BIOLOGY AND CONTROL OF THE WEED *Mikania micrantha* H.B.K. IN KERALA

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Doctor of Philosophy in Agriculture

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VELLANIKKARA, THRISSUR - 680 654
KERALA, INDIA

1999

DECLARATION

I hereby declare that the thesis entitled "BIOLOGY AND CONTROL OF THE WEED *Mikania micrantha* HBK IN KERALA" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that the thesis entitled "**BIOLOGY AND CONTROL OF THE WEED *Mikania micrantha* ~~HBK~~ IN KERALA**" is a record of research work done independently by **Ms. Mini Abraham** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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We, the undersigned members of the Advisory Committee of **Ms. Mini Abraham** a candidate for the Degree of **Doctor of Philosophy in Agriculture**, agree that the thesis entitled "BIOLOGY AND CONTROL OF THE WEED ***Mikania micrantha*** HBK IN KERALA" may be submitted by **Ms. Mini Abraham** in partial fulfilment of the requirement for the degree.

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ACKNOWLEDGEMENT

With immense pleasure, I wish to express my heartfelt gratitude and indebtedness to ***Dr. C.T. Abraham****, Associate Professor and Principal Investigator, AICRP on Weed Control and Chairman of my Advisory Committee for his expert guidance, unreserved help and utmost sense of patience shown in the progress of investigation. His knowledge and keen interest on the subject 'weeds' is highly distinguishable. To him goes the credit for keeping up my spirit, when I found the going too tough. I consider myself being fortunate in having the privilege of being guided by him.*

I am extremely grateful to ***Dr. R. Vikraman Nair****, Associate Director of Research (southern zone) and* ***Dr. P.J. Joy****, Professor and Head, RARS, Kumarakom for the valuable suggestions and timely help as members of my Advisory Committee. My special thanks are due to* ***Dr. Mercy George****, Assistant Professor of Agronomy for her constant encouragement for the speedy completion of the text preparation and for having devoted her valuable time in editing the manuscript and to* ***Dr. A. Sukumara Varma****, Professor and Head, Department of Plant Pathology for his technical advice and sincere help in conducting the pathological studies. Without his valuable guidance the results on the bio-control aspect would not have come to light.*

Dr. N.N. Potty*, Professor and Head,* ***Dr. P.S. John*** *and* ***Dr. K.E. Savithri****, Associate Professors, Department of Agronomy have been an inspiration at all stages of thesis preparation. I gratefully acknowledge the help rendered.*

I respectfully acknowledge ***Dr. A.I. Jose****, Associate Dean, College of Horticulture for providing all facilities needed for the smooth conduct of the study.*

My obligation to the AICRP on Weed Control cannot be expressed in words. I sincerely acknowledge the whole hearted co-operation and gracious help of Smt. K.M. Durga Devi, Assistant Professor, Sri. Nandakumar, Sri. Paul and other staff members, without whose help it would have been difficult to conduct the study. Smt. Mareen Abraham, Assistant Professor has been a helping hand during the survey work. I am very much grateful to her for the help rendered.

It is with immense pleasure, I acknowledge Dr. K.C. George, Retired Professor and Smt.K.P. Santhabhai, Programmer, Department of Statistics for their valuable help in the statistical analysis.

My heartfelt thanks are expressed to Dr. J. Thomas and Dr. Samual Mathew, Associate Professors, AMPRS, Odakkali and other staff members for providing all facilities in the laboratory for chemical analysis. Their whole-hearted co-operation and sincere help made the burden work lighter.

Dr. Luckins C. Babu, Associate Dean, College of Forestry had been of great help in identification of the species of Mikania. I have great pleasure in acknowledging him.

Sincere thanks are due to Dr. George Mathew, Scientist, KFRI; Dr. Ananthakrishnan, Lyola College, Madras; Dr. B. Suresh, Assistant Professor of Agricultural Entomology, TNAU; Dr. M. Mohanasundaram, Professor of Agricultural Entomology, TNAU; Dr. Samiran Chakabarty, Professor of Entomology, University of Kalyani and the staff of the Mycology division, IARI, New Delhi, for identifying the insect pests and type cultures.

I would like to acknowledge my deep gratitude to Dr. S. Beena and Sri. K. Surendra Gopal, Department of Plant Pathology; Dr. A.M. Renjith, *Dr. K.R. Lyla, Smt. R. Ushakumari, Department of Agricultural Entomology; Dr. V.K. Mallika and Dr. D. Girija, Department of Biotechnology for the help and support during the thesis work.*

With all regards, I sincerely acknowledge the valuable and timely help offered by my friends and classmates especially Lency, Deepa, Vanajachechy, Reeni, Haseena, Smt. K.E. Usha, Sri. D.V.K. Rao and Sri. A.P. Vijayan.

The Senior Fellowship awarded by the Kerala Agricultural University is also acknowledged.

My appreciation also goes to Sri. R. Noel for the neat typing of the manuscript.

I am forever beholden to my beloved parents, brothers, sisters and in-laws for their boundless affection, constant prayers, unfailing inspiration and moral support. Without them, it would have been impossible to complete my study.

At this moment, I may recall the love and concern of my husband, Jomon who silently bored a lot.

*Above all I bow my head before the **GOD ALMIGHTY** who drives me all along.*

With heartful thanks I dedicate this work to IIM.

Mini Abraham

To The God Almighty

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Introduction

INTRODUCTION

Mikania (*Mikania micrantha* H.B.K.) is a vigorous creeping and climbing weed native to tropical south and central America. It is commonly known as "climbing hempvine". Because of its quick growth and fast spreading nature, it is called `mile-a-minute weed' also. It is a perennial plant belonging to family Asteraceae.

In Asia, *Mikania* was first introduced to Malaysia, where it was tried as a cover crop in rubber because of its fast growth rate. But later on it was realised that it was much more competitive to the crop than the leguminous cover crops (Weng, 1964). Now it has become a serious weed in plantations of forest trees, tea, rubber, oil palm etc in India, Bangladesh, Myanmar, Indonesia, Philippines etc. (Holm, *et al.*, 1977).

In India, it was first introduced to North-Eastern regions during 1940's. It is believed that this plant was inducted in this region by the American soldiers during World war II for camouflaging purpose. Now it is a serious weed in the forests, orchards, farms and tea gardens in Assam and adjoining states.

In Kerala, it was first reported by Nair (1968) from the Rubber Research Institute of India, Puthupally, Kottayam. But during the last 30 years, its spread was very fast and it is now distributed densely in the districts of Ernakulam, Kottayam, Thrissur, Alappuzha, Idukki and Pathanamthitta. Only localised infestation is noticed in other districts. It is a problem weed in forests, plantations and in agricultural fields where the crop is over-grown and smothered by *Mikania* growth which reduces the availability of sunlight. Thus the growth of the crop plant is adversely affected. It is also seen on the roadsides, climbing on the fences, hedges and staywires of electric and telephone posts. It's growth is more luxuriant in moist soils and thick perennial growth is noticed on the banks and borders of aquatic areas and canals. A detailed survey needs to be conducted to study the present distribution and its severity in different parts of the state.

As *Mikania* has become a problem to agricultural and non agricultural areas, it is essential to develop an efficient method to manage this weed. Studies on the biology of the weed is essential to understand its growth, reproduction and spread as a first step to plan development of an appropriate control measure.

Many crops like pineapple, rubber, coconut, banana, cocoa, coffee, cassava etc. and forest trees face competition from *Mikania*. However the effect of competition from *Mikania* on these crops have not been quantified. In crops like rubber, allelopathic effect of *Mikania* have already been reported (Weng, 1964). Such effects on the other common crops also need our attention.

Efficiency of different methods like physical, chemical and biological method individually as well as in an integrated way have to be tested to identify the most economic and efficient method to control this weed. Being an introduced weed spreading fast in non agricultural areas like forest, biological method of weed control may be the most ecologically sound method of control. For this, studies on the bio organisms of these region as well as neotropical region from which *Mikania* has originated is essential. Different microorganisms infecting *Mikania* have to be identified and potential for utilising them as bioherbicide have to be tested.

Utilisation of *Mikania* for useful purposes also need to be studied. It can be used as a good source of organic manure and green manure as well as for making compost. It is also relished by cattle and many farmers use it as a fodder. However there are some reports against grazing by cattle since it causes hepatotoxicity in animals feeding on *Mikania* (Gaullier, 1986 and RIAD, 1986). Hence studies are to be conducted to find out its fodder value.

Considering the problem from *Mikania* and the urgent necessity to develop methods to manage the weed, this study was taken up with the following objectives:

1) to survey the distribution of *Mikania* in Kerala,
2) to study the biology, propagation, flowering behaviour and seed characters of *Mikania*,
3) to find out the competition and allelopathic effect of *Mikania* on major crops like rubber, coconut, teak, cocoa, banana and pineapple,
4) to test different methods of control to develop an economic and ecologically sound method and
5) to assess the utility of *Mikania* as a source of organic manure, fodder etc.

Review of Literature

REVIEW OF LITERATURE

Research on various aspects of *Mikania* and related plants such as biology, crop-weed competition, control methods, utility as fodder green manure and allelopathic effects are reviewed in this chapter.

2.1 Distribution of *Mikania*

Mikania has been noticed in different parts of Kerala and recently it is found spreading to newer areas at a faster rate (KAU, 1993). It has been observed in North eastern parts of India about half a century back as a problematic weed in forests and plantation crops. Choudhury (1972) reported that *Mikania* was introduced in this region by the American soldiers during World War II for camouflaging purpose. It was observed that *Mikania* was spreading so fast that it became the most prominent weed suppressing other plants in forests, tea garden, orchards, farms, crop fields, road sides and wastelands (Borthakur, 1977).

