

**STUDIES ON POPULATION DYNAMICS AND GROWTH
OF A FEW WEEDS AS INFLUENCED BY
DIFFERENT FARMING SYSTEMS**

By

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**THESIS SUBMITTED IN FULFILMENT OF THE DEGREE OF
DOCTOR OF PHILOSOPHY IN BOTANY**



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I certify that the thesis entitled "Studies on population dynamics and growth of a few weeds as influenced by different farming systems" submitted by Mr. Gopal Pradhan, M.Sc., for the Degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong, carries the record of original research work carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. degree. The work has not been submitted for any Degree of any other University.

IN MEMORY
OF MY
LATE MOTHER

[Handwritten Signature]

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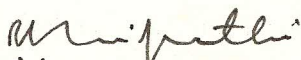
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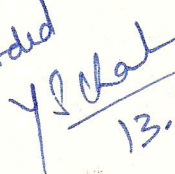
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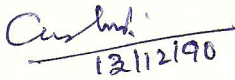
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Agriculture throughout the world is still man's single most important activity and is still the only reliable source of food and an important source of fibres and other products (Haines, 1982). With the increase in the population pressure the growing demand for food could not be met by the old traditional agricultural system and with this growing perception of the failure of mainstream agricultural research, the evolution of Farming Systems Research took place (Merrill Sands, 1986). Okigbo (1975) defines a farming system as a specific agricultural enterprise satisfying well defined objectives and involving various kinds of plant and/or animal inputs together with the practices of operations with which they are managed in a given environmental setting. Merrill Sands (1986) defines a farming system as a unique and reasonably stable arrangement of farming practices in response to physical, biological and socio-economic environments and in accordance with the household's goals, preferences and resources.

Diverse activities collectively described as Farming Systems Research (FSR) have become a prominent feature of the work of the International Agricultural Research Centres (IARCs) and also of many National Agricultural Research Systems (NARSS) in the past 10-15 years (Simmonds, 1986).

The evolution of Farming Systems Research dates back to the post "green revolution" era (Merrill Sands, 1982). The farming systems in the tropics and sub-tropics have evolved in response to particular agro-climatic, ecological and socio-economic conditions (Harwood, 1979; Hieldebrand, 1981; Hart, 1982a; Norman et al., 1982; Collinson, 1983).

Pioneering works on FSR were of CIMMYT group in Mexico by Perrin et al. (1976) and Byerlee and Collinson (1980); Caqueza Project in Columbia (1971-75) by Zandstra et al. (1979); IRRI group in the Philippines by Gilbert et al. (1980) and Zandstra et al. (1981); in West Africa by Norman et al. (1982) and in East Africa by Collinson (1984). However, these works were mainly based on concepts and methodology for technology developments aimed at improving agricultural production.

In recent years, there has been considerable increase in agricultural activities in north-eastern region of India. Of the different land use practices prevalent in the region, slash and burn agriculture locally known as 'Jhum' is quite common. More than 80% of the total land area is under jhum cultivation. The practice consists of cutting down the forest at various stages of development on the hill slopes, allowing the slash to dry for a few months and burning it before cropping. Mixed cropping is a common feature of jhum cultiva-

tion. The jhum is carried out even on the hill slope of 20-40°.

Terrace cultivation has been introduced in the recent past as an alternative to jhum. This system is similar to jhum cultivation so far as mixed cropping is concerned, but here bench terraced lands are prepared for cultivation. In addition to this, valley cultivation of rice is also carried out on flat lands between mountain slopes. Valley land cultivation consists largely of rice monoculture and is a sedentary and settled form of agriculture.

