Proc. Indian natn Sci. Acad. **49B** No. 1 pp 50–56 (1983)

Competition Between *Imperata cylindrica* and *Eupatorium odoratum* at two Levels of NPK Treatment

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(Received 26 August 1982)

The study deals with intra-and inter-specific competition related to NPK nutrition between *Imperata cylindrica* (L.) Beauv. and *Eupatorium odoratum* L., two noxious weeds coming up in the early-successional plant communities after slash and burn agriculture (jhum) in north-eastern India. *I. cylindrica* was more susceptible to mortality under pure stand density stress as compared to *E. odoratum*, probably due to which the yield per plant and m^3 of the latter was more affected as compared to the other. In mixtures, *I. cylindrica* had an advantage over *E. odoratum* by reducing the "space" for the latter through allelopathic inhibition of growth of this species. The significance of these results is discussed.

Key Words: Slash and burn agriculture, Jhum, Competition, Allelopathy, Space

Introduction

Competitive relationships existing between natural species populations have been considered by many from the point of view of coexistence of closely related species (Harper & Chancellor 1959, Marshall & Jain 1960, Harper & Mc Naughton 1962, Ramakrishnan & Jeet 1972, Ramakrishnan & Gupta 1981, Tripathi & Harper 1973). According to Bergh van den and Braakhekke (1978) coexistence between two species is possible when they are able to occupy different ecological niches of the same area avoiding niche overlap. Thus, the studies of Ramakrishnan and Gupta (1981) have implicated the differential response of two closely related species *Argemone mexicana* and *A. ochroleuca* to NPK nutrition as partly responsible for their apparent coexistence in nature.

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The present study pertains to two important weeds, namely *Imperata cylindrica* (L.) Beauv. and *Eupatorium odoratum* L. which occur in early successional herbaceous communities developing during secondary succession, after slash and burn agriculture (jhum) in north-eastern India (Ramakrishnan et al. 1980). Both these species coexist in jhum fallows upto a period of about 5–6 years at lower elevations of Meghalaya (Kushwaha et al. 1981) while the former species also occurs in jhum fallows at higher elevations (Ramakrishnan & Mishra 1981). The competitive relationships existing between these two species may explain their adjustment to each other under conditions of fluctuating nutrient conditions of early secondary successional communities arising after slash and burn agriculture. An attempt, therefore, has been made to study the growth of the two weeds in relation to intra-and inter-specific competition as affected by NPK nutrition.

Materials and Methods

Experiments were performed at Burnihat (26°·02'N latitude and 91°.52'E longitude) experimental garden. Populations were raised separately from rhizome fragments with one node in the case of *I. cylindrica* and from seeds in *E. odoratum* collected from Burnihat in Meghalaya. Rhizome fragments in the case of *I. cylindrica* and seeds in the case of *E. odoratum* were used to simulate the natural regeneration of these two weeds after slash and burn agriculture. Pots (20.8 cm diam.) were filled with garden soil which was thoroughly mixed to remove soil heterogeneity. Monoculture studies comprised of 30, 60, 120, 240, 480 and 960 plants/m^2. For mixed culture studies, de Wit's replacement series (de Wit 1960) with varying proportions of the two species keeping the overall density constant, was used. The mixture proportions for the two species were 240+0, 120+120 and 0+240 plants/m^2. The transplantation of the individuals of both the species for pure and mixed culture studies was done on 5th June 1979, when individuals of both the species were uniformly 2-leaved and 2 cm in height.

Three series of 36 pots were maintainde for the de Wit's series of set up. The first series was kept as control while the second and the third series were supplied with low NPK (1.2 g $NaNO_3$, 2.0 g NaH_2PO_4 and 0.88 g K_2SO_4 per pot), fertilizer doses determined on the basis of the soil fertility status. The total dose was given in two equal parts, the first when plants had established in early July and the other at the time of peak vegetative growth in August. The nutrients were dissolved in water and then applied to the pots. Monoculture studies did not receive any fertilizer alteration. Plants were watered daily till the third harvest so as to provide sufficient moisture to them. Three harvests were taken for the mixed culture experiments after 8, 16 and 24 weeks but only one harvest, after 24 weeks, was done for the monoculture studies. At harvest, the plants were thoroughly washed with water and dried at 80° for 48 hrs for determining dry matter yields. From the yield data, relative yield total (RYT), relative yield quotient (RYQ) and the relative replacement rate (RRR) (Bergh van den 1968) were determined.