Mikania, native to Tropical America, was introduced to South East Asia as a ground cover in rubber (Weng, 1964), is now a serious threat to various agricultural systems. Thus it became a serious weed in South East Asia particularly in plantations of forest trees, tea, rubber, oilpalm, cocoa and in field crops of taro and sugarcane in India, Bangladesh, Myanmar, Malaysia, Indonesia, Philippines, S. Sumatra, Western Samoa and Cintamanis (Watson *et al.*, 1964; Weng, 1964; Mainstone and Weng, 1966; Gray and Hew, 1968; Parker 1972; Holm *et al.*, 1977; Dutta, 1977; Sauerborn, 1985; Pratiwi, 1989; Swarbrick, 1989 and Kuntohartono *et al.*, 1990). Widjaja and Tjitrosoedirdjo (1991) reported *Mikania* as the most prominent weed in one year old bamboo plantation in Lampung. In Guam, it was introduced as an ornamental plant (Mc Connell and Muniappan, 1991).

Mikania was reported as an important weed in coconut, cocoa, pineapple, mango, arecanut, teak, pineapple and banana (Soerjani, 1977; Suharto and Sudjud, 1978; Gangar *et al.*, 1987). A survey conducted by Gangar *et al.* (1987) on distribution and infestations of *Mikania* in S. Andaman Island (India) during 1986 showed that the highest coverage of the weed was recorded along natural water sources (45.50 t fresh weight ha^{-1}). Cleared forest areas, roadside trees and shrubs were also heavily infested by the weed. In plantation crops, the highest incidence of *M. cordata* (16 t fresh weight ha^{-1}) occurred in *Areca catechu* followed by red oilpalm (14.8 t) and coconut (13 t). In mango, banana and pineapple fields, *Mikania* infestations of more than 10 t fresh weight ha^{-1} was recorded.

2.2 Biology of *Mikania*

Understanding the biology of a weed will help us to understand the most sensitive stage in its life cycle, and its method of propagation and reproduction. This knowledge is very important to develop and plan effective programme for managing the weed.

2.2.1 Morphology

The climber is a perennial, having 5-10 cm long cordate - ovate leaves with crenately toothed margin. It generally produces a set of subsidiary offshoots to twine round objects of any kind, including 15-20 m tall trees, and spread from one bush to another in search of light (Choudhury, 1972). The laterals are equally vigorous like main stem and it becomes difficult to distinguish between the two. In the beginning of its growth, the new suckers from old stock become violet or purple in colour during June-July. Some stems facing the sun also become purple. In the same plant itself, some stems become hairy while others become smooth. The top part of *Mikania* plant dies out every year but suckers on the ground or main stock may survive for years (Dutta, 1977). Ipor (1991) studied the influence of shade on the growth and development of *Mikania micrantha* under glass house conditions. Shading significantly affected the vegetative growth, dry matter production, leaf area and biomass partitioning. Plants grew vigorously under 50 per cent shade. With maximum shading (75 per cent), *Mikania* showed the highest values of leaf weight ratio, specific leaf area and leaf area ratio.

2.2.2 Flowering

Many researchers have studied the inflorescence morphology of *Mikania* (Choudhury, 1972; Dutta, 1977). The inflorescence of *Mikania* is an umbel of heads. The head is four to five mm long with small ovate bracts at the base, the involucral scales are oblong-elliptic and shortly acute at the top, the limbs of the corolla is broadly funnel shaped. The petals are white in colour. In Assam, *Mikania* blooms in November-December and fruits mature in January (Choudhury, 1972; Dutta, 1977). Sasikumar and Prakash (1998) noticed flowering of *Mikania* in Kerala from October onwards and fruiting from February to April. Flowering was delayed in plants growing in partly shaded area.

Sauerborn (1985) studied the biology of selected weeds of western Samoa and reported that flowering of *Mikania* was not influenced by day length.

2.2.3 Seed output

Seed output of *Mikania* is very high. According to Dutta (1977), Single

Mikania has the potential to produce 40,000 viable seeds. He observed that average number of inflorescence per plant was 350, average number of flowers per inflorescence was 40 and number of fertile seeds per flower was three. However in Kerala, Sasikumar and Prakash (1998) estimated the average seed output of *Mikania* as high as 4,33,500. They took observation from 100 plants that were rooted at only one region in the soil and found twining on shrubs and small trees.

2.2.4 Seed dormancy

Dutta (1977) reported no dormancy period in the life cycle of *Mikania*. Seed germination becomes effective and quick in January, decreasing gradually in subsequent months. Sauerborn (1985) also observed no dormancy period in *Mikania*. However, Sasikumar and Prakash (1998) reported dormancy of freshly collected seeds which recorded only 13.3 per cent germination in contrast to 50 per cent germination after breaking up the dormancy. The treatments to break dormancy included mechanical and acid scarification, washing in water soaking the seeds in hot water and storage. Among these treatments, four months storage alone gave 50 per cent germination indicating that the embryo needs a resting period before its germination. They also reported decline in germination per cent after four months storage.

2.2.5 Reproduction of *Mikania*

Mikania holds an advantage over many other weed because of its potential for vigorous vegetative and sexual reproduction. While studying the vegetative propagation of *Mikania*, Mercado (1994) found that both stem (branches) and leaves gave rise to new plants. Eventhough the internodes also root easily, they did not give 'rise to new plants. Sasikumar and Prakash (1998) also made similar observations. *Mikania* propagates more profusely by runners (rooting at the nodes) than the seeds

(Choudhury, 1972; Swamy and Ramakrishnan, 1986). Eventhough percentage of seed germination is very low, the small number of plants that grow from the seeds can cover a wide area within a few months time (Choudhury, 1972; Mercado, 1994). Seedlings of *Mikania* were very weak in early stages and showed slow establishment in the field with a mortality rate of 43.6 per cent (Sasikumar and Prakash, 1998).

Temperature and light have influence on seed germination. Sauerborn and Koch (1988) reported that the lowest temperature at which seed germination occurred was in the range of 10-15°C, the highest at 40°C and the optimum between 20°C and 35°C. According to Hu and But (1994) germination per cent at 5°C, 25-30°C and 40°C was 0.33 per cent, 83.7 per cent and 1.0 per cent respectively. *Mikania* seeds were light sensitive with only 35.3 per cent germination under complete darkness (Hu and But, 1994). But Mercado (1994) reported only 13.3 per cent germination in darkness in contrast to 63.3 per cent in continuous light.

2.3 Crop weed competition

Weed competition is probably the most important single factor limiting yield of crop plants. *Mikania* is highly competitive because of its fast growing and twining nature. It can twine round even 15-20 m tall trees.

Mikania has been reported to be a problematic weed which affects the growth and yield of plantation crops such as tea, oilpalm, rubber etc. in India, Bangladesh, Myanmar, Malaysia, Indonesia, Philippines etc. (Weng, 1964; Mainstone and Weng, 1966; Gray and Hew, 1968; Parker, 1972; Dutta, 1977 and Holm *et al.*, 1977). Weng (1964) reported that rubber trees grown together with *M. cordata* have shown lower contents of N and P in their leaves, depressed rooting in the litter layer and A horizon and have developed relatively small canopies.

Palit (1981) reported that *Mikania* caused damage in timber trees by smothering the crown and causing deformation. Eventually the plant was completely killed. Even when a plant was not completely killed, it was left emaciated and stag headed - ultimately producing defective timber. In his studies, the most affected were the sal plantations, which are slow starters. *Mikania* over-tops them easily, if not attended to even for a short period and wipes out the plantation completely. The fate of the miscellaneous species that are raised with sal was not different. Teak trees could hold on for a little longer on account of their initial fast growth. But it was also over-powered and the trees were generally left malformed and crooked. Widjaja and Tjitrosoedirdjo (1991) also observed the same effect in bamboo plantation in Lampung.

Effect of weed competition on crop plants was studied by many researchers. Kasasian and Seeyave (1968) observed that the main effect of weed competition on bananas was the delay in maturity. Seeyave and Philips (1970) found that the banana plants in clean weeded plots were taller with more girth, showed early bearing, produced higher yield and softer fruits. Utulu (1986) observed reduction in oilpalm seedling dry weight, height, leaf area and leaf number due to weed competition.

2.4 Control methods

Mikania is currently controlled by physical and herbicidal methods. Being a predominant weed in nonagricultural areas and forests, biocontrol methods are gaining importance. Each of these methods has its own importance for different situations.

2.4.1 Physical methods

Physical methods such as slashing and digging are the most commonly practised method to control *Mikania* (Mainstone and Weng, 1966). Spread of the weed could be prevented by cutting away the weed at its base before September, so that the weed died before producing flowers (Borthakur, 1977).

Growth behaviour of the plant showed that physical method is not a practical approach. *Mikania* stock was able to survive against burning or cutting and new suckers grew from the old stocks (Dutta, 1977). So slashing, the practice followed currently, was not successful as the weed regenerates profusely (Sarma and Mishra, 1986).

Mechanical control is an important part of management of *Mikania,* but it is expensive. Palit (1981) estimated the expenditure involved for different weeding such as cultural, mechanical and chemical methods to control *Mikania* in plantation forestry in West Bengal. He reported that the cost of mechanical control had gone up considerably about 12.5 - 17.5 per cent higher than other methods. In a study conducted in Malaysia comparing three weeding methods (grazing by 433 sheep/acre, mechanical slashing and use of scout (glyphosate + picloram) at 3 ha^{-1}) for the control of weeds including *Mikania* in rubber garden, best result was obtained in chemically weeded plots. Two months after giving the treatment, more than 90 per cent of weeds had regrown in grazed and slashed plots while in chemically weeded plots only less than 10 per cent weeds regenerated (Faiz, 1992).

2.4.2 Chemical methods

Physical methods are not practical and economic as the weed regenerates profusely and spreads rapidly. The situation necessitates the use of chemicals. Suitable herbicides for cropped and noncropped areas have to be identified.

