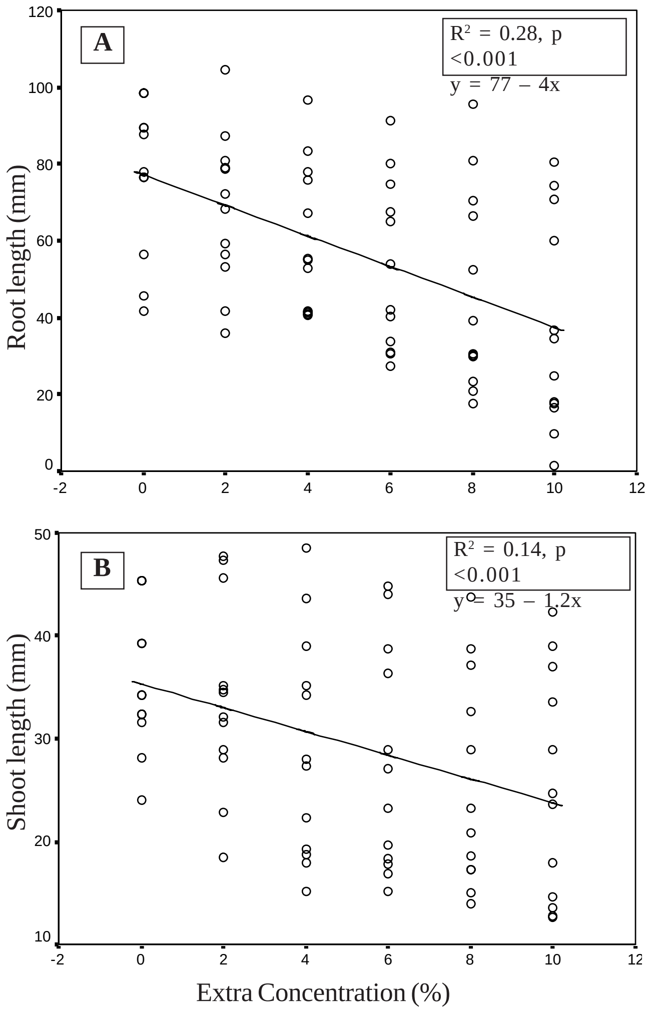

Figure 4: Decline in root (A) and shoot (B) length of paddy seedlings with increasing concentration of the extracts. Data of all weed species and all organs were pooled to obtain this relation.

Table 4: Concentration of aqueous extracts of weed species in which reduction in root and shoot length of paddy seedling as compared to control was significant at $p < 0.05$. Result was obtained from analysis of Least Significant Difference (LSD) between the mean values of root and shoot length paddy seedlings. ns: not significant.

Source of Extracts		**Extract Concentration (%)**	
Weed Species	Organs	Root length	Shoot length
Echinochloa colona	Root	4 - 10	4 - 10
	Stem	10	2 - 10
	Leaf	4 - 10	2 - 10
Echinochloa crusgalli	Root	4, 8, 10	4 - 10
	Stem	2 - 10	2 - 10
	Leaf	2 - 10	ns
Cyperus iria	Root	2 - 10	8 - 10
	Stem	2 - 10	4 - 10
	Leaf	2 - 10	6 - 10
Ageratum conyzoides	Root	6 - 10	10
	Stem	ns	ns
	Leaf	4 - 10	6 - 10

Table 5: Mean root and shoot length (mm) of rice seedlings germinated in aqueous extract (10%) of different organs of four weed species and control (distilled water). Values with same alphabet in vertical rows are not significantly different to each others (á = 0.05).

Plant Species	**Root extract**		**Stem extract**		**Leaf extract**	
	Root length	**Shoot length**	**Root length**	**Shoot length**	**Root length**	**Shoot length**
Echinochloa colona	17.8a	17.9a	9.7ab	12.7a	16.6a	14.6a
Echinochloa crusgalli	74.3b	42.3b	24.7b	12.8a	33.3b	37.0c
Cyperus iria	80.3b	39.0b	1.3a	13.6a	34.4b	24.7b
Ageratum conyzoides	17.5a	23.6a	87.6c	34.2b	70.7c	33.6c

shoot elongation due to allelopathic effect of leaf aqueous extract of *Parthenium hysterophorus* was also reported by Maharjan et al (2006). The inhibitory effect of 10% extract was the maximum in stem extract followed by leaf and root extract of *Cyperus iria, Echinochloa colona* and *E. crusgalli* (Table 5). But in case of *Ageratum conyzoides,* root extract showed maximum inhibitory effect on seedling growth followed by leaf and stem extract. At 10% extract shoot length of paddy seedling was shortest in *Echinochloa colona* for all organs but root length did not show such consistent pattern (Table 5). Root and shoot length of paddy seedling was shortest in stem extract of *Cyperus iria* and *Echinochloa colona* respectively. It is thus evident that these weed species has some active allelochemicals; identification of these allelochemicals will help to enhance understanding the crop weed competition and thereby appropriate measures for weed management.

CONCLUSION

In conclusions, 52 weed species were recorded in transplanted paddy field of Kirtipur. Total weed density and number of species were higher in September than in August. There was significant reduction in straw and grain yield of paddy in weedy plots and negative correlation between weed species richness and straw yield. Weed growth changed soil chemistry (pH) and reduced soil N and P content. Aqueous extracts of root, stem and leaf of dominant weeds showed a weak effect on germination of paddy seeds however most of them had inhibitory effect on root and shoot elongation of paddy seedlings. Root elongation of paddy seedling was more sensitive to allelopathic inhibition of weeds than shoot elongation.

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