The ICAR Research Complex for North-Eastern Hill region, Shillong has initiated a long term project on Farming Systems Researches, at its farm at Barapani. The Barapani farm of the ICAR is situated 22 Km north of Shillong, the capital of Meghalaya. The Farming Systems Research Project of the ICAR was initiated in 1984. It comprised evaluation of single and mixed land use systems by bringing 8 micro watersheds under different farming systems. These farming systems are livestock-based farming system, forestry, agro-forestry, agriculture system, agri-horti-silvi pastoral system, horticulture system, control (natural fallow) and jhum fallow. A large number of weedy species grow luxuriantly on these watersheds. It is an established fact that the weeds modify or suppress the growth of crop plants as a result of competi-

tion for nutrients, water and light etc. and cause tremendous loss to the crop yield. On account of their economic importance, the studies on weeds, especially the aspects directly related to their control measures, have engaged the attention of agricultural scientists during the past several decades.

'The studies on population dynamics and growth of exotic weeds in relation to burning, age of jhum fallows, associated vegetation and varied density, and light and soil conditions indicate that they are particularly successful on disturbed habitats. These weeds are very aggressive and spread fast posing serious threat to certain useful elements of native flora. Further, the disturbed habitats are being created at a much faster pace which brings the impending problems connected with rapid increase in populations of these weeds into sharp focus. Therefore, there is an urgent need to undertake intensive studies on exotic weeds with particular reference to their population dynamics, analysis of factors contributing to their remarkable success in the region, niche divergence, and possible impact on the native flora' (Tripathi, 1985).

A plant is assigned as a weed not only on the basis of its characteristics but its relative position with reference to other plants and man. Even a plant that is useful, is a weed when it grows where it is not wanted. Thus, all

plant species may at one time or another, be classified as weeds. The intensive system of land management practices by man break down the natural equilibrium of plant communities and new habitats are continually created which offer fresh opportunities for colonization of unwanted plants and these frequently become serious weeds. Since weeds have unique characteristics for adaptation, they thrive well in any environment.

Workers Weeds assume importance and pose problems because of their nuisance value (Tripathi, 1977). The significant losses to crop yield caused by these unsown and undesirable plant species reported by various workers justify worldwide efforts to control them. Although the economic importance and nuisance value of weeds in agriculture have resulted in numerous studies, the realization that they are also excellent material for addressing basic evolutionary and ecological issues have stimulated further interest in the study of weeds during recent years (Tripathi, 1985). Tripathi (1977) analysed the possible consequences of a complete eradication of the weed flora from agro-ecosystems. Mishra & Ramakrishnan (1984) suggested that the non-weed concept where weeds have a useful role to play, is an essential ingredient of traditional agro-ecosystems in different parts of the world and in the north-eastern India.

Each constituent species besides being characterised by its own ecological amplitude has a particular relationship with the environment and the associated species. Therefore, species composition of a given community may depend on the reaction of the species to the prevailing non-living and living environment of the system.

Species diversity and phytosociology of the Indian forest and grassland communities have been studied by several workers e.g., Pandeya (1952), Ramam (1966), Misra (1972), Choudhury (1974), Dagar & Mall (1980), Jain (1986), Khan et al. (1986), Singh & Verma (1986), Bihari & Lal (1989) and Rao et al. (1990). However, the agro-ecosystems have not been extensively analysed. Some of the earlier works on agricultural systems are those of Majumdar (1962), Roberts (1963), Tripathi (1964), Tripathi & Misra (1971), Patro (1971), Ambasht & Chakhaiyar (1979), Ayeni et al. (1984). Recent works relating to weed communities in different agricultural systems are those of Thomas (1985), Chancellor (1986), McIntyre et al. (1988), Pujadas Salva (1988), Wheeler (1988), Yeaton (1988), Hill et al. (1989), Marshall (1989), Saavedra et al. (1989) and Thompson & Shay (1989). The dynamics of weed communities can be satisfactorily quantified by determining various phytosociological attributes such as frequency, density and importance value indices of the

constituent species at regular intervals. This approach has been adopted in the present study as well.

Since the introduction of the terms 'ecosystem' (Tansley, 1935) and 'biogeocoenose' (Sukachev, 1945) the ecologists have been actively engaged in studying the structural and functional aspects of various natural and man-modified ecosystems. Productivity being an important attribute of community function (Odum, 1960), has attracted much attention in recent years.