2.4.2.1 Control of *Mikania* with pre-emergence herbicides

Application of pre-emergence herbicide to prevent the establishment of *Mikania* could be a better approach than spraying post-emergence herbicides in cropped areas. Effective control of weeds including *Mikania* was obtained for a period of about 2 to 3 months in tea plantation by pre-emergence application of simazine at a rate of 3 to 4 kg ha^{-1} (Dutta, 1966 and Dutta, 1977). Application of diuron and cynazine gave good control of *Mikania* in rubber, tea, coffee and oil palm plantations in N. Sumatra and Java (Soerjani *et al.,* 1976). A trial in tea plantation in North East India showed that oxyflourfen at 0.125 kg ha^{-1} applied pre-emergence of weeds in May followed by oxyflourfen at 0.06 kg ha^{-1} + either paraquat at 0.24 kg ha^{-1} or 2,4-D at 0.80 kg ha^{-1} as post-emergent controlled *Mikania* throughout the season. The cost of weed management with herbicides was lower than that with the traditional garden practices (Ghosh and Ramakrishnan, 1981).

2.4.2.2 Control of *Mikania* with post-emergence herbicides

Post emergence application of herbicides was found promising in controlling *Mikania*. Spread of *Mikania* can be prevented by applying the herbicide before flowering.

Paraquat was found to be effective in controlling *Mikania* in rubber, oil palm and tea plantations (Seth, 1969; Seth, 1971; Teoh *et al.*, 1985; Hee *et al.*, 1993 and Ipor and Price, 1994). Repeated application of paraquat at different doses (0.28, 0.56, 0.84 and 1.12 kg ha^{-1}) have been tried to control *Mikania* in rubber. Duration of control increased with increasing dose. All doses produced high initial scorch, but was only short lived and vigorous regrowth followed. The best treatment was paraquat at 0.56 kg ha^{-1} followed three weeks later by a second application at a rate of 0.28 or 0.56 kg ha^{-1}. The repeated application of paraquat provided lasting control of *Mikania* while the use of single spray of paraquat did not provide lasting control (Seth, 1971).

Glyphosate application gave prolonged control of *Mikania* in rubber, tea and oilpalm plantation (Sukasman, 1979; Wong, 1973; Teng and Teh, 1990 and Hee *et al.* 1993). Application of roundup (glyphosate) at a rate of three litres in 700 litres of water for one hectare completely killed *Mikania* with only less than 10 per cent regrowth even three months after treatment (Sukasman, 1979). In a trial conducted in oilpalm plantation in Malaysia using wallop (Glyphosate 16.20 per cent w/w + dicamba 8.10 per cent w/w) at a rate of 3 l ai ha^{-1} gave 90 per cent control of *Mikania* 30 days after application (DAA) and 40 per cent control, 120 DAA compared to a maximum of 95 per cent by 7 DAA and zero per cent by 120 DAA by paracol (paraquat + diuron) at 2.80 l ha^{-1} (Teng and Teh, 1990). In rubber and oilpalm plantations, glyphosate application resulted in a shift to predominantly broad leaf weeds whereas paraquat mixture maintained similar floral composition (Hee *et al.*, 1993).

2,4-D is a widely used chemical against broad leaved weeds. *Mikania* could be effectively controlled by any 2,4-D formulation sprayed at the rate of 0.50 to 0.75 kg ai ha^{-1} (Seth, 1971; Mangoensoekarjo and Kadnan, 1973; Soewardji and Butar, 1975; Dutta, 1977; Borthakur, 1977; Mangoensoekarjo, 1978; Palit, 1981; Hutauruk *et al.*, 1982 and Teoh *et al.*, 1985). Seth (1971) compared repeated sprays of paraquat at 0.28 kg ha^{-1} with a single application of 2,4-D at 2.24 kg ha^{-1} and reported that two closely spaced applications of paraquat gave control similar to that with a single application of a high rate of 2,4-D. Trial at North Sumatra on eradication of *Mikania* in immature rubber showed that 2,4-D amine at 0.75 kg ha^{-1} sprayed twice at an interval of four weeks proved to be more effective and economical than hand weeding or MCPA, paraquat, MSMA ioxynil or glyphosate (Mangoensoekarjo and Kadnar, 1973). Hutaurak *et al.* (1982) studied the effectiveness of glyphosate, picloram + 2,4-D and 2,4-D amine for the control of *Mikania* in young oil palm plantations and reported that 0.75 l picloram + 2,4-D ha^{-1} gave the best result, but glyphosate at 2-4 l ha^{-1} gave only moderate control after four weeks. 2,4-D is effective and the cost involved in using 2,4-D was substantially less compared to other herbicide (Palit, 1981; Soewardji and Butar, 1975). Eradication of *Mikania* could be possible by spraying 2,4-D at three weeks interval (Soewardji and Butar, 1975). But, according to Mainstone and Weng (1966), spot spraying with 2,4-D only delays the invasion rather than its prevention in subsequent years.

2.4.3 Biological methods

Nonchemical methods of weed control is gaining importance now a days because of the high cost and environmental hazards caused by herbicides. At the same time, the chemical method is not always safe to the crop plants. *Mikania* is considered as the major agricultural pest in one or more regions and screened by research workers for control by biological methods (Cock, 1982b; Sarma and Misra, 1986 and Evans, 1987).

2.4.3.1 Pests on *Mikania*

Prospects for biological control of *Mikania* by insects have been reported by various workers. Survey and assessment of natural enemies of *Mikania* was done in regions where *Mikania* was a problem weed. Promising biological control agents were recommended for introduction to a particular region after studying the life history, culture techniques, host specificity and natural enemies (Cock, 1980; Cock, 1981; Cock, 1982b; Cock, 1985; Teoh *et al.*, 1985). Cock (1980) identified biocontrol agents from Venezuela, Costa Rica, Panama, Colombia and Trinidad. According to his investigation, eriophiid mite, *Acalitus sp.* was almost specific to *Mikania. Liothrips sp.* (Phloeothripidae), *Tetrastichus thripophomus* (eriophid mite) and *Omoplata quadristillata* (Cassidinae) were found host specific to *Mikania. Physimerus pygmaeus* (Halticinae) feeds on *Mikania.* Seed feeding weevil, *Apion luteirostre* (Apionidae) had been reared from flowers of *M. micrantha. Pseudoderelomus baridiiformis* (Curculionidae) was the most abundant beetle feeding on the flowers of *M. micrantha* and sometimes caused 25 per cent damage. However, attempts to rear it on flowers were unsuccessful.

Among the species given, *Liothrips sp.* and *Acalitus sp.* were recommended as the most promising control agent for introduction to South East Asia. Works under the Commonwealth Institute of Biological Control have identified nine major and 20 minor natural enemies from the neotropics, the native home of *Mikania* (Cock, 1982a). Out of these *Liothrips mikaniae* was the most promising one for introduction to South East Asia. Other host specific species were eriophiid mite, *Acalitus sp.*, the seed feeding weevil *Apion luteirostre*, the flower midge *Neoelasioptera sp.*, the inflorescence inhabiting lace bugs *Teleonemia sp.*, the cassids *Omoplata sp.* and the weevil *Pseudoderelomus baridiiformis.* According to his observations, the reason for the aggressive occurrence of *Mikania* in the Old World and mild occurrence in the New World was the presence of wide range of phytophagous insects in the New World.

Works in North East India revealed *Mikania* as an alternate host of tea mosquito bugs (*Helopeltis theivora* Waterh) and the caterpillar *Diacrisia* as a large scale defoliater of *Mikania* (Dutta, 1977). A survey conducted at KAU under AICRP on bio-control of crop pests and weeds showed that *Mikania* is severely infested by *Spilosoma obliqua (Diacrisia),* tea mosquitoes, jassids, aphids, cowbugs and mealybugs (KAU, 1992).

2.4.3.2 Fungal pathogens on *Mikania*

Potential of fungal pathogens as biocontrol agent for *Mikania* have been studied by many researchers (Chupp, 1954; Sharma, 1976; Dutta, 1977; Evans, 1987; Barreto and Evans, 1995 and Caunter and Lee, 1996). In a detailed study on the pathogenic organisms infecting important weeds in tropical and subtropical countries, Evans (1987) reported a number of pathogenic organisms infecting *Mikania* in different tropical and subtropical countries. They were *Plasmopara mikaniae* from Ivory coast; *Schiffnerula spectabilis* from Uganda; *Aecidium mikaniae* from Kenya, Sudan and Brazil; *Cronartium portoricensis* from West Indies, Central and South america, *Puccina spegazzinii* from West Indies, Trinidad, C. America, Brazil and USA; *Uromyces mikaniae and Coniothyrium mikaniae* from Brazil; *Cercospora mikaniae, Mycovellosiella sp.* and *Cladosporium mikaniae* from Puerto Rico.

In another survey on the fungi associated with *Mikania micrantha* in Southern Brazil, nine species were identified. Out of these *Basidiophora montana* has potential as a classical biological control agent of the weed in old world subtropical or montane climates whilst *Mycosphaerella mikaniae micranthae* appeared to be equally damaging to the host but to have wider climatic range (Barreto and Evans, 1995).

In Malaysia, Caunter and Lee (1996) reported that *Mikania* was seriously infected by *Cercospora mikanicola*. But it was difficult to use this pathogen for controlling *Mikania* because of its poor sporulation in culture and slow disease development.

Current strategy is to weaken the competitiveness of *Mikania* by the combined attack of both insects and fungi. But studies conducted at Malaya indicated that the majority of pests and pathogens caused only insufficient damage to *Mikania* (Teoh *et al.*, 1985). Also, difficulties are encountered with the establishment of biological control agents (Ooi, 1992).

In India, studies were conducted on the indigenous pathogens infecting *Mikania* in North Eastern regions where this weed was introduced almost half a century back. The major fungi reported were *Alternaria sp., Rhizoctonia sp.* and *Erysiphe cichoracearum* (Sharma, 1976 and Dutta, 1977). But killing *Mikania* by using this fungus was not successful.

2.5 Alternate uses

2.5.1 Utility as green manure

Large biomass production per unit time, high mineral nutrient content and fast decomposition rate are the important qualities for a green manure plant (IRRI, 1988).

