Weed seed populations in rubber and oil palm plantations with legume cover crops

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Summary

The seed populations in the top 10 cm soil of 0–6, 7–20 and more than 20-year old plantations of rubber and 0–3, 4–20 and more than 20-year old plantations of oil palm grown with legume cover crops were studied by physical extraction and germination. Seeds belonging to 21 and 25 species were recorded in rubber and oil palm plantations respectively, with *Asystasia gangetica* (L.) T. Anders., *Cleome rutidosperma* DC., *Borreria alata* DC. and *Paspalum conjugatum* Berg. being most abundant in both plantations and accounting for more than 80% of the total weed seeds. An average of 3298 and 3262 seeds m^{-2} were recorded in the soil of rubber and oil palm plantations, respectively. Total seed number declined with increasing maturity of plantations. The monthly emergence of *A. gangetica, Ageratum conyzoides* L., *Oldenlandia herbacea* L., *Cyperus rotundus* L., *P. conjugatum* and *C. rutidosperma* are presented. Most species emerged during the first month after planting.

Introduction

Most agricultural soils contain a large reservoir of weed seeds which germinate over a period of time reflecting previous weed populations. The number and type of seeds in the reservoir are determined by edaphic characteristics such as moisture-holding capacity and pH, as well as past weed control practices, tillage, land preparation practices and, perhaps of greatest importance, weed seed dormancy (Pareja *et al.* 1985).

Weed seed populations in soil also depend on the species composition of weed cover and are closely associated with the history of land use (Wilson *et al.* 1985, Sastroutomo and Yusron 1987). The populations in cultivated soils are generally composed of a few dominant species that are present in high numbers, a few species present in moderate levels and many species present at low levels (Vengris 1953).

Very little information is available on the population of buried seeds in arable soils of the tropics, or on time of emergence of annual weeds (Marks and Nwachuku 1986). Most studies have been concerned with aspects of the chemical control of weed seeds (Chung *et al.* 1988), but weed seed populations in vegetable crops in Indonesia (Sastroutomo and Yusron 1987) and in pineapple plantations in Malaysia (Wee 1974) have been studied. However, no data on weed seed populations in either oil palm or rubber in Malaysia have been reported.

Knowledge of the amount, distribution and dynamics of weed seeds in soils under different crops and cultural practices is useful for developing control strategies. The objective of the present study was to determine the weed seed populations and their pattern of emergence after disturbance under different growth stages of rubber and oil palm plantations.

Materials and methods

Study sites

Soil samples from rubber plantations were taken from the Rubber Research Experimental Station near Sungai Buloh, Selangor, Malaysia. Samples were collected from areas with immature plants (up to 6 years), mature plants (7–20 years) and old plants (more than 20 years). The oil palm plantation soil samples were taken from the Prang Besar Research Station near Kajang, Selangor from areas of immature plants (up to 3 years), mature plants (4–20 years) and old plants (more than 20 years old). Legume cover crops were planted in both plantations to suppress weed growth.

Table 1. Total number of weed seeds m^{-2} in soil from rubber plantations.

Species	Growth stage			Viability (%)	Occurrence (% of trays)
	Young	Mature	Old		
Acanthaceae					
Asystasia gangetica (L.) T. Anders.	1072	989	428	25	93
Capparidaceae					
Cleome rutidosperma DC.	1273	1120	425	29	90
Compositae					
Ageratum conyzoides L.	209	355	224	47	73
Crassocephalum crepidioides Moore	21	14	0	26	20
Mikania micrantha H.B.K.	0	3	0	100	3
Cyperaceae					
Cyperus rotundus L.	270	95	25	36	53
Eleocharis sp.	0	3	0	100	3
Euphorbiaceae					
Croton hirtus L.Herit	0	5	0	0	6
Phyllanthus niruri L.	2	3	0	100	10
Phyllanthus urinaria L.	2	3	0	100	10
Gramineae					
Axonopus compressus (Sw.) Beauv.	40	19	0	41	23
Digitaria sp.	37	26	0	67	17
Eleusine indica Gaertn.	0	35	5	48	30
Paspalum conjugatum Berg.	656	819	256	30	90
Paspalum scrobiculatum L.	40	3	0	0	23
Leguminosae					
Cassia mimosoides L.	8	68	29	31	33
Mimosa pudica L.	55	77	19	69	30
Melastomaceae					
Clidemia hirta Don	0	5	3	38	13
Melastoma malabathricum L.	0	5	6	100	20
Rubiaceae					
Borreria alata DC.	37	70	26	26	47
Mitracarpus scaber Succ.	118	40	0	12	37
Oldenlandia herbacea L.	319	147	138	86	37
Richardia sp.	61	101	54	27	47
Scrophulariaceae					
Scoparia dulcis L.	3	3	0	100	13
Verbenaceae					
Stachytarpheta indica Vahl.	3	0	21	21	17
Total	4226	4008	1659		
Average m^2		3292			

