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Weed Population in Cowpeas (*Vigna Unguiculata* (L) Walp) as Influenced by Water Table, Moisture Regime and Cultivar

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Experiments were conducted during the 1987-88 dry season to determine the influence of irrigation water and naturally occurring water table depths in a toposequence, on the weed ecology of two cowpea [Vigna unguiculata (L.) Walp] cultivars at Los Baños, Philippines. In the line source sprinkler irrigation experiment on a Typic Tropudalf, saturated and wet treatments had a higher weed population than the dry treatment. In the toposequential agrohydrology experiment, the shallow and medium water table depths had greater weed populations than the deep water table depth regime. In both experiments the early maturing cultivars had a higher LAI in their early phase of growth. This was associated with reduced weed competition as compared to the medium maturing cultivars, irrespective of moisture regimes.

Keywords: Early maturing, medium maturing, line source irrigation, toposequential agro-hydrology, post-rice environment

Cowpea is grown in lowland rice fields during the dry season in the tropics. During this season the crop generally suffers from excessive moisture during its vegetative growth stage because of intense rainfall (Herrera and Zandstra, 1977; Herrera and Zandstra, 1979) and/or a shallow water table which is prevalent in lowland fields (Hulugalle and Lal, 1986). However, in some post-rice situations, drought is the predominant stress due to a rainfall deficit in association with a deep water table. Timsina et al (1984) reported a wide range of weed species in cowpea fields in the post rice dry season. They concluded that cowpea cultivars that produce good vegetative cover may minimize the weed problem.

Previous studies reported the influence of moisture regimes on the weed ecology of rice (Moomaw et al, 1966; Smith, 1970; Smith and Fox, 1973; Navarez et al, 1979; Janiya and Moody, 1982; Pathak et al, 1989). Most of these studies agreed that flooding suppresses, but saturated soil encourages, the growth of dryland weeds (Garcia, 1931; Smith and Fox, 1973; Civico and Moody, 1979). Samiano and Motooka (1979) also reported a direct correlation between the frequency of irrigation and weed density.

High plant population or closer spacing is a recommended practice for minimizing weed problems in many crops (Kawano et al, 1974; Moody, 1979; Kim and Moody, 1980). Similarly, some studies have shown cultivar differences in the suppression of weeds (IRRI, 1976; Moody, 1979). But not all studies have shown such differences (Kim and Moody, 1980). The competitive ability of crop cultivars against weeds was attributed to their respective morphological characteristics.

Cowpea cultivars vary in their competitive ability against weeds. The cowpea cultivar EG #1 was found to be more competitive than cowpea cv California Black Eye (IRRI 1976). Yield reduction due to weeds in this study was directly related to the weight of weeds growing with the cultivars. Similarly, in a subsequent trial (IRRI, 1979), another cultivar, EG #2, was found to be more competitive than California Black eye. A higher leaf area index was associated with increased ability to compete with weeds.

These studies reported on the influence of applied water on the weed ecology of different crops. The influence of different water table depths on weed ecology has not been reported. The objectives of this study were: 1) to explore the influence of differences in applied irrigation water on the weed ecology of early and medium maturing cowpea cultivars, and 2) to explore the influence of naturally occurring water table depths on the weed ecology of the cultivars.

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MATERIALS AND METHODS

Line source sprinkler irrigation experiment

The study was conducted at the International Rice Research Institute (IRRI) experimental farm on an isohyperthermic, clayey, Typic Tropudalf from February to April 1988. The experimental area was previously grown to lowland rice, which was harvested in the last week of November. The rice stubble was cut to just above the ground surface before planting the experiment. Shallow furrows were made with a drag stick at 0.5 m distance under zero tillage conditions. Fertilizer at the rate of 30-13-25 NPK kg ha^{-1} was applied in the furrows before planting the cowpea seeds.

A strip plot design with four replications was used. Two early (IT82D-889 and CES 41-6) and two medium (TVX1948-012F and TVX3827-02F) maturing cowpea cultivars were the vertical factor treatments and five moisture regimes were the horizontal factor treatments. A line source sprinkler irrigation system (Hanks et al, 1976) was used to generate the moisture regimes. Each 6 m x 15 m plot of a cultivar was subdivided into five subplots (6 m x 3.0 m) representing five moisture regimes. The regime near the line source was irrigated to full saturation, whereas the regime farthest from the line source was virtually unirrigated. The applied water plus rainfall during the period prior to weed sampling is given in Table 1.