2.5.1.1 Biomass yield, growth rate and mineral content

Mikania is also known as `mile-a-minute' weed. As the name indicates, *Mikania* grows about 8 to 9 cm day^{-1} (Choudhury, 1972) and it could cover up 20 to 25 sq.m. of space with a biomass production of 15 kg fresh weight per plant (Dutta, 1977).

Broughten (1977) studied the effect of various covers including *Mikania* on soil fertility under rubber and reported that on comparing the natural covers and legumes, *Mikania* yielded the least drymatter production, mineral content (N, P, Ca and Mg) and litter yield. But the K content was highest for *Mikania*. Average C/N ratio of litter accumulating from the growth of *Mikania* was 27, which indicates poor mineralisation rate. Alam *et al.* (1994) reported more than 1.8% N, 0.22% P, 0.22 - 0.35% Ca and more than 0.12% Mg content in *Mikania* leaves.

Suharte and Santoso (1985) studied the possibility of using *Mikania* leaves as green manure and reported that addition of dried leaf powder of *Mikania* to the soil increased height, total dry weight and number of needles produced in three month old potted seedlings of *Pinus merkusii*. In rice cultivation in Mizoram, use of *Mikania* as green manure increased the paddy yields (Saha, 1986). Nutrient cycling process in forest fallows in North Eastern India was studied by Ramakrishnan (1989) and found that *Mikania* conserve potassium in the system during the first few years of fallow regrowth.

2.5.1.2 Rate of decomposition

Litter decomposition is the primary mechanism by which organic matter and nutrients are returned to the soil for reabsorption by plants. Litter dynamics studies were reported to be very important in the nutrition budgeting of tropical ecosystems where the vegetation depended on the cycling of nutrients (Prichett and Fisher, 1987). The rate of decomposition is influenced by substrate quality and the micro-environmental conditions in which the litter is placed (Williams and Gray, 1974; Singh and Gupta, 1977; Kumar and Deepu, 1992; Sankaran, 1993 and Kunhamu, 1994).

Toky and Ramakrishnan (1984) studied the litter decomposition of five species during initial phases of secondary succession after slash and burn agriculture. According to their study, *Eupatorium odoratum* and *Borreria hispida* lost weight more rapidly than the other species; about 99 per cent of the initial weight was lost during the first 273 days. *Dendrocalamus hamiltonii* had the slowest rate of decomposition with 99 per cent loss in weight only after one year. They also reported that rate of litter decomposition and nutrient release were affected both by the micro-environmental conditions and the chemistry of decomposing litter. Kunhamu *et al.* (1994) reported that 90 per cent of the litter of *Acacia auriculiformis* disappeared within six months and the residual mass was remaining upto 16 months.

2.5.2 Utility as fodder

One of the main uses for the weeds, especially grasses, is their utility as fodder. In a country like India where the land is scarce, the area allotted for growing fodder crops is very less. Most of the fodder material is obtained from the crop wastes or from the weeds growing in cropped and noncropped areas.

Mikania is relished by the cattle (CSIR, 1962). Many farmers use it as a fodder along with other grasses. Arope *et al.* (1985) suggested grazing sheep as a measure for controlling weeds including *Mikania* in rubber gardens of Malaysia. He observed that sheep preferred *M. micrantha* to leguminous cover crops. Bogidarmanti (1989) also reported the importance of this weed as a livestock feed in tropical America and Asia.

However reports are there on avoiding of grazing *Mikania* by cattle. Gaullier (1986) studied the control of weeds in oilpalm groves by grazing cattle and reported that *Mikania* was not palatable to cattle. Reports are also available indicating the hepatotoxicity to animals feeding on *Mikania* (RIAD, 1986). Reasons for the liver damage of dairy cattle in N. Sumatra were studied by Murdiate and Stoltz (1987) and reported that *Mikania* contains some alkaloid like material.

Studies on the nutritive value of *Mikania* conducted by several workers have proved the utility of *Mikania* as a good source of roughage (Arope *et al.*, 1985; Ibrahim *et al.*, 1988; Alam *et al.*, 1994 and Baidya *et al.*, 1995). *Mikania* contains about 2.36% N, 0.21% P, 1.02% Ca and 0.12% Mg.

Total digestible nutrient content of *Mikania* was 72.63 per cent (Baidya *et al.*, 1995) and the *in vitro* organic matter digestibility (IVOMD) was 60 per cent (Ibrahim *et al.*, 1988).

2.6 Allelopathic effects of *Mikania*

Allelopathy is the effect of one plant on another through its metabolic products and is an important aspect of weed-crop interactions (Rice, 1979). Responses to allelochemicals have been reported to vary widely among species (Philips and Tucker, 1976). Studies conducted at Malaysia on growing *Mikania* as a cover crop for rubber showed that it had deleterious effect on growth and yield of rubber (Weng, 1964; Mainstone and Weng, 1966 and Mangoensoekarjo and Soewadji, 1973). Gray, 1963 and Gray and Hew (1968) also observed similar effects on oil palm.

Mikania was found to adversely affect other leguminous cover crops and also to reduce the nitrification in the soil. Result of the study conducted by Weng (1964) showed that green material extract of *Mikania* significantly reduced the dry weight and nitrogen content of tomato seedlings and legume cover crops. He also reported that

Mikania contained substances which on leaching or excretion could depress the growth of *Hevea brasiliensis,* tomato and *Pueraria phaseoloides* and also strongly inhibit the *in vitro* growth of *Fomes lignosus* and depress nitrification in the soil. Bioassay test with *F. lignosus* using oven dried fresh leaves, stem and roots, dead leaves and dead stems of *Mikania* showed that all extracts inhibited growth of the fungus, with root extracts showing greatest activity. He also did steam distillation tests to identify the growth inhibitory substances. Distillates of green material contained droplets of pale yellow oil which had little effect on soil nitrification and growth of tomato seedlings, but produced significant depressive effects on growth of *H. brasiliensis* seedlings. But root distillates were found to inhibit growth of *F. lignosus.*

Ismail and Mah (1993) conducted laboratory, green house and field studies to determine the allelopathic potential of *Mikania micrantha* on the germination and growth of weeds such as *Asystasia intrusa, Chrysopogon aciculatus* and *Paspalam conjugatum.* They reported that height of test weed species was decreased with increasing amounts of leaf or root of *Mikania* present as soil mulch or incorporated into the soil. *Mikania* incorporated into the soil caused a greater reduction in growth (5-10 per cent of control) than when used as soil mulch. Full-strength aqueous extract (28.9 g l^{-1}) of either leaf or root caused a significant decrease in germination, radicle length and fresh weight of the test sp. Effect was different for different test sp. In one study, leaf extract caused greater reduction of germination of *Asystasia* than of the other two species. They also reported that plants growing in *Mikania* infested soil gave lesser biomass yield than those on non infested soil.

Positive effect of *Mikania* on growth and yield of crop was also reported. Suhartaand Santoso (1985) studied the possibility of using *Mikania* leaves as green manure and reported that extracts of *Mikania* did not affect germination and subsequent growth of *Pinus merkusii* seedlings. Saha (1986) reported increased yield of rice by using *Mikania* as green manure.

Materials and Methods

MATERIALS AND METHODS

Studies on the biology and control of the weed *Mikania micrantha* HBK in Kerala were conducted at Kerala Agricultural University, Trichur during the period from 1995 to 1999. The project consisted of five parts.

1. Survey on the distribution of *Mikania* in Kerala
2. Biology of the weed *Mikania*
3. Weed crop competition studies
4. Studies on different control methods
5. Alternate uses of of *Mikania*

Details of the materials used and methods adopted in the studies are described in this chapter.

3.1 Location of the studies

Survey on the distribution of Mikania was conducted throughout Kerala. Experiments to study biology, weed crop competition, control methods and economic importance were done at College of Horticulture, Vellanikkara. Analysis of the fodder value was done at Aromatic and Medicinal Plants Research Station, Odakkali.

3.2 Distribution of *Mikania*

A survey was conducted to document the distribution and density of *Mikania* at different parts of Kerala by travelling along the major terrestrial routes of the state. Extent of infestation of *Mikania* in agricultural fields and nonagricultural areas such as waste lands, sides of canals, rivers and water bodies was noted and recorded. The rating of intensity of the infestation was done by visual observation and was classified as follows:

1. Isolated - Infestation in isolated locations, separated far apart.
2. Mild - At least one Mikania in one kilometre distance.
3. Moderate - Atleast one *Mikania* in 500 m distance.
4. Severe - At least one *Mikania* in 200 m distance.
5. Very severe - Heavy infestation in agricultural and non-agricultural field areas; at least one *Mikania* in 100 m distance

3.3 Biology of Mikania

3.3.1 Morphology of Mikania

Sample of Mikania from different parts of the state were observed for variation in the growth habit, colour of stem, hairiness and floral characters. The species of Mikania, was identified by comparing the floral characters of three species as described by Choudhury (1972).

3.3.2 Life cycle of *Mikania*

The life cycle of *M. micrantha* from germination, growth, flowering, seed production and death was studied in natural field conditions. Details of the observations made are given below.

3.3.2.1 Germination time under field conditions

During first week of March, the seeds were sown in field in a demarcated area. The area was kept undisturbed and was subject to the natural environmental conditions. The site was watered regularly and the time of germination was observed.

3.3.2.2 Time of flowering

Sites in each district where Mikania was a serious problem was selected and time of flowering was noted.

3.3.2.3 Period from flowering to seed maturity

During the first week of December 1996, developing flower buds were selected and tagged. The tagged buds were observed and the time taken from bud opening to maturity of seeds (when seeds became black) was recorded.

3.3.2.4 Seed production capacity

A *Mikania* plant was allowed to trail on a tapioca plant in the field. Average number of inflorescence per plant and number of heads (umbels) per inflorescence were counted. Observation from 10 such Mikania plant was taken.

Seed output = No. of seeds/head x
No. of heads/inflorescence x
No. of inflorescence/plant

3.3.2.5 Thousand seed weight

Weight of 1000 seeds was taken and recorded in grams.

