

# **Studies on the Eco-Physiology of Early Successional Plant Populations of Jhum Fallows**

**ABSTRACT**

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Slash and burn agriculture (locally known as Jhum) is the most prevalent form of cropping in the hill areas of north-eastern India. The early successional herbaceous communities constitute an important phase in the fallow development during secondary succession subsequent to cropping. This community which holds the ground for about 5-6 years, often gets arrested at this stage due to shortening of the Jhum cycle (the intervening fallow period before cropping is again done on the same site). The present study deals with the eco-physiological analysis of this community and a comparison with the herbaceous communities of older fallows of secondary succession which is important both from the view points of understanding the biological and environmental aspects related to Jhum. *The study was carried out in Byrnihat in the Khasi Hills (26°N and 91.5°E).*

#### 1. Organization of herbaceous weed communities under Jhum:

Organization of herbaceous weed communities was studied under 4, 6, 10 and 20 year Jhum cycles. Under shorter Jhum cycles of 4 and 6 years, the species of the pre-burn stage reestablished subsequent to the burn whereas under longer cycles of 10 and 20 years shade tolerant herbaceous species of the pre-burn stage were replaced by more competitive and ruderal species after the burn. Abundance as well as biomass of weeds was significantly

higher under shorter cycles of 4 and 6 years as compared to longer cycles of 10 and 20 years. Further, the density and biomass values were significantly higher in the uncropped sites than that in the cropped sites under all Jhum cycles. Diversity indices based on numerical abundance increased sharply immediately after the burn under all the cycles. However, while diversity index based on biomass increased sharply after the burn under 4 and 6 year cycles, reverse was the case under 10 and 20 year cycles. Weed problem has been discussed in relation to the length of Jhum cycle.

2. Germinable seed population <sup>in</sup> soils:

Germinable seed population in soil was estimated under 4, 6, 10 and 20 year Jhum cycles at three times - just before the burn, immediately after the burn and after one year of cropping. At all the sampling times, the total number of germinable seeds was significantly higher under 4 and 6 year Eupatorium dominated cycles compared to 6 year Imperata dominated, 10 year and 20 year ones at all samplings. Though there was no significant difference between 6 year Imperata dominated fallow and 10 or 20 year fallows at the pre-burn stage, the former had significantly higher number at the immediate post-burn stage and after one year of cropping. The number of germinable seeds decreased after the burn and cropping and it was more pronounced in case of

longer cycles of 10 and 20 years. Species like Eupatorium odoratum, Erigeron linifolius and Ageratum conyzoides were more abundant after cropping as compared to others. Results are discussed in light of the weed problem in relation to the length of Jhum cycle.

### 3. Partitioning of biomass and nutrients in the secondary successional herbaceous populations:

Three categories of secondary successional herbaceous communities subsequent to slash and burn viz. early successional non-sprouting, early successional sprouting and late successional populations were analysed for their resource allocation pattern, nutrient uptake efficiency and seed production efficiency. Early successional non-sprouters directed a higher proportion of resources to stem and seed components whereas late successional populations allocated a greater proportion to leaf and below-ground components. The former was also more efficient from the point of seed production and nutrient uptake. Early successional sprouting populations also directed a lesser proportion to the leaf component than that of late successional ones but a higher proportion was allocated to the underground organs of regeneration instead of to the sexual propagules as in the early successional non-sprouters. Sexual reproductive potential was found to be

dependent upon the vigour of the plant in the early successional non-sprouters whereas in the other two categories no significant relationship existed. In the early successional non-sprouting perennials resource allocated to seed was more dependent upon the total available resource as compared to the annuals where the vigour of the plant is less critical. The findings are discussed in relation to the adaptive strategy during post-fire succession.

4. Reproductive efficiency of secondary successional herbaceous populations:

Three categories of secondary successional herbaceous communities subsequent to slash and burn, viz. early successional non-sprouting, early successional sprouting and late successional populations, were investigated for their reproductive efficiency considering leaf component since it is the chief organ of photosynthesis. Early successional non-sprouting populations were found to be reproductively the most efficient whereas the early successional sprouting populations allocated more to vegetatively reproducing organs. While the high reproductive potential of early successional non-sprouting species is associated with vigour and production efficiency of the species, this relationship is stronger with the latter

characteristic. On the other hand, early successional sprouting populations show inverse relationship between vegetative and sexual reproductive effort. The strategy of late successional species seems to be to maximise vegetative growth in a closed habitat. The significance of these strategies is discussed. ~~xxxxxxx~~

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5. C<sub>3</sub>/C<sub>4</sub> strategy during secondary succession:

Herbaceous communities of 4, 6, 10 <sup>and 20</sup> year old fallows were analysed at the pre-burn and post-burn (after 270 days of regrowth) for the relative abundance of C<sub>3</sub> and C<sub>4</sub> species. The number of C<sub>4</sub> species increased sharply after the burn in all the cases except for the 4 year old fallow. Such an increase was also found in terms of biomass contribution for all the fallows. However, while the proportion of C<sub>4</sub> individuals increased following the burn in 6 year Imperata dominated fallow, 10 year fallow and 20 year fallow, there was no significant change in case of 4 year and 6 year Eupatorium dominated fallows. The number of C<sub>4</sub> species was maximum in the youngest fallow of 4 year age at the pre-burn stage compared to others, though at the post-burn stage the number of C<sub>4</sub> species remained the same in different sites. ~~at the post-burn stage.~~ The C<sub>4</sub> species had significantly lower concentration of nitrogen in the leaf tissue compared

to the C<sub>3</sub> ones in the early successional environments but were more efficient from the point of nutrient uptake and use. The ecological implications of the two contrasting strategies are discussed in relation to the secondary successional environments.