Weeds were sampled just before the first handweeding (20 days after emergence) and just before the second weeding (35 days after emergence) from a 1.0 m^2 quadrant in each plot. Dry weight of each weed species was obtained after drying at 60 °C for 48 h. Leaf area index (LAI) of the cowpea cultivars was determined using an automatic leaf area meter (Hayashi Model AAM-7) during the weed sampling period. It was hypothesized that there would be insignificant differences between the two cultivars of the same maturity group. Likewise the contrasting moisture regimes would show clearcut weed intensity differences. Hence, the dry weights of the weeds associated with only one early (IT82D-889) and one medium (TVX1948-012F) maturing cowpea cultivar for three moisture regimes were determined.

Toposequential agrohydrology experiment

This study was conducted from December 1987 to February 1988 at the IRRI experimental farm on a naturally occurring sloping field (Typic Tropudalf) differing in water table depths along the toposequence. The field was plowed and rotovated once. Weeds were removed from the field by handweeding after taking weed samples at 20 and 35 DAE. Fertilizer at the rate of 30-13-25 NPK kg ha^{-1} was uniformly applied to the field before planting cowpea seeds. The seeds were sown at 0.5 m row spacing using an IRRI designed Inverted-T seeder. A strip plot design with three replications was used. Four cowpea cultivars (TVX3236-01G, TVX3410-02J, BS6, and IT82D-892) were the vertical factor treatments, and three naturally occurring water table depths were the horizontal factor treatments. The water table fluctuated during the sampling period, with rainfall events. The trend of water table depths is shown in Table 2 for shallow (SWT), medium (MWT), and deep (DWT) water table sites.

Weeds were sampled just before the first weeding (20 days after emergence) and before the second weeding (35 days after emergence) from a 1.0 m^2 quadrant in each plot.

Table 1. Water applied from line source irrigation plus rainfall (mm) for two cowpea cultivars subjected to different moisture regimes. IRRI, 1988 dry season.

Days after crop emergence	Moisture regimes					
	Fully saturated		Wet		Dry	
	TVX1948-012F	IT82D-889	TVX1948-012F	IT82D-889	TVX1948-01F	IT82D-889
11	22.8	23.7	14.3	14.0	3.8	3.5
15	18.8	18.8	8.2	9.1	1.8	1.5
17	39.0	39.7	22.1	22.1	2.9	2.5
20	41.9	45.2	25.9	25.7	3.0	3.2
23	34.3	36.3	18.3	14.1	1.6	1.1
27	26.0	26.1	14.6	15.2	0.8	0.7
30	26.3	27.3	17.6	15.9	1.6	1.5
Total	209.1	217.1	121.0	116.1	15.5	13.0
Rainfall	24.2	24.2	24.2	24.2	24.2	24.2
Total water (irrigation rainfall)	233.3	241.3	145.2	140.3	39.6	37.2

Table 2. Seasonal fluctuations in water table depth (cm) for shallow (SWT) medium (MWT) and deep (DWT) water table regimes. IRRI, 1987-88 dry season.

Days after crop emergence	Water table depth (cm) SWT	MWT	DWT
8	14.8	57.1	108.1
9	29.4	53.9	97.4
11	6.9	27.6	67.2
14	17.8	58.6	118.4
16	18.1	42.6	92.8
18	16.2	55.6	112.0
21	20.8	63.6	122.4
23	21.0	59.0	115.6
25	33.5	66.9	128.0
28	48.8	86.1	138.8
30	35.6	80.4	135.2
32	34.6	74.8	133.7
35	13.1	41.8	84.3
37	22.1	63.6	90.9
39	25.8	71.9	124.9
41	21.4	61.4	115.2

The weed count and dry weight of each species was recorded. The leaf area index of the cowpea cultivars was determined. The dry weight of weeds associated with one early (IT82D-892) and one medium (TVX3236-01G) maturing cowpea cultivars for the 3 water table depths were recorded.