3.3.2.6 Longevity of seeds

Longevity of seeds was determined by conducting germination tests. Mature seeds of Mikania were collected from the plant during December in 1996 and 1997. The seeds were air dried and stored. Germination percentage of seeds was determined by conducting germination tests on moist filter paper. The germination percentage was determined at monthly intervals for one year from the date of collection for seeds in both the years.

3.3.3 Reproduction of *Mikania* from cuttings, seeds and leaves

3.3.3.1 Cuttings

Experiment was conducted during the month of June in 1997. It was laid out in randomised block design with seven treatments and three replications. The treatments were the combinations of cuttings from four parts of the stem (apex, middle, base and internode) planted at four depths (0, 2, 5 and 10 cm). In each plot of one square metre area, 16 cuttings of 20 cm length were planted horizontally at the desired depth. Number of shoots sprouted and dry matter production were recorded at 30 days after planting.

3.3.3.2 Leaves

Leaves were kept in moist soil in a plastic tray with the lower side in contact with soil and incubated at room temperature in the laboratory. Ten leaves were kept after cutting the petiole close to the leaf blade. In another set, ten leaves plucked from the plant by pulling were kept as such (with the axillary bud). Observation on rooting and sprouting percentage were taken.

3.3.3.3 Seeds

Germination of seeds sown at different depths (0,5,10,15 cm) was tested in a field trial in randomised block design with four treatmentsand three replications. Plots of one square metre area were prepared and in each plot, two furrows of 10 cm width were taken at a spacing of 50 cm. Depth of the furrow was adjusted to 5,10 and 15 cm as per the treatment. For the zero depth of sowing, seeds were sown on surface as two lines at 50 cm spacing. In each furrow, 25 seeds of Mikania were sown after mixing with soil (total 50 seeds per plot). After sowing the seeds, the furrows were covered with soil to the surface level.

3.4 Crop-weed competition

Effect of competition from *Mikania* on the growth of crop plants such as cocoa (var. local), rubber (var. RRII-105), coconut (var. WCT), teak (var. local), banana (var. Nendran) and pineapple (var. Mauritius) were studied in the College of Horticulture, Vellanikkara during June 1996 to September 1997. For each crop, separate experiments were laid out in RBD with five replications. There were four treatments as detailed below:

1. Competition with one *Mikania*
2. Competition with two *Mikania*
3. Competition with four Mikania
4. Control (without weed competition)

Seedlings or suckers of uniform age were selected and planted during the month of June 1996. One month later, *Mikania* stem cuttings were planted beside the crop plants and the shoot growth were allowed to climb on them. The extra *Mikania* seedlings were thinned to maintain their number as per the treatments. In order to avoid spreading of *Mikania* on plants other than the treatments, the crop plants were planted at a wider spacing (4 m). For rubber, coconut, cocoa and teak, observations on height, girth and biomass yield of the plants were recorded one year after planting. For pineapple and banana, these observations were taken after the harvest of the crop. In addition, the time of flowering and the yield of the fruits were also recorded for banana and pineapple. The weight of *Mikania* growing over the crop plants was also recorded.

3.5 Control methods

3.5.1 Physical methods

Study was conducted in the rubber plantation near the College of Horticulture, Vellanikkara which had a fairly uniform infestation of *Mikania*. The experiment was laid out in randomised block design with five treatments and four replications in plots of 5 m x 5 m size. The treatments were:

1. Sickle weeding at monthly intervals
2. Sickle weeding at bimonthly intervals
3. Digging and removing stubbles at monthly intervals
4. Digging and removing stubbles at bimonthly intervals
5. Control

The trial was started in October 1996 and continued for 18 months. Observations on number of shoots sq.m^{-1} and drymatter production of regrowing shoots sq.m^{-1} were recorded at monthly intervals.

3.5.2 chemical methods

3.5.2.1 Effect of pre-emergence herbicides

A pot culture experiment in CRD with three replications and nine treatments was carried out in April-June, 1998 to study the effect of common pre-emergence herbicides for preventing germination and establishment of *Mikania.*

Treatments

1. Atrazine	:	1.5 kg ha^{-1}
2. Diuron	:	1.5 kg ha^{-1}
3. Oxyflourfen	:	0.2 kg ha^{-1}
4. Fluochloralin	:	1.0 kg ha^{-1}
5. Butachlor	:	1.5 kg ha^{-1}
6. Alachlor	:	1.5 kg ha^{-1}
7. Pretilachlor	:	0.5 kg ha^{-1}
8. Metolachlor	:	1.0 kg ha^{-1}
9. Control (unsprayed)		

Fifty *Mikania* seeds were sown in each pot filled with potting mixture and the herbicides (details of the herbicides used are given in Appendix I) were applied with a hand sprayer on the same day. Three pots representing three replications of a treatment were placed inside an iron quadrat of 1 m x 1 m and the quantity of the herbicide required for one square metre area was mixed with 100 ml of water and the entire quantity was sprayed uniformly inside the quadrat. Pots were watered regularly. Observation on number and dry matter production of *Mikania* seedlings were recorded at 60 days after sowing.

3.5.2.2 Effect of post-emergence herbicides

A field experiment was carried out in rubber plantation, college of Horticulture, Vellanikkara uniformly infested with *Mikania.* The trial was laid out in RBD with 13 treatments and four replications.

Treatments

1. 2,4-D Na	:	1.0 kg ha^{-1}
2. 2,4-D Na	:	2.0 kg ha^{-1}
3. 2,4-D Na	:	3.0 kg ha^{-1}
4. Glyphosate	:	0.4 kg ha^{-1}
5. Glyphosate	:	0.8 kg ha^{-1}
6. Glyphosate	:	1.2 kg ha^{-1}
7. Paraquat	:	0.4 kg ha^{-1}
8. Paraquat	:	0.8 kg ha^{-1}
9. Paraquat	:	1.2 kg ha^{-1}
10. Glufosinate ammonium	:	0.15 kg ha^{-1}
11. Glufosinate ammonium	:	0.30 kg ha^{-1}
12. Glufosinate ammonium	:	0.45 kg ha^{-1}
13. Control		

The area between four rubber plants planted at a spacing of 5.0 m apart formed a plot for herbicide spray. Spraying was done in October during 1996 and 1997, when *Mikania* was in the active vegetative growth stage. Chemicals were sprayed with an ASPEE back pack sprayer fitted with a flood jet nozzle with a spray volume of 600 litres ha^{-1}. The details of the herbicides used are given in Appendix 1.

Observations on percentage control of *Mikania* at 15,30,60 and 90 DAS (visual rating) and number of new shoots emerged after spraying and their dry weight were recorded at 30,60 and 90 days after spraying, from three randomly selected spots of $0.25m^2$ area using a quadrat of 0.5 m x 0.5 m size.

3.5.2.3 Effect of 2,4-D on *Mikania*

As the lowest dose of 2,4-D (1.0 kg ha^{-1}) tested in the previous trial resulted in 100 per cent control of *Mikania,* lower doses and different forms of 2,4-D (Na salt, ester and amine) were tested in a separate trial. The procedure followed for the trial and observations were the same as those for the above trial. Experiment was conducted in RBD with four replications. The details of the herbicides used are given in Appendex 1.

Treatments

1. 2,4-D Na	:	0.25 kg ha^{-1}
2. 2,4-D Na	:	0.50 kg ha^{-1}
3. 2,4-D Na	:	1.00 kg ha^{-1}
4. 2,4-D Na	:	2.00 kg ha^{-1}
5. 2,4-D Na	:	3.00 kg ha^{-1}
6. 2,4-D E.A	:	0.25 kg ha^{-1}
7. 2,4-D E.A	:	0.50 kg ha^{-1}
8. 2,4-D E.A	:	1.00 kg ha^{-1}
9. 2,4-D E.A	:	2.00 kg ha^{-1}
10. 2,4-D E.A	:	3.00 kg ha^{-1}
11. 2,4-D E.E	:	0.25 kg ha^{-1}
12. 2,4-D E.E	:	0.50 kg ha^{-1}
13. 2,4-D E.E	:	1.00 kg ha^{-1}
14. 2,4-D E.E	:	2.00 kg ha^{-1}
15. 2,4-D E.E	:	3.00 kg ha^{-1}
16. Control		

(Na - Sodium salt; E.A. - Ethanol amine, E.E. - Ethyl ester)

3.5.3 Biological methods

3.5.3.1 Indigenous pests on *Mikania*

3.5.3.1.1 Collection, preservation and identification of insects

Insect pests seen on *Mikania* were collected from the field, preserved and identified with the help of insect taxonomists.

3.5.3.1.2 Studies on the nature of damage

The nature of damage of aphids, thrips, jassids, mites and beetles found feeding on *Mikania* was studied in specimen tubes of size 10 x 2.5 cm. A tender shoot was wrapped in moist cotton at its basal portion and inserted into the tube containing test insects. The mouth of the tube was closed with muslin cloth. The nature of damage by lepidopteran pests was studied by rearing the caterpillar on *Mikania* grown in cages.

3.5.3.1.3 Intensity of tea mosquito attack

Extent of damage caused by tea mosquito bug (*Helopeltis theivora*) in the rubber plantation heavily infested with *Mikania* (at the College of Horticulture, Vellanikkara) was studied during October 1996. Observations on total number of leaves and number of damaged leaves in one square metre area were noted. The intensity of attack (I) was calculated by using the expression,

$$I = a/b \times 100$$

where,

`a' is the number of damaged leaves and `b' is the total number of leaves present in one square metre area.

3.5.3.1.4 Feeding capacity of lepidopteran pests

The caterpillars of lepidopterans collected were reared to adult singly in the laboratory. The larvae were reared in glass containers of size 15 cm height and 8 cm diameter in which *Mikania* leaves were supplied. Extent of consumption of leaves by third and fourth instar larvae was estimated from the difference in the area of *Mikania* leaves before and after feeding. The top of the bottle was covered with muslin cloth and secured by putting rubber bands. One to three leaves (pre-determined leaf area) were put in the bottle depending on the size of the leaves. In order to keep the leaves turgid, a boll of moist cotton was placed inside the bottle near the lid by tying with a thread and kept periodically moistened. For each insect species, three caterpillars were fed separately and the average was worked out.