Ten plots (10 × 10 m) were selected randomly for each of the different growth stages of rubber and oil palm. Soil core diameter was 5 cm and depth was 10 cm, and two cores were collected from each plot. The two soil samples from each plot were mixed thoroughly and air-dried. The mixture of two samples was divided into two subsamples (approximately 3 kg each), one each for identification and quantification of weed seeds.

Estimation of total weed seed populations in soil

Each sample was passed through a descending series of 4 mm, 2 mm, 850 µm, 425 µm and 250 µm sieves (Wilson *et al.* 1985). Large seeds found in the first three sieves could be easily removed by forceps; the last sieve retained almost all the minute seeds together with clay and organic materials. The small seeds were separated from the last sieve by floating the seeds in 50% Na_2CO_3 solution (Hayashi 1975). Seeds were dried at 28–35°C in an oven, separated according to species, and counted under a dissecting microscope. The total number of buried seeds found in soil from different growth stages was expressed in numbers per square metre.

Estimation of viable weed seeds

The soil samples from each area were placed in separate plastic trays (38 × 25 × 10 cm), kept in a greenhouse at 30°C, and watered daily. The number of seedlings emerging was recorded monthly. Seedlings were identified using the seedling keys of Chancellor (1966). The soil was turned over monthly for one year. Seedlings that could not be identified were transferred to pots and grown until maturity to facilitate identification. The timing of seedling emergence for the six most abundant weed species was expressed as the number of seedlings emerging in each month (N_m) divided by the total number of seedlings (N_t) that emerged during one year period times 100, or $(N_m/N_t) \times 100$.

Results

Species composition of the buried seed

Both plantations showed similar species composition (Tables 1 and 2), with 25 and 21 species of weed seeds identified in the soil taken from rubber and oil palm plantations respectively. Of the 25 species from the rubber plantation, two were sedges (Cyperaceae), five grasses (Poaceae) and 18 broadleaves, while in the oil palm plantation, one sedge, five grasses and 15 broadleaves were recorded. Twenty species were common to both oil palm and rubber plantations.

Most of the weeds growing in both plantations reproduced by seeds. Many of them produce a large number of seeds. Some seeds such as *Phyllanthus niruri*, *P. urinaria*, *Eleocharis* sp. and *S. dulcis* were found in small numbers.

Total weed seed population

The total weed seed populations found in soil samples of different growth stages of rubber and oil palm are presented in Tables 1 and 2. The average number of seeds in rubber and oil palm were 3292 and 3262 m^{-2}, respectively.

The highest number of buried seeds m^{-2} in the three growth stages of rubber was recorded for *C. rutidosperma* (939), *A. gangetica* (829), *P. conjugatum* (577) and *A. conyzoides* (263) (Table 1), which together represented 80% of the total weed seeds in rubber plantations. In oil palm, the seed numbers of *C. rutidosperma*, *A. gangetica*, *P. conjugatum*, *A. conyzoides* and *B. alata* were 425, 656, 516, 163 and 863 m^{-2} respectively (Table 2), representing 80% of the total seeds found in the oil palm plantation.

The total number of seeds found in soil declined with the increase of crop plant maturity. The total number of weed seeds in the immature rubber area was 4226 m^{-2}, while in the mature and the old rubber areas the numbers declined to 3008 and 1659 m^{-2} respectively (Table 1). The weed seed populations in the soil of immature, mature and old oil palm areas were 5152, 2692 and 1945 m^{-2}, respectively (Table 2). Viable *A. gangetica* seeds occurred more frequently than other species in both plantations; the percentage of occurrence of many species was higher, but they had lower percentage viability. Only a few species showed 100% viability, but their numbers in the soil were extremely low.