RESULTS AND DISCUSSION

Line source sprinkler irrigation experiment

Several weed species were associated with the two cowpea cultivars before the first handweeding at 20 DAE (Table 3). Most of these weed species were observed previously in post-rice dry season cowpea plots (Timsina et al, 1984). *Echinochloa colona* (L.) Link was the predominant grass while *Fimbristylis littoralis* (Gaud.) was the predominant sedge under saturated and wet regimes. Their dry weights were lower in the dry regime. Broadleaf weeds were not a severe problem in any moisture regime.

The predominance of *E. colona* may be due to its adaptability under wet conditions in the post rice environment. It may be considered as a semi-aquatic weed. Mercado (1979) reported that this weed can grow well in the post-rice environment irrespective of moisture regime. In this experiment, growth in the dry regime was more than two thirds lower than in the wet regime. *F. littoralis* (Gaud.) is a semi-aquatic or aquatic weed and can become severe under saturated conditions. Differential cowpea cultivar response was not evident during this stage.

E. colona Link continued to be the predominant weed in all moisture regimes at the second weeding of cowpea (Table 4). The weight of sedges and broadleaves was reduced compared to their weight before the first handweeding (Table 3). The reduction of *F. littoralis* was due to less soil water as the season progressed. There was relatively less weed dry weight with IT82D-889, the early maturing cultivar, than with TVX1948-012F, the medium maturing cultivar. This may have been influenced by the tendency for relatively higher LAI of the former than of the latter in the early phase of crop growth (21-31 DAE), resulting in better crop cover (Table 5). Thus, IT82D-889 may have suppressed weeds relatively better as compared to TVX1948-012F. The competitive ability of selected cowpea cultivars against weeds has previously been reported in the Philippines (IRRI, 1976; 1979). The competitive ability was attributed to the higher LAI of the cultivars with lower weed weights

Table 3. Weed dry weight (g m^{-2}) before the first weeding of cowpea (20 DAE) as influenced by cowpea cultivar and moisture regime. IRRI, Los Baños, 1988 dry season.

Weed species	TVX1948-012F Fully saturated	Wet	Dry	IT82D-889 Fully saturated	Wet	Dry
Broadleaves 1	0.3 b	0.6 a	0.1 c	0.1 c	0.4 ab	0.1 c
Grasses						
E. colona (L.) Link	14.3 ab	14.3 ab	4.3 c	11.6 b	17.3 a	5.3 c
Others[2]	0.2 b	7.5 a	0.3 b	0.0	7.0 a	0.5 b
Sedges						
Cyperus sp.[3]	0.6 ab	0.3 bc	0.2 c	0.9 a	0.7 ab	0.5 b
Fimbristylis littoralis (Gaud.)	6.3 a	7.1 a	2.8 b	2.1 b	7.4 a	0.4 c
Others	0.0	0.0	0.3 a	0.3 a	0.0	0.2 a

[1] Lindernia sp predominating
[2] Cynodon dactylon (L.) Pers predominating
[3] C. iria (L.) predominating

Data followed by the same letter in any row are not significantly different at the 5% level of significance.

Table 4. Weed dry weight (g m^{-2}) before the second weeding of cowpea (35 DAE) as influenced by cowpea cultivar and moisture regime. IRRI, Los Baños, 1988 dry season.

Weed species	TVX1948-012F			IT82D-889		
	Fully saturated	Wet	Dry	Fully saturated	Wet	Dry
Broadleaves[1]	0.0	0.5 a	0.0	0.0	0.1 b	0.0
Grasses						
E. colona (L.) Link	13.4 ab	14.7 a	7.6 c	9.7 c	11.4 b	6.3 c
Others[2]	0	1.1 a	0.6 b	0	0.3 b	0.3 b
Sedges						
Cyperus sp.[3]	0.5 b	1.0 a	0.4 b	0.2 b	2.0 a	1.0 a
Fimbristylis littoralis (Gaud.)	1.1 b	1.6 b	2.1 a	1.1 b	0.7 c	0.5 c
Others	0.0	0.0	0.1	0.0	0.0	0.0

[1] Lindemia sp. predominating.
[2] Cynodon dactylon (L.) Pers predominating.
[3] C. iria (L.) predominating.
Data followed by the same letter in any row are not significantly different at the 5% level of significance.

Table 5. Leaf area index (LAI) of two cowpea cultivars subjected to different moisture regimes. IRRI, Los Baños, 1988 dry season.