3.5.3.2 Indigenous pathogens on *Mikania*

3.5.3.2.1 Identification of pathogen

Diseased leaves of *Mikania* were collected from the field and the fungal pathogens were isolated by culturing in potato dextrose agar (PDA) medium. Pathogenicity was proved by reinoculating the pathogen to a healthy plant. Spore suspension of the fungus prepared in sterile water was sprayed on healthy plant using an atomiser and the plants were kept in humid chamber. An equal number of plants sprayed with sterile water served as control. Progressive development of the disease was observed. After the production of symptom, fungus was reisolated. The fungi were got identified at the Department of Mycology and Plant Pathology IARI, New Delhi.

3.5.3.2.2 Production of toxic metabolites by *Colletotrichum* sp. and *Alternaria* sp.

The methods used for toxin experiments were as described by Varma (1991). The fungus was cultured in potato dextrose broth in 250 ml Erlenmeyer flasks. The liquid media were dispensed at the rate of 100 ml per 250 ml flask and sterilised by autoclaving at 1.05 kg cm^{-2} for 15 minutes. The media were inoculated with mycelial discs of 5 mm diameter obtained from the actively growing periphery of seven day old cultures of the fungi on PDA. For each treatment three replications were maintained. The inoculated flasks were incubated at room temperature. After the desired period of incubation, the cultures were filtered and filtrate and mycelium were utilised separately for toxin assay as follows.

The culture was filtered through Whatman No.1 filter paper. The filtrates obtained from the broth were pooled separately. The culture filtrate is designated as

`Exotoxin'. The mycelial mat was homogenised with five volumes of water, centrifuged at 1000 rpm for 15 minutes and the pellets discarded. The supernatant solution was again centrifuged for 15 minutes. Second centrifugate is designated as `Endotoxin'. The supernatant was reduced to one-tenth of its original volume under reduced pressure, combined with equal volume of methanol, stirred well and stored at 5°C overnight. The methanol solution was clarified by filtration and methanol was removed by evaporation under vacuum.

The toxin was assayed on *Mikania* leaves, stem and petioles (detached and attached) to detect the toxin activity. Drops of 0.05 ml of the test solution were applied on one half of the leaf with mild pin pricks. The other half of the leaf was inoculated with distilled water as control. Toxin was also sprayed on healthy potted *Mikania* plant, after mixing with one per cent teepol using an atomiser. Observations on development of necrotic spots after different periods of treatment (4,8,12,24 and 48 hrs) were taken and the diameter measured for comparative purposes.

3.5.3.2.2.1 Thermostability of the culture filtrates

The thermostability of the toxic metabolites obtained from the isolates of pathogen was investigated by boiling the culture filtrate at 100°C for five minutes as well as by autoclaving at 1.05 kg cm^{-2} for 20 minutes.

3.6 Alternate uses

3.6.1 Utility as green manure

3.6.1.1 Biomass yield

Mikania seeds were sown in first week of May in 1997 and irrigated. Isolated *Mikania* seedlings were allowed to climb on separate tapioca plants under field conditions. In October, Just before flowering the *Mikania* plants were cut and oven dry weight was recorded. From this, biomass production per plant per day was worked out. Average of ten plants was taken and recorded.

In order to work out the biomass yield of *Mikania* from unit area under natural conditions, all the *Mikania* growth in one sq.m. area was collected using a quadrat of 1 m x 1 m size. It's fresh weight and oven dry weight were noted. From the dry matter content of the samples taken, dry matter production of *Mikania* per unit area was worked out. Samples were taken from 10 point in an area where *Mikania* was growing as a thick growth covering the ground in the rubber garden.

3.6.1.2 Shoot growth rate

Growth rate of shoot of *Mikania* was studied under field conditions. A healthy *Mikania* shoot was tagged exactly 5 cm behind the tip. After 10 days, length from tagging point to 5 cm behind the tip was taken. Similar observation from 10 plants were taken and average growth rate per day was worked out.

3.6.1.3 Nutrient content in *Mikania*

Plant samples collected from five districts (Cannanore, Trichur, Ernakulam, Alleppey and Idukki) were separated into old stem, young stem, old leaf and young leaf. The samples were dried in hot air oven at 70°C.

Total N content of the samples was determined by Kjeldahl digestion and distillation method (Jackson, 1958). For the estimation of total P and K, the plant samples (1 g) were digested using diacid mixture (HNO_3 : $HclO_4$ in the ratio of 2:1) and the contents were made upto 50 ml. This diacid extract was used for P and K determination. Phosphorus was determined by vanadomolybdo phosphoric yellow colour method (Jackson, 1958) in Spectronic 20 Spectrophotometer. Potassium was determined using EEL flame photometer (Jackson, 1958). The same diacid extract was used for the determination of Ca, Mg, Zn, Cu, Mn and Fe also by using Atomic Absorption Spectrophotometer.

3.6.1.4 Rate of decomposition of *Mikania*

Decomposition rate of *Mikania* was studied using the litter bag technique (Sreekala, 1997). Study was conducted using 2 mm mesh nylon bags of size 0.3 m x 0.3 m. Quantity of *Mikania* biomass to be taken inside each litter bag was determined based on the average amount of *Mikania* biomass present per unit area under field conditions. Average quantity required for 0.3 m x 0.3 m size litter bag was calculated by taking six samples from field using 0.5 m x 0.5 m quadrat. Thus 200 g fresh *Mikania* (34 g dry weight) was taken in each litter bag. Both fresh and partially oven dried *Mikania* were used in separate experiments. Partial oven drying (for 12 hours at 80°C) was done to avoid the sprouting of *Mikania* from the litterbag. The mouth of the bags were closed to avoid loss of the sample. They were placed under the thick cover of *Mikania* in the field in contact with soil.

The study was started in September 1996 and was conducted in a completely randomised design with five replications. Five bags of each type (fresh and partially dried) were recovered after 10,20 and 30 days from start and thereafter at monthly intervals for one year. The samples were carefully separated from mineral particles, washed, cleaned well and oven dried. The undecomposed residue left was estimated. Difference in weight between the initial weight (34 g dry weight) and the weight of undecomposed residue left was taken as the quantity decomposed. Percentage of decomposition was then calculated on dry weight basis.

3.6.2 Utility as fodder

Whole plant samples collected from four districts (Trichur, Ernakulam, Aleppey and Idukki) were dried, powdered and the composite samples were used for the analysis of fodder value. The parameters studied, the methods followed and the references are given in Table 1.

3.6.3 Allelopathic effects of *Mikania*

This investigation was carried out to determine whether *Mikania* produced growth inhibitory or toxic substances. Pot culture experiments were conducted with rice (var. Jyothy), cowpea (var. Kanakamany) and rubber (var. Marthandam) seedlings as test plants following the procedure of Weng (1964).

3.6.3.1 Allelopathic effect of fresh *Mikania*

3.6.3.1.1 *Mikania* used as mulch

Five seeds of the test crops were sown in separate pots (14 inch diameter) holding 5 kg soil and mulched with fresh *Mikania* at rates of 0%, 1%, 2% and 4% of the soil on oven dry weight basis. To get this concentration, 0 g, 225 g, 450 g and 900 g fresh *Mikania* (22.2% dry matter) was required. These doses, much higher than the quantity of green manure usually applied to crop fields, was used to see whether continuous application of *Mikania* would be deleterious to the crop plants due to the allelochemicals that may be present in it. These four treatments were tested in CRD with five replications. The seedlings were thinned to three in the case of rice and one in the case of cowpea and rubber, at five days after germination.

To avoid the sprouting of *Mikania*, the whole plant was cut into small pieces of 2-5 cm size before mulching. The pots were watered regularly. Observations on the height of the plants and dry matter production were taken after six weeks.

3.6.3.1.2 *Mikania* incorporated in soil

Fresh *Mikania* chopped into small pieces was mixed well with the soil in the pots and the effect was studied with rubber, cowpea and rice as test crops. The treatments and the corresponding quantity of *Mikania* used were the same as for the above study (3.6.3.1.1.). Observations were also noted as in the above study.

Table 1 Details of the parameters studied for estimation of fodder value

Parameters	Method	Reference
A. Chemical composition	Weinde Method (Proximate analysis)	AOAC (1990)
(1) Crude protein		
(2) Crude fibre		
(3) Ether extract (crude fat)		
(4) Nitrogen free extract		
(5) Total ash		
(6) Acid insoluble ash		
(7) Calcium		
(8) Phosphorus		
B. Fibre fraction	Van Soest method	Van Soest (1963)
(1) Neutral detergent fibre		
(2) Acid detergent fibre		
(3) Cellulose		
(4) Lignin		
(5) Hemicellulose		
C. Antinutritional factor	Picric acid paper method	AOAC (1990)
(1) Hydrocyanic acid qualitative		
(2) Hydrocyanic acid - quantitative	Alkaline titration method	AOAC (1965)

3.6.3.2 Allelopathic effect of water extract

3.6.3.2.1 Effect of water extracts on seed germination

Aquous extracts of whole plant samples were prepared by soaking ground green material and roots for 18 hours in water followed by filtration (Weng, 1964). The different treatments (concentrations) were 0%, 1%, 2% and 4% (based on number of grams of dried material used for preparation of 100 ml).

To study the effect of extracts of *Mikania* on germination of seeds of cowpea and rice, ten seeds of each were placed in separate petriplates containing Whatman No.1 filter paper. Ten ml of the four per cent extract was added to wet the filter paper. Another set of petriplates wetted with distilled water served as the control. Percent germination and radicle length of seedlings were recorded at 24, 48 and 72 hours.