6. Growth and allocation pattern of some important annual Weeds:

Four important annual weeds of the secondary successional environments following slash and burn agriculture, viz. Borreria articularis, Cassia tora, Ageratum conyzoides and Erigeron linifolius were analysed for their growth and allocation pattern. Cassia tora had maximum value of relative growth rate and net assimilation rate. Nitrogen concentration in the leaf tissue was also maximum in this species. However, this species was found to be least efficient from the point of nutrient uptake and use. Reproductive allocation of nitrogen and phosphorus was much more expended as compared to that of dry matter and potassium in all the species. Ageratum conyzoides showed the minimum allocation of biomass or nutrients to seeds but it has substantially higher seed production efficiency. compared to Borreria articularis and Cassia tora. Results are discussed in relation to the ecological success of these species in the secondary successional environments.

7. Growth and allocation pattern of some important perennial weeds:

Growth and allocation pattern of four important perennial weeds viz. Eupatorium odoratum, Grewia elastica, Thysanolaena maxima and Imperata cylindrica were analysed. E. odoratum a C<sub>3</sub> species and dependent upon sexual mode of reproduction had maximum relative growth rate and net assimilation rate. This species also showed maximum concentration of nutrients in the leaf tissue. E. odoratum allocated a higher proportion of its total biomass as well as nutrients to the stem than in the other three sprouting species, <sup>w</sup>While the reverse was true for the leaf component. The two rhizomatous species I. cylindrica and T. maxima exhibited significantly higher allocation of resources to the belowground compartments compared to the non-rhizomatous species. The C<sub>4</sub> species I. cylindrica and T. maxima showed higher nutrient uptake efficiency in spite of their low nutrient demand for dry matter production compared to C<sub>3</sub> species E. odoratum and G. elastica. Findings are discussed in relation to photosynthetic and regenerative strategies of these species.

8. Growth and allocation pattern of Eupatorium odoratum in secondary successional environments:

Growth and resource partitioning of Eupatorium

odoratum, an important early successional species were studied in the seral environments following slash and burn. Growth rates and nutrient uptake efficiency declined with the increasing age of the fallow. Concentration of potassium in the whole plant was much lower in older fallows as compared to fresh ones, while no such clearcut and marked differences were observed for nitrogen and phosphorus. Higher proportion of the available resources to stem but lower proportion to leaf compartment was allocated in older fallows compared to fresh ones. On the other hand, allocation to seed was higher in younger fallows than older ones. Reproductive effort, if considered as proportion of current increment in biomass or nutrients absorbed was much higher in older fallows compared to fresh ones. Growth was adversely affected by low soil fertility and severe competitive interference in the fresh fallows. Further, while the allocation pattern was not affected by reduced soil fertility, under the competitive environment, the limited resources were utilized for vegetative development at the cost of reduced reproductive potential. Adaptive strategy of this species is discussed.

9. Growth strategy and allocation pattern of *Eupatorium odoratum* and *Imperata cylindrica* at different soil fertility levels:

Growth and allocation pattern of *Eupatorium odoratum*

and Imperata cylindrica with contrasting photosynthetic and reproductive strategies were studied at varied fertility levels of the soil. Sexual reproductive allocation in E. odoratum was maintained irrespective of the imposed nutrient stress. However, plasticity in vegetative reproductive allocation was noted in the case of I. cylindrica. More nitrogen and phosphorus were allocated for reproductive growth in both the species as compared to potassium and this was achieved through greater translocation of these nutrients from other vegetative organs at the time of reproductive growth. I. cylindrica, a C<sub>4</sub> species was more efficient from the point of nutrient uptake and its use as compared to E. odoratum, a C<sub>3</sub> species. However, the latter was found to be always more productive than the former. The significance of these results is discussed.

#### 10. Nitrogen mineralization:

Rate of nitrification was studied under three Jhum sites (4, 6, and 10 year Jhum cycles) and 1, 3 and 20 year old fallows of secondary succession following the cropping. A sharp increase in the rate of nitrification after slashing the vegetation was found in the Jhum sites while a marked decline was noted soon after the burn. Another peak in the nitrification rate was found in the month of

September again followed by a decrease in the following months. It was maximum under a 4 year cycle and minimum under a 10 year cycle. Successional fallows also showed nearly a similar pattern for nitrification rate during the year and it decreased with the increasing age of the community. Soil from all the sites showed higher rate of nitrification when incubated with an additional supply of  $NH_4^+$  - N. Though in the initial stage the nitrifying activity was slow, in case of the soils incubated with leaf material, a sharp increase in the  $NO_3^-$  - N concentration was found after 24 days of incubation. Nitrification activity in soil was found to be more critically associated with the availability of  $NH_4^+$  - N rather than the allelopathic interactions.

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