Studies on productivity of a number of ecosystems have been carried out by various workers (e.g. Singh & Yadava, 1974; Dwivedi, 1978; Falk, 1980; Ayeni et al., 1984; Khokhar, 1985; and Karunaichamy & Paliwal, 1989). Although some of these studies pertain to agro-ecosystems there is conspicuous lack of intensive and indepth analysis of productivity of weed communities in different farming systems.

Weedy species, in general, have a high biotic potential and their populations, therefore, tend to grow fast in spite of the fact that efforts are always made to keep them under control. Among the factors and environmental stresses that regulate the size of weed populations (e.g. resource competition, diseases, insect herbivory etc), weeding is the most important.

In the north-east, variations in rainfall, temperature and altitude create a variety of ecological habitats to promote invasion and colonization of a large number of weeds. Considerable studies have been made recently on weed-crop interference where competitive influences have been assessed not merely as an agronomic problem but more as an ecological problem (Harper & Gajic, 1961; Tripathi, 1967; 68 and 69; Ramakrishnan & Kumar, 1971; Roberts & Potter, 1980; Sen, 1981; Tripathi, 1985; Kushwaha, 1985; Marshall, 1989 and Saavedra et al., 1989).

The dynamics and growth of plant populations are generally studied by continuously monitoring the fate of individuals at short and regular intervals. Population dynamics of weedy species have been studied by several workers (e.g. Harper & White, 1971; Sarukhan & Harper, 1973; Hawthorn & Cavers, 1976; Mack, 1976; Watkinson & Harper, 1978; Kushwaha Ramakrishnan & Tripathi, 1981; Rai & Tripathi, 1984; Kotanen & Jefferies, 1987 and Pandey & Dubey, 1989). The mortality and plasticity of plant populations in pure and mixed stands have also been analysed by several workers (e.g. De Wit et al., 1966; Tripathi & Harper, 1973; Bazzaz & Harper, 1976; Tripathi & Gupta, 1980; Berendse, 1981; Ayeni et al., 1984; Ibrahim, 1984 and Beckett, 1988).

The survivorship and dynamics of several perennial

grass and herb populations from different geographic regions have been studied by a number of workers (e.g. Williams, 1970; Antonovics, 1972; Sarukhan & Harper, 1973; Hawthorn & Cavers, 1976; Johnson & Thomas, 1978; Bishop et al., 1978; Kushwaha et al., 1981; Law, 1981; Yadav & Tripathi, 1981; Silvertown & Dickie, 1981; Schellner et al., 1982; Zimmerman & Weiss, 1984; Tripathi, 1985; Fernandez-Quintanilla et al., 1986; Tripathi & Yadav, 1987; Bradstock & Myerscough, 1988; and Pandey & Dubey, 1989). The population studies on biennials, however, have not engaged much attention although a few studies (Holt, 1972; Werner, 1977; and Klemow & Raynal, 1981) made on such species are both intensive and quite interesting. In view of the fact that population studies of annual plant species pose relatively lesser practical problems (Harper & White, 1974), extensive researches have been carried out on dynamics and regulation of their populations (Sharitz & McCormick, 1973; Watkinson & Harper, 1978; Regehr & Bazzaz, 1979; Weiss, 1981; Rai & Tripathi, 1984; Kelly, 1989 and Pandey & Dubey, 1989). Weiss (1981) studied population dynamics of Emex australis and reported heavy mortality during seedling stage especially in dense populations. The increase in the density may also reduce the reproductive potential of the species populations as reported by several workers (Palmlad, 1968a; Tripathi, 1968; Myerscough & Marshall, 1973; Williams & Ingber, 1977;

Tripathi & Gupta, 1980; Clay & Shaw, 1981; Trivedi & Tripathi, 1982a; Rai & Tripathi, 1982a).

The resource competition offered by the associated vegetation exercises a strong regulatory influence on plant populations (Harper & Gajic, 1961; Sagar, 1970; Putwain & Harper, 1970; Dwivedi & Tripathi, 1980; Yadav & Tripathi, 1981; Rai & Tripathi, 1985). Certain plant species have also been reported to inhibit the growth of neighbouring plants by producing allelochemicals (Rice, 1974; 1979; Friedman *et al.*, 1977; Hussain & Godoon, 1981; Rai & Tripathi, 1982b).