3.6.3.2.2 Effect of water extracts on seedling growth

In a second experiment, seeds were sown in pots (8 inch size) holding one kg soil (fresh weight) and treated twice weekly with 250 ml of aquous extracts. The experiment consisted of four treatments (0%, 1%, 2% and 4% extract) and five replications in a completely randomised design. Observations on the length of the plants and dry matter production (oven dried) were taken six weeks after sowing.

3.8 Statistical analysis

The data collected were subjected to statistical analysis using the analysis of variance technique as described by Panse and Sukhatme (1985). Data on weed count, which showed wide variation were subjected to square root transformation and data on proportionate value were subjected to arcsine transformation to make the analysis of variance valid as suggested as Bartlett (1947). Comparisons among treatment means were done by using Least Significant Difference (LSD) and Duncans Multiple Range Test (DMRT).

Results

RESULTS

4.1 Distribution of *Mikania* in Kerala

Distribution of *Mikania* in Kerala is given in Table 2 and illustrated in Fig.1. Infestation of the weed is severe in all parts of Ernakulam and Kottayam districts. It is also seen in some parts of other districts mainly the adjoining areas of Ernakulam and Kottayam districts.

The weed has not yet spread to the southern most district of Kerala (Trivandrum). In North-eastern regions of Kollam district (Punalur, Anchal, Pandalam, Kulathupuzha, Thenmala and Aryankavu areas), isolated incidence of *Mikania* is found. In Pathanamthitta district, infestation is mainly in the North-western region. *Mikania* infestation is more severe along the sides of Achankovil river. Infestation in Alappuzha district is towards the northern region starting from Ambalapuzha onwards. In Idukki district, though this is a severe problem in lower altitude regions (Thodupuzha, Neriamangalam, Kattappana, Painavu, Neendapara, Adimaly etc.), it is not seen at the higher altitude regions like Moonnar and Devikulam where the altitude is 3500-4000 m from MSL. Incidence is serious upto lower Periyar, including the forest areas. Severe infestation of *Mikania* is noticed along the National Highway route from Chalakudy to Pattikad in Trichur district and is extending upto Kuthiran. In Chalakudy, severe infestation is seen along the Sholayar route where the forest plantations are infested. Other areas of Trichur where mild occurrence is noticed include Irinjalakuda and Kodungallur. Mild to moderate infestation is observed at Kollamkodu, Alathur, Nelliampathy, Palakkad town and Mannarkkad in Palakkad district.

Table 2 Distribution of *Mikania* in Kerala

Sl. No.	District	Location	Intensity of infestation
1	Thiruvananthapuram	No infestation	
2	Kollam	Thenmala	Isolated
		Aryankavu	Isolated
		Kulathupuzha	Isolated
		Anchal	Isolated
		Pandalam	Moderate
		Adoor	Isolated
		Quilon	Isolated
		Kottarakkara	Isolated
3	Pathanamthitta	Thiruvalla	Severe
		Chengannoor	Mild
		Omalloor	Mild
		Pathanamthitta	Mild
		Pattanapuram	Mild
		Punaloor	Mild
		Konni	Mild
		Kozhencherry	Severe
		Ranni	Very severe
		Achamkovil	Severe
		Aranmula	Mild
		Pamba	Severe
4	Alappuzha	Ambalapuzha	Mild
		Alappuzha	Very severe
		Kalavoor	Very serious
		Cherthala	Very serious
		Kuthiathodu	Very serious

Table 2 contd....

5	Kottayam	Vaikom	Severe
		Melukavu	Severe
		Arakkulam	Severe
		Kottayam	Very severe
		Karukachal	Severe
		Kuravilangad	Very severe
		Vakuthanam	Severe
		Palai	Severe
		Teekoy	Severe
		Bharananganam	Severe
		Ramapuram	Severe
		Erattupetta	Severe
		Poonjar	Severe
		Kanjirappally	Severe
		Manimala	Very severe
		Erumely	Very severe
		Parathodu	Moderate
		Ponkunnam	Moderate
		Mundakkayam	Serious
6	Ernakulam	Koothattukulam	Very severe
		Moovattupuzha	Very severe
		Vazhakulam	Very severe
		Arakuzha	Very severe
		Kothamangalam	Very severe
		Kuruppumpady	Very severe
		Odakkali	Very severe
		Perumbavoor	Very severe
		Kalady	Very severe

Table 2 contd....

		Nileswaram	Very severe
		Malayattoor	Very severe
		Manjapra	Very severe
		Angamali	Very severe
		Aluwa	Very severe
		Kalamassery	Very severe
		Palarivattom	Very severe
		Ernakulam	Very severe
		Kolencherry	Very severe
		Payipra	Very severe
		Piravam	Very severe
		Mazhuvannoor	Very severe
		Tripunithura	Very severe
7	Idukki	Thodupuzha	Very severe
		Neriamangalam	Very severe
		Ponnukal	Very severe
		Irumbupalam	Very severe
		Adimali	Very severe
		Pallivasal	Very severe
		Machiplavu	Severe
		Chattupara	Severe
		Idukki	Moderate
		Cheruthoni	Moderate
		Painavu	Moderate
		Udumbanchola	Isolated
		Elappara	Isolated
		Kattappana	Isolated
		Vellayamkudy	Isolated

Table 2 contd.....

		Neendapara	Moderate
		Kaliamala	isolated
		Karimban	Moderate
		Churuli	Moderate
		Keerithodu	Moderate
		Lower Periyar	Severe
		Kumili	Mild
		Peerumedu	Mild
		Kuttikkanam	Mild
8	Trichur	Chalakudy	Severe
		Pudukkad	Mild
		Amballur	Mild
		Irinjalakuda	Mild
		Kodungalloor	Mild
		Trichur	Very severe
		Mannuthy	Very severe
		Vellanikkara	Very severe
		Pattikad	Very severe
		Peechi	Very severe
9	Palakkad	Kuthiran	Moderate
		Kollangode	Mild
		Palakkad	Mild
		Alathur	Moderate
		Nelliampathy	Moderate
		Mannarkad	Moderate
10	Malappuram	Anakkayam	Isolated
11	Kozhikode	Kozhikode	Isolated
		Meenchanda	Isolated

Table 2 contd....

		Mancombu	Isolated
		Quilandi	Isolated
12	Wynad	Pulpalli	Isolated
		Nedumpoi	Isolated
		Mananthavadi	Isolated
		Karthikulam	Isolated
		Meenangadi	Isolated
		Thirunelli	Isolated
		Panamaram	Isolated
13	Kannur	Dharmadam	Isolated
		Aramula	Isolated
		Valapattanam	Isolated
14	Kasaragod	Kanjangad	Isolated
		Sullia	Isolated

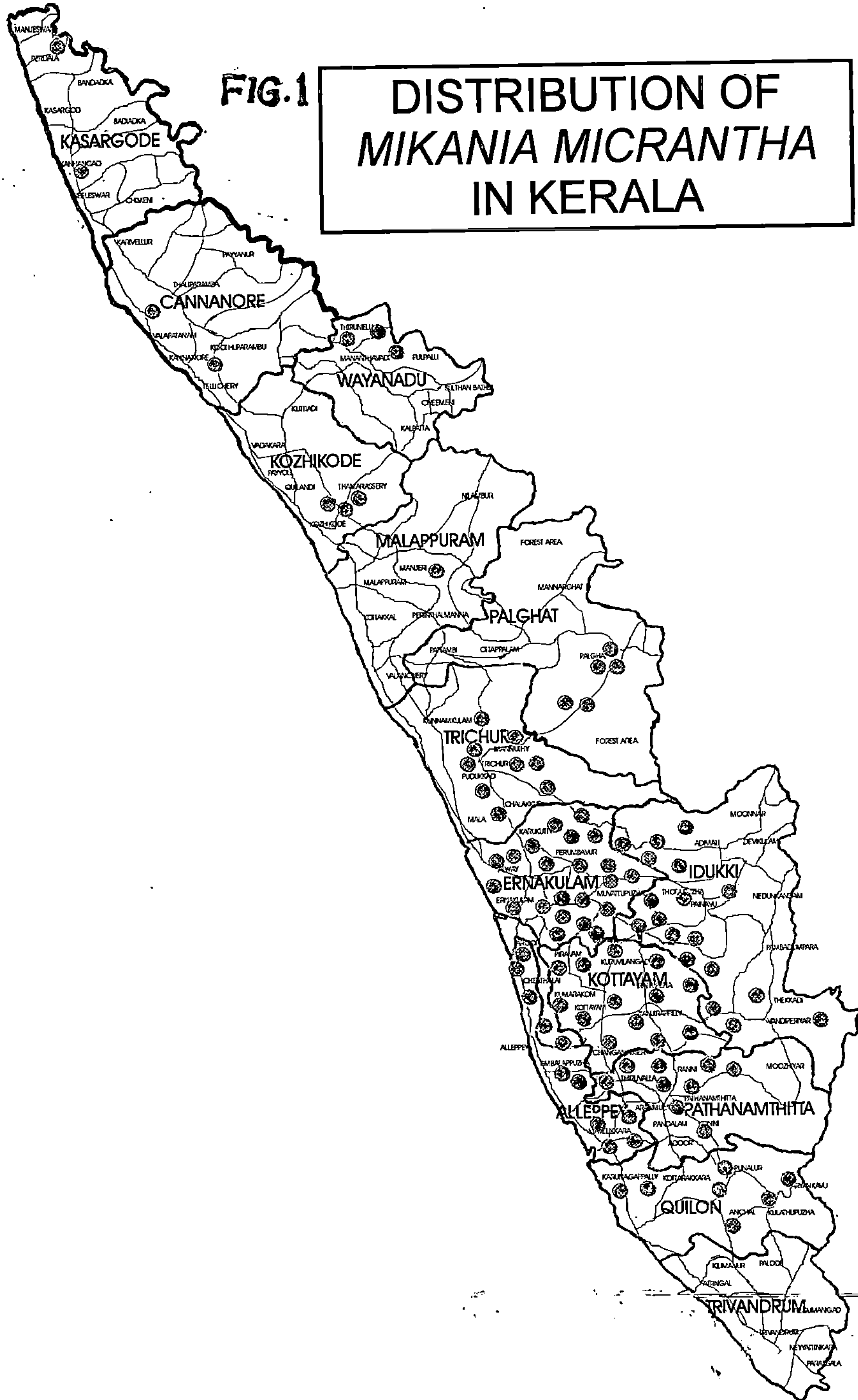


FIG.1 DISTRIBUTION OF *MIKANIA MICRANTHA* IN KERALA

The weed is yet to spread in Northern districts of Kerala. In Malappuram district, the only place where the weed was observed is Anakkayam. In Calicut district, the infestation is seen at Meenchanda in Calicut city located at sea level and at Pakranthalam, the higher altitude region in the eastern side. In Wynad district, the infestation is seen only at Panamaran, Mananthavadi and the forest areas around Pulpalli and near Thirunelly, near the Karnataka border. Only isolated incidence of *Mikania* is seen in the districts, north of Calicut. In Kannur district, it is noticed in Dharmadam and Valapattanam. In Kasaragod district, the only place where *Mikania* is present in the Kanjangad.