Days after crop emergence	Moisture regimes					
	Fully saturated		Wet		Dry	
	TVX1948-012F	IT82D-889	TVX1948-012F	IT82D-889	TVX1948-01F	IT82D-889
12	0.13 a	0.15 a	0.13 a	0.15 a	0.13 a	0.15 a
21	0.78 c	0.87 bc	0.97 ab	1.06 a	1.04 a	0.73 c
31	0.62 c	0.64 c	1.13 b	1.19 a	1.32 a	1.49 a
41	0.97 c	0.98 c	1.55 b	1.04 c	2.34 a	1.24 b

Data followed by the same letter in any row are not significantly different at the 5% level of significance.

Toposequential agrohydrology experiment

Several weed species were associated with the two cowpea cultivars before the first handweeding (Table 6). Two sedges, *Cyperus iria*(L.) and *Cyperus difformis*(L.) were predominant in TVX3236-01G, a medium maturing cultivars, with a shallow water table, whereas their incidence was less in IT82D-892, an early maturing cultivar. *Cyperus rotundus* (L.) was prominent under MWT and DWT with both cultivars. With IT82D-892 highest weight *Cyperus spp.* occurred under MWT and lowest under SWT. There were mixtures of different *Cyperus* species in the medium water table regime. Broadleaves and grasses were not severe under any water table regime in either cultivar. Cultivar differences were not distinct during this stage.

Cyperus sp. continued to be the dominant weed in all moisture regimes at the second weeding of cowpea (Table 7). There were clear differences in the weed ecology among different water table depths. *C. iria* (L.) was dominant in the shallow water table regime whereas *C. rotundus* (L.) was dominant with a deep water table. *Fimbristylis littoralis* Gaud., another sedge, was also a predominant weed associated with the shallow water table regime. Several grass species emerged and grew during this stage. *E. colona* (L.) was the most important. Its dry weight was highest under the shallow water table. Several broad leaves also emerged and grew during this stage, and *Ludwigia octovalis* (Jacq.) Raven was dominant.

Influence of water table depth using a toposequence on growth and yield of several crops including cowpea, was reported earlier by several workers (Moya and O'Toole, 1976; Mambani and Lal, 1983; Hulugalle and Lal, 1986). The differences in response to differing water table depths by the crop weredue to damage in the root systems under shallow water table conditions. The shallow water table creates anaerobiosis in the root zone, and only certain

Table 6. Weed dry weight (g m^{-2}) before the first weeding of cowpea as influenced by cowpea by cowpea cultivar subjected to different water table depth regimes IRRI, 1987-88 dry season.

Weed Species	TVX3236-01G			IT82D-892		
	SWT	MWT	DWT	SWT	MWT	DWT
Broadleaves[1]	1.2a	0.1 b	0.1 b	1.6 a	0.0	0.2 b
Grasses						
E. colona (L.) Link	2.5 a	0.0	0.0	3.8 a	0.0	0.2 b
E. indica (L.) Gaertn	0.9 a	0.1 c	0.4 c	1.0 a	0.7 b	0.3 c
C. dactylon (L.) Pers.	0.0	2.1 a	1.6 b	1.3 b	2.0 a	2.6 a
Sedges						
Cyperus sp.[2]	22.8 b	16.5 c	17.9 c	3.3 d	33.4 a	21.3 b
Fimbristylis littoralis Gaud	2.3 a	0.0	0.0	0.9 b	0.0	0.0
Others						

[1]Include Ludwigia octovalvis (Jacq.) Raven, Heliotropium sp., Eclipta alba (L.) Hassk, Aegeratum conyzoides (L.), C. rutidosperma Dc., and Hedyotis sp. predominantly.

[2]Include C. iria (L.), C. rotundus (L.), and C. difformis (L.) predominantly.

Data followed by the same letter in any row are not significantly different at the 5% level of significance.

Table 7. Weed dry weight (g m^{-2}) before the second weeding of cowpea as influenced by cowpea cultivar subjected to different water table depth regimes. IRRI, Los Baños, 1987-88 dry season.