The success of an organism in a given environment is often determined by the allocation of limited available resources to diverse activities such as maintenance, growth and reproduction (Abrahamson & Gadgil, 1973). Plants respond to environmental variables and stresses in a complex manner, and these responses find expression in the rate as well as extent of growth. The growth of both weeds and crop plants has been analysed in relation to light & temperature and nutrients and in a variety of agricultural situations. Eagles (1973), Hughes (1973), Boston (1986), Chapin (1986), Petter-son *et al.* (1988) and Harrington *et al.* (1989) carried out growth analysis in relation to light and temperature. The plant growth has been analysed in relation to nutrients by several workers (e.g. Clarkson, 1967; Boston, 1986; Chapin,

1986; Shipley & Keddy, 1988; and Konings et al., 1989). Eze (1973), Bremester & Barnes (1981), Saxena & Ramakrishnan (1983), Banyikwa & Rulangaranga (1985), Bourdot et al. (1985), Swamy & Ramakrishnan (1988) and several others have analysed plant growth in agricultural situations.

Harper & Ogden (1970) studied the biomass allocation pattern in Senecio vulgaris expressing the dry matter stored in each organ type as a percentage of total biomass accumulated by the plant during its life time. They emphasized the significance of such studies in identification of distinct ecological strategies. Biomass allocation pattern has been extensively studied for gaining insight into the reproductive strategies of plants by a number of workers such as Harper & Ogden (1970), Tripathi & Harper (1973), Hickman (1977), Abrahamson (1979), Trivedi & Tripathi (1982), Bazzaz et al. (1987), Bittman & Simpson (1987).

The present investigation primarily aims at analysing the population dynamics and growth of two species of Ageratum (A. conyzoides and A. houstonianum) and Bidens pilosa as related to conditions prevailing in various watersheds. The study also examines the changes in structure of the weed communities and analyses the growth behaviour and dry matter allocation pattern of the above mentioned species under different farming systems.

Ageratum conyzoides L., A. houstonianum Mill. and Bidens pilosa L. occur abundantly in the local agricultural ecosystems. They also grow abundantly in roadsides, forests, wastelands, and disturbed places. Out of these three annual weeds, A. conyzoides and A. houstonianum are sympatric species and have synchronous growth. The growing period of B. pilosa also partly overlaps with that of Ageratum species. All of them are present in the crop fields together for most part of their life cycle. Thus, such species form an interesting and excellent group for population dynamics studies. A. conyzoides is reported to be a weed in 36 different crops in 46 different countries, whereas B. pilosa is a weed in 31 crops in more than 40 countries (Holm et al., 1977).

The watersheds under different farming systems are subjected to different cropping practices. The agricultural operations play a significant role not only in maintaining the structure of different farming systems, but may even decide the fate and success of the species composing the weed communities in different farming systems. Considering the above facts, the present study on the population dynamics and growth of A. conyzoides, A. houstonianum and B. pilosa has been made to cover the following aspects -

1. Weed community composition in relation to different farming systems.

2. Biomass and productivity of weeds and crops as affected by different farming systems.
3. Influence of farming systems on the population dynamics of A. conyzoides and A. houstonianum.
4. Influence of farming systems on the population dynamics of B. pilosa.
5. Dry matter allocation and growth of the three weeds as related to various farming systems.

The experimental data on the above mentioned aspects have been presented in Chapter IV-VIII. These chapters are preceded by the 'General Introduction' (present chapter), which sets out the objectives of the thesis. Chapter II (Review of Literature) presents the state-of-art of the subject. A brief description of climate, soil and vegetation of the study area and biology and distribution of the three species are provided in Chapter III. The result of the individual chapters have been discussed separately in each chapter, however, an attempt has been made to integrate the results and discussions contained in various chapters under 'General Discussion'.