The most frequently encountered seeds in soil of plantations of rubber at all three maturity stages were *A. gangetica* (93%), *C. rutidosperma* (90%), *P. conjugatum* (90%) and *A. conyzoides* (73%) (Table 1). The highest percentage of seed occurrence in oil palm soil was shown by *A. gangetica* (87%), *B. alata* (80%), *C. rutidosperma* (83%) and *P. conjugatum* (83%) (Table 2).

The pattern of seedling emergence for six dominant species was expressed as a percentage of the total emerged during 10 months and is presented in Figure 1. No seedling emergence was observed after 10 months. Among the earliest emerging

Table 2. Total number of weed seeds m^{-2} in soil from oil palm plantations.

Species	Growth stage			Viability (%)	Occurrence (% of trays)
	Young	Mature	Old		
Acanthaceae					
Asystasia gangetica	1007	882	80	39	87
Capparidaceae					
Cleome rutidosperma	632	235	408	26	83
Compositae					
Ageratum conyzoides	161	140	189	58	60
Crassocephalum crepidioides	76	2	3	3	23
Mikania micrantha	58	74	10	22	37
Cyperaceae					
Cyperus rotundus	115	15	18	69	17
Euphorbiaceae					
Croton hirtus	16	19	21	18	30
Phyllanthus niruri	0	8	6	36	10
Phyllanthus urinaria	2	0	0	100	3
Gramineae					
Axonopus compressus	64	2	98	20	37
Digitaria sp.	6	0	0	0	3
Eleusine indica	45	2	11	28	17
Paspalum conjugatum	938	361	248	28	83
Paspalum scrobiculatum	177	2	99	2	27
Leguminosae					
Mimosa pudica	32	16	8	55	23
Melastomaceae					
Clidemia hirta	0	0	3	100	6
Melastoma malabathricum	0	2	5	100	20
Rubiaceae					
Borreria alata	1553	796	242	29	80
Borreria hispida	10	12	347	30	20
Oldenlandia herbacea	83	122	50	91	20
Richardia sp.	177	2	99	24	30
Total	5152	2692	1942		
Average m^{-2}		3262			

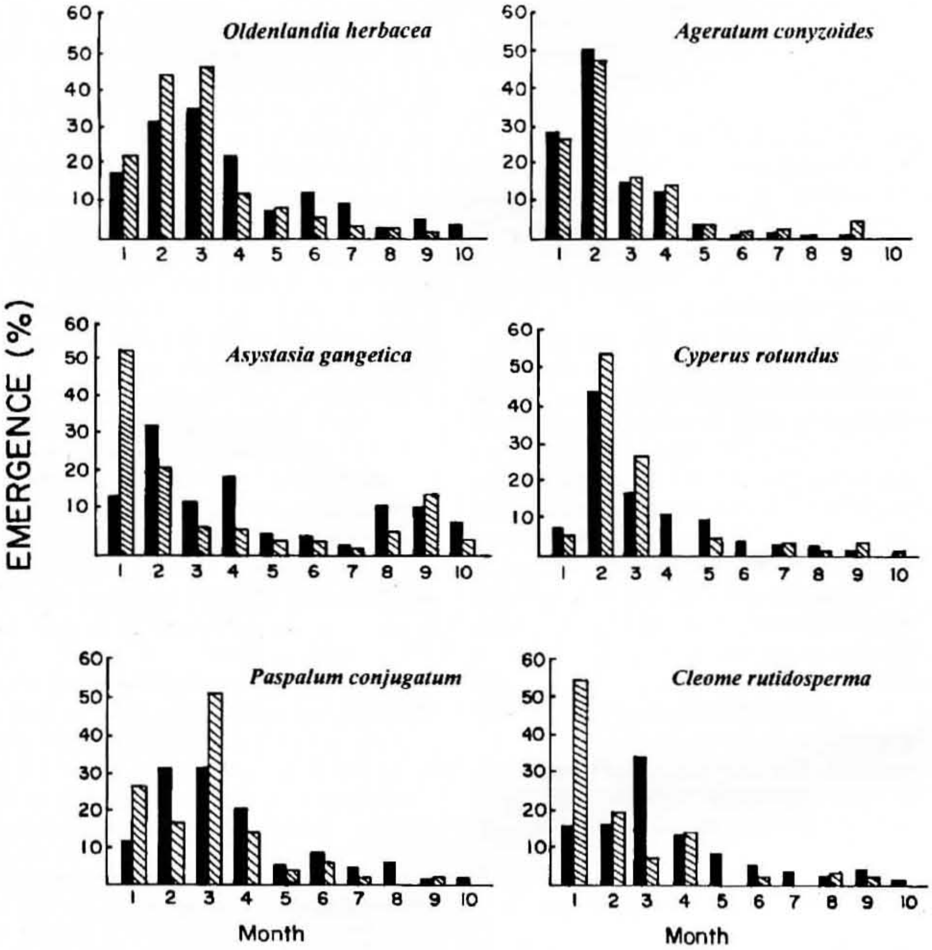

Figure 1. The pattern of seedling emergence of six most abundant weed seeds in soil from rubber ■ and oil palm ▧ plantations.