Weed species	TVX3236-012G			IT82D-892		
	SWT	MWT	DWT	SWT	MWT	DWT
Broadleaves[1]	11.3 a	2.9 c	3.8 c	7.6 b	1.6 c	1.4 c
Grasses						
E. indica (L.) Gaertn.)	1.6 b	1.7 b	4.7 a	2.1 b	5.5 a	2.3 b
E. colona (L.) Link	25.6 a	0.0	0.0	6.0 b	0.7 d	2.3 c
Leptochloa chinensis (L.) Nees	3.3 a	0.2 b	0.0	0.1 b	0.0	0.0
C. dactylon (L.) Pers.	0.8 b	2.6 a	2.2 a	1.0 b	0.8 b	0.4 b
Digitaria ciliaris	0.0	11.1 a	2.9 b	0.2 c	9.1 a	0.4 c
Others[2]	0.1 b	0.0	0.0	0.5 a	0.0	0.4 a
Sedges						
Cyperus sp.[3]	42.6 a	18.5 b	15.6 c	10.3 d	19.0 b	15.2 c
Fimbristylis littoralis Gaud	49.3 a	0.1 c	0.0	11.9 b	0.3 c	0.0

[1] Include *Ludwigia octovalis* (Jacq.) Raven, *Heliotropium sp., Eclipta alba* (L.) Hassk., *Aegeratum conyzoides* (L.), *C. rutidosperma* Dc, E. hirta (L.), *Phyllanthus niruri, Portulaca oleracea* (L.), M. Mollugo and *Murdannia nudiflora* (L.) Brenan predominantly.

[2] Include *Rottboellia cochinchinensis* (Lour.) W.D. Clayton and *Brachiaria sp.*

[3] Include *C. iria* (L.), *C. rotundus* (L.), and *C. difformis* (L.) predominantly.

Data followed by same letter in any row are not significantly different at the 5% level of significance.

aquatic and semi-aquatic weeds with thick adventitious roots can thrive (Sena Gomes and Kowzlowski, 1980a, b; Kawase, 1981). *C. iria* and *F. littoralis* may have formed fibrous, adventitious roots so as to survive under shallow water table conditions (Holm et al, 1977). The outstanding characteristic of these species is their prolific production of underground tubers that can remain dormant and carry the plant through extreme conditions of heat, drought, flooding, or lack of aeration (Holm et al, 1977). The predominance of *C. rotundus* in the deep water table regime may have been associated with the existence of aerobic conditions in the top soil. *C. rotundus* grows well under upland conditions (Mercado, 1979).

Differential cultivar response to water table depth was evident during this stage. Fewer weeds were associated with the early maturing IT82D-892 than with TVX3236-

Table 8. Leaf area index (LAI) of two cowpea cultivars subjected to different water table depth regimes. IRRI, Los Baños, 1987-88 dry season.

Days after crop emergence	Water table depth					
	SWT		MWT		DWT	
	TVX3236-012F	IT82D-892	TVX3236-012F	IT82D-892	TVX3236-01F	IT82D-892
15	0.12 b	0.30 a	0.10 b	0.35 a	0.12 b	0.40 a
31	0.38 d	0.67 c	0.79 c	2.00 a	1.00 b	1.14 b
43	0.76 b	1.14 b	2.16 a	2.62 a	2.70 a	2.60 a

Data followed by same letter in any row are not significantly different at the 5% level of significance.

01G, the medium maturing cultivar, due apparently to its greater competitive ability. The competitive early cultivar had higher LAI in its early phase of growth (15-31 DAE) resulting in good crop cover (Table 8). Because of such differences, IT82D-892 may have suppresssed weed growth to a greater extent as compared to TVX3236-01G. The results agree with those of the line source sprinkler experiment presented earlier.

The results of the line source experiment suggest that saturated and wet soils pose more weed problems as compared to dry soil. *E. colona* and *F. littoralis* were the major weeds from seeding until the early vegetative stage of cowpea. *E. colona* was also the major weed in the late vegetative stage, irrespective of moisture regime. The results of the toposeqence experiment suggest that a shallow water table pose more weed problems compared to a deep water table. *C. iria* was the major weed from seeding to late vegetative stage of cowpea under shallow water table conditions. However, in the late vegetative stage and with prolonged shallow water table conditions, *F. littoralis* and *E. colona* also become dominant weeds. Under deep water table conditions, *C. rotundus* became dominant. Both experiments suggest that the early maturing cultivars tended to minimize weed growth as compared to the medium maturing cultivars, and to do so due to a higher LAI in early phase of their growth.

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