Results

Pure Culture Studies

The percentage survivorship of both

the species decreased with increase in the population density. Mortality, however, was more pronounced in *I. cylindrica* than in *E. odoratum*. The two species also showed varied degrees of plastic responses to increasing density. Although both the species showed reduced plant height and leaf area with increase in density, the decrease in plant height was more marked in *E. odoratum*, whereas the decrease in leaf area was steeper for *I. cylindrica*. Leaf area for *I. cylindrica* was markedly higher than for *E. odoratum* at very high densities. Tiller number in the case of *I. cylindrica* was drastically reduced under high density stress. *E. odoratum* did not show any branching at high densities. Number of rhizomes and total rhizome length per plant, both declined sharply with increase in density stress, in the case of *I. cylindrica* (table 1).

The dry weight yield per plant too decreased with increase in density and this decrease was more marked in *E. odoratum* than in *I. cylindrica*. The dry weight yield per m^2 increased in the case of *E. odoratum*, the increase was only upto 120 plants per m^2 after which it declined drastically (table 2).

Table 1 *Effect of increasing density on survivorship, plant height, leaf area, number of branches/tiller of* E. odoratum *and* I. cylindrica *and number of rhizames and total length of rhizomes per plant of* I. cylindrica

Density/m^2	Survivorship (%)		Height (cm)		Leaf Area (cm^2)		No. of branches/tiller		*I. cylindrica*	
									No. of rhizomes	Total length of rhizomes (cm)
	IC	EO	IC	EO	IC	EO	IC	EO		
30	100.0	100.2	168.1	198.5	87,298	10,771	22.0	8.0	35.6	786.2
60	100.0	100.0	140.0	186.0	5,077	6,262	21.0	6.1	32.1	621.6
120	100.0	100.0	122.5	142.3	2,766	3,757	11.4	3.5	23.0	336.0
240	99.0	100.0	104.2	95.7	1,460	1,252	6.9	1.5	12.4	175.5
480	87.5	92.1	86.3	52.0	730	475	4.1	0.0	6.7	91.0
960	61.2	78.0	68.2	30.3	387	125	2.4	0.0	3.0	49.1

Table 2 *Effect of increasing density on dry weight yield of* I. cylindrica *and* E. odoratum

Density/m^2	Yield (g)/Plant		Yield (g)/m^2	
	IC	EO	IC	EO
30	77.7	43.0	2331.9	1290.0
60	45.2	25.1	2712.0	1500.6
120	24.6	15.2	2955.5	1824.4
240	13.0	5.1	3120.2	1224.3
480	6.5	1.9	3216.6	912.0
960	3.4	0.5	3312.7	480.0

**IC*, Imperata cylindrica; *EO*, *Eupatorium odoratum*

The percentage reproductive plants in *E. odoratum* decreased with the increase in density and at the highest density of 960 plants/m² only about 9% of the plants reproduced. No flowering occurred in *I. cylindrica* at all densities. The seed output per plant of *E. odoratum* also showed a decline with increase in density and a similar trend was also noted for seed output/m² (table 3).

Mixed Culture Studies:

There was no mortality of the plants of either of the species in this experimental set up. The total yield of the mixture (figure 1) at all the harvests and at each treatment, was intermediate to the yields of the either of the species in monocultures. There was an increase in the dry matter production from lower to higher NPK nutrition but *I. cylindrica* responded better to increased fertilizer doses than *E. odoratum*. The relative concavity/convexity in the replacement curve suggests that *I. cylindrica* is more aggressive than *E. odoratum* in both unaltered and altered soils. The aggressiveness of *I. cylindrica* seems to be more at latter harvests. In general, there was an increase in the relative yields of *I. cylindrica* from the first to third harvest. However, no clear-cut trend was noted in the relative yields of *E. odoratum*. The relative yield quotient values were always more than one. Further, the relative yield total for both the species, progressively increased from the first to third harvest. The relative replacement rate of *I. cylindrica* with respect to *E. odoratum*, decreased with passage of time in the control series while in the altered sets, *I. cylindrica* seemed to do better with time (table 4).

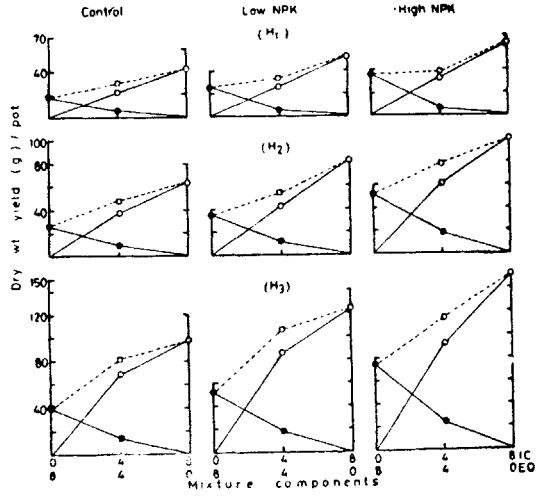

Figure 1 Replacement diagrams (dry weight yields) at three harvests and at two nutrient levels. H_1, H_2 and H_3 refer to the three harvests taken after 8 16 and 24 weeks. *I. cylindrica* (O): *E. odoratum* (●); total yield of the mixture (□).