weeds from soil of rubber and oil palm were *A. conyzoides* and *A. gangetica*, whose seedlings began to emerge two weeks after sowing. *A. gangetica* and *C. rutidosperma* showed a high level of emergence in soil collected from oil palm plantation during the first one-month period. *C. rotundus* and *A. conyzoides* seedlings showed high emergence in both plantation soils during the first two months after sowing. Generally, the percentage emergence of most weeds studied decreased 2–4 months after sowing.

Discussion

The average total populations of buried weed seeds in the soil of rubber and oil palm plantations studied (irrespective of their growth stage) were 3297 and 3262 m^{-2} respectively. This is extremely low as compared to the total population of buried seeds recorded from an arable soil in Scotland (16 000 m^{-2}) (Warwick 1984) or from a vegetable field of Indonesia (48 700 m^{-2}) (Sastroutomo and Yusron 1987). The total number of weed seeds in pineapple-growing areas in Malaysia was 6630–9593 m^{-2} (Wee 1974), which is higher than the numbers reported in this paper. Our figures, however, were higher than the 1707–4413 m^{-2} from vegetable fields in England (Froud-Williams *et al.* 1983).

The lower number of buried seeds in the rubber and oil palm plantations is attributed to the long periods of time since last significant weed seed production due to the planting of legume cover crops, which in well-managed plantations reduces weed growth and hence seed production (Wilson *et al.* 1982). The seeds are unable to germinate due to the reduction in light reaching the soil surface, whilst the thick crop canopy and intensive weed management reduce weed growth and weed seed production (Yeoh and Phang 1980).

A striking feature of the flora in the young rubber and oil palm areas was the dominance of *A. gangetica, B. alata, C. rutidosperma* and *P. conjugatum*. *Borreria alata, P. conjugatum* and *C. rutidosperma* are all rapid-growing weeds with high production of viable seeds (Scholaen and Koch 1988), whose seed production may contribute to an increase of the seed reservoir in soil.

From the results obtained, it appears that there was a tendency toward decreasing numbers of buried seeds with increasing plant maturity. These results are in line with the work of Wee (1974), who noted that in mature plantation areas after 10 years of growth, weed seeds in soil decreased significantly. The species making the greatest contribution to the seed banks were annuals, which are more susceptible to the reduction of light. Most of these annual weed species, such as *A. gangetica, C. rutidosperma, B. alata,* and *O. herbacea* are predominant species of newer fields (Wee 1974).

It should be noted that no tillage was carried out in the plantations after planting legume cover crops. Chancellor (1986) reported that less germination occurred in undisturbed soil because conditions are not conducive to germination.

Just a few species, notably *A. gangetica, P. conjugatum, B. alata, A. conyzoides* and *C. rotundus*, appear capable of making up the bulk of the seed population in the soil. There could be a serious problem in controlling these weeds due to high numbers of their seeds in the soil and the ability of these seeds to survive for a long period in the soil. In disturbed soil, these seeds would germinate in higher numbers during the first three months after planting. However, in the two plantations studied, the soil surface was not disturbed, which also may have reduced germination and viability of these seeds.

The cultural practices and environmental parameters associated with legume cover crops in rubber and oil palm plantations are unfavourable for emergence of certain of these dominant species, such as *A. gangetica, A. conyzoides, C. rutidosperma,* and *B. alata,* while *O. herbacea* and *Richardia* sp. were found to have high viability in rubber and oil palm fields. These weeds are classified as secondary weeds and have not been reported to cause problems in either rubber or oil palm growing areas.

Results indicate that many of the weeds growing with legume cover crops in rubber and oil palm plantations could be predicted based on types of weed seeds and their density in soil. Based on data collected in these experiments, investigating and evaluating seed viability and seed reservoir in the soil would be very helpful in predicting weed infestations in rubber and oil palm plantations.

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