Table 3 *Effect of increasing density on number of fertile plants and the seed output of* E. odoratum

Density/m²	Fertile plants (%)	Seed output	
		Per plant	Per m²
30	100.0	6000	180000
60	100.0	4500	270000
120	100.0	3200	384000
240	87.0	2250	240120
480	37.0	1230	182928
960	8.5	875	71400

Table 4 *Relative yield, relative yield quotient (RYQ), relative yield total (RYT), and the relative replacement rate (RRR) (reference to H_1) at three harvests*

Treatment	Harvests	Relative Yield IC	EO	RYQ IC/EO	RYT	RRR IC with respect to EO
Control	H_1	0.5	0.3	1.67	0.8	—
	H_2	0.6	0.3	2.00	0.9	1.19
	H_3	0.7	0.3	2.33	1.0	1.17
Low NPK	H_1	0.5	0 2	2.50	0.7	—
	H_2	0.6	0.3	1.67	0.8	0.67
	H_3	0.7	0.3	2.33	1.0	1.39
High NPK	H_1	0.5	0.2	2.50	0.7	—
	H_2	0.6	0.4	1.50	1.0	0.60
	H_3	0.6	0.3	2.00	0.9	1.33

Discussion

The results obtained for both the species in pure stands, indicate that increase in the density resulted in both mortality and plastic reduction in vegetative growth of the plants. The reactions of the two species to similar density stress, were found to be different. While mortality was more severe in the case of *I. cylindrica* than in *E. odoratum*, the reverse was the case as far as plasticity is concerned. This is reflected in leaf area and dry weight yield per plant. This differential plastic behaviour may be a consequence of the differential reduction in numbers of the species. Thus the species suffering from mortality exhibited greater vegetative growth. The plastic reduction in plant growth with increase in density is an important population regulating mechanism (Ramakrishnan & Kumar 1971). Dry weight yield/m^2 is shown to increase with increase in the density in pure stands reaching a plateau value beyond a certain point. However, it is interesting to note a differential behaviour in the two species studied here where at the density levels tried, *I. cylindrica* tended to show an increase in yield/m^2, whereas there was a drastic decline in the yield in *E. odoratum* beyond a particular density level. This again may be related to the greater susceptibility of *E. odoratum* to density stress, as far as plasticity is concerned.

The yield per pot data suggest that *I. cylindrica* is more aggressive than *E. odoratum* as seen from the relative convexity/concavity of the replacement curves. A comparison of the relative yields of the two species also showed that *E. odoratum* reacts to the presence of *I. cylindrica* by a strong decrease in yield, whereas *I. cylindrica* does not suffer from any yield loss at different harvests and nutrient levels. The fact that in general, the RYT$<$1, implies that *E. odoratum* is more affected than might be expected from crowding for the same space (Sandfaer 1970). Apparently there is some factor in *I. cylindrica* plants which reduces the space for *E. odoratum* as has also been shown by Eussen et al. (1976) for some crop species. In a similar set of experiments with *I. cylindrica* and sorghum, they noticed a reduction in the RYT values which was later confirmed

by them to be due to certain allelopathic substances produced by the former species. The increase in the RYT values with progressive harvests in all the treatments, however, may be on account of the compensatory increase in the yield of *I. cylindrica* during later stages of competition due to availability of "additional free space" (Trenbath 1974). Trenbath also pointed out that the occurrence of the RYT=1 is not conclusive for the absence of any allelopathic effect and that an RYT value below 1 occurs only in situations where the reduction of space caused by one of the mixture components, is not compensated for by additional utilization of space by the other; RYT=1 reveals that it does utilize the space. The competitive superiority of *I. cylindrica* is suspected to be due to its allelopathic property which reduces the available space for *E. odoratum* in the initial stages of growth though this space is occupied by *I. cylindrica* as a result of which there is compensatory yield gain which is also reflected inRYQ and RRR values.

It is interesting that in spite of the start from vegetative propagules in pure stands in the case of *I. cylindrica*, the mortality is more severe than that in *E. odoratum*, starting from small seed resources. However, this trend may not hold good for *I. cylindrica* when the resources are normally utilized from a massive net work of rhizomes as it occurs in nature (in contrast to small cut pieces of rhizomes used for this study). However, *I. cylindrica* once established seems to have a better competitive ability than *E. odoratum* both in pure and mixed cultures, though nutrients status does not influence much the outcome of competition between the two species.

Acknowledgement

This research work was supported under the "Man and Biosphere" programme by the Department of Science and Technology, Government of India.

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