In the areas where *Mikania* is present, it is densely found on roadsides, railway tracks, sides of canals and rivers and near waterbodies. Most of the staywires on road sides are twined by *Mikania*. In many places, *Chromolaena odorata,* the major weed of these regions, is being smothered and replaced by *Mikania*. Thick mass of water hyacinth growing in marshy areas of Ernakulam are seen grown over and suppressed by *Mikania.*

Mikania is a serious weed in the fields of pineapple (Plate 1e), banana (Plate 1a), sugarcane (Plate 1b) and tapioca and in plantations of rubber (Plate 1c), cashew (Plate 1d), coconut, arecanut and oil palm. It is a serious threat to pineapple cultivation in Moovattupuzha, the major pineapple growing area of Kerala. It spreads over the plant like mat and cuts off sunlight fully. Because of the difficulty in controlling *Mikania* cost effectively, farmers usually abandon the severely infested pineapple field. In young plantations of rubber, coconut, arecanut and cocoa, damage is by smothering the plant. It can twine round forest trees and rubber trees of

Plate 1. Infestation of *Mikania* on common crops

a. Banana

b. Sugarcane

c. Rubber

d. Cashew

e. Pineapple

15-20 m height. *Mikania* is seen growing over sugarcane fields of Moovattupuzha, Koothattukulam and Thiruvalla; in oil palm, teak and reeds (*Ochlandra rheedii*) plantation in Athiramppally (Chalakudy); cashew plantation in Malappuram and coffee and cardamom plantations in Idukki.

4.2 Biology of *Mikania*

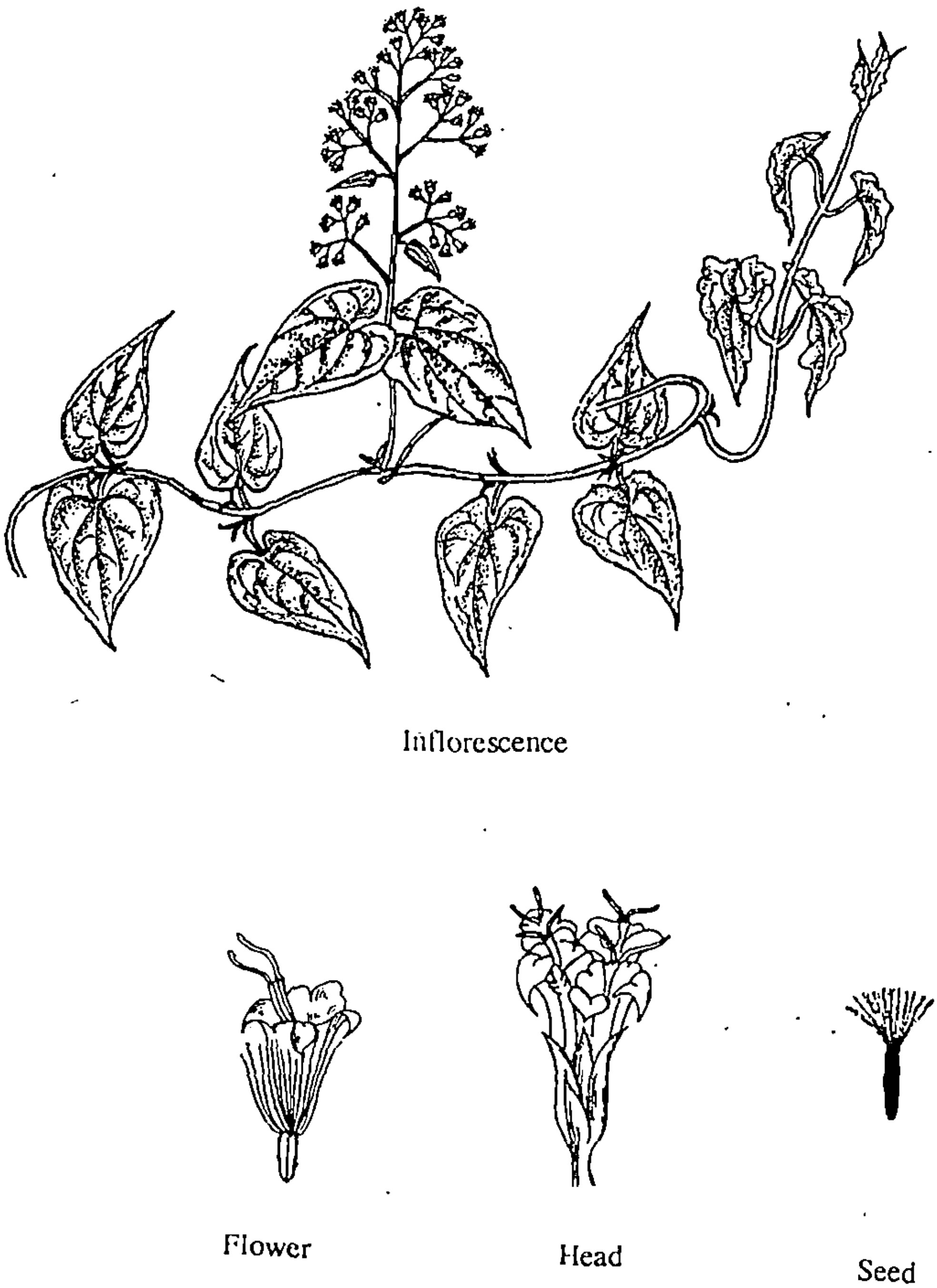
4.2.1 Morphology of *Mikania*

Mikania is a fast growing herbaceous perennial climber. Leaves are cordate ovate with crenately toothed margin. Runners which develop from basal part of the plant creep along the ground for a short distance, form roots at the nodes and produce 2 to 3 shoots from each node on the ground. Perennating nature of *Mikania* is due to the presence of tuberous root stocks. In the same plant, some of the newly grown shoots may be light violet or purple in colour which turn green upon flowering. Some stems are hairy.

In rainfed upland conditions, the top portion of *Mikania* plant dries out every year at the onset of the summer (February) and it regenerates during April-May after the receipt of pre-monsoon showers. When it is growing near the canals, ponds and other water bodies where moisture is plenty, it survives even during the summer season.

The climber produce very small whitish flowers in heads (size 4-5 mm long). The inflorescence is umbel of heads (Fig.2). In a single inflorescence, there are 30 to 40 composite flowers or heads. Each flower head has four flowers. The head of *Mikania* are about 4 to 5 mm long with very small ovate bracts at the base. The involucral scales are oblong-elliptic and shortly acute at the tip, the limbs of the

Fig.2 Floral characters of *Mikania*



corolla is broadly funnel shaped. The colour of the petal is white. Achene is less than 2 mm long with silky white pappus hairs.

4.2.2 Life cycle of *Mikania*

4.2.2.1 Time of germination under field conditions

Mikania seeds were found to germinate soon after the receipt of first rainfall (pre-monsoon showers) during the month of April.

4.2.2.2 Flowering and seed production

Flowering of *Mikania* commenced in October during 1996 and 1997. But in 1998 when the South-West monsoon was extended upto the middle of October, the flowering started only in the first week of November (Appendix 2).

After flower opening, it took 9-12 days for seed maturity (black seed stage).

Single *Mikania* produced, on an average, 357 inflorescence (Table 3) with 32 flowers per inflorescence. Each flower head had four seeds, about 50 per cent of which were light brown non-viable seeds and 50 per cent were viable large black seeds. Thus the average seed output per plant worked out to 45,812 number with a range of 35,520-54,720.

4.2.2.3 Thousand seed weight

Average weight of 1000 seeds was 0.1304 g.

4.2.2.4 Longevity of seeds

Germination percentage decreased with the duration of storage, with very little seeds (below 10%) germinating after six months of storage (Table 4 and Fig.3). Fresh seeds collected during December recorded the maximum germination (80%).

Table 3 Seed production capacity of *Mikania micrantha*

Plant No.	No. of inflorescence per plant	No. of heads per inflorescence	No. of heads per plant	No. of seeds per plant
1	330	27	8910	35640
2	355	33	11715	46860
3	380	34	12920	51680
4	350	36	12600	50400
5	365	37	13505	54020
6	400	25	10000	40000
7	370	24	8880	35520
8	320	40	12800	51200
9	340	28	9520	38080
10	360	38	13680	54720
Range	320-400	24-40	8880-13680	35520-54720
Average	357	32	11453	45812

Table 4 Germination (%) of seeds of *Mikania* after different periods of storage

Duration of storage	Germination (%)*
Fresh seed	80
1 month	70
2 months	60
3 months	48
4 months	45
5 months	35
6 months	5
7 months	5
8 months	4
9 months	4
10 months	Nil
11 months	Nil
12 months	Nil

* Average of data for 1996 and 1997

Fig.3 Effect of period of storage on seed germination of *Mikania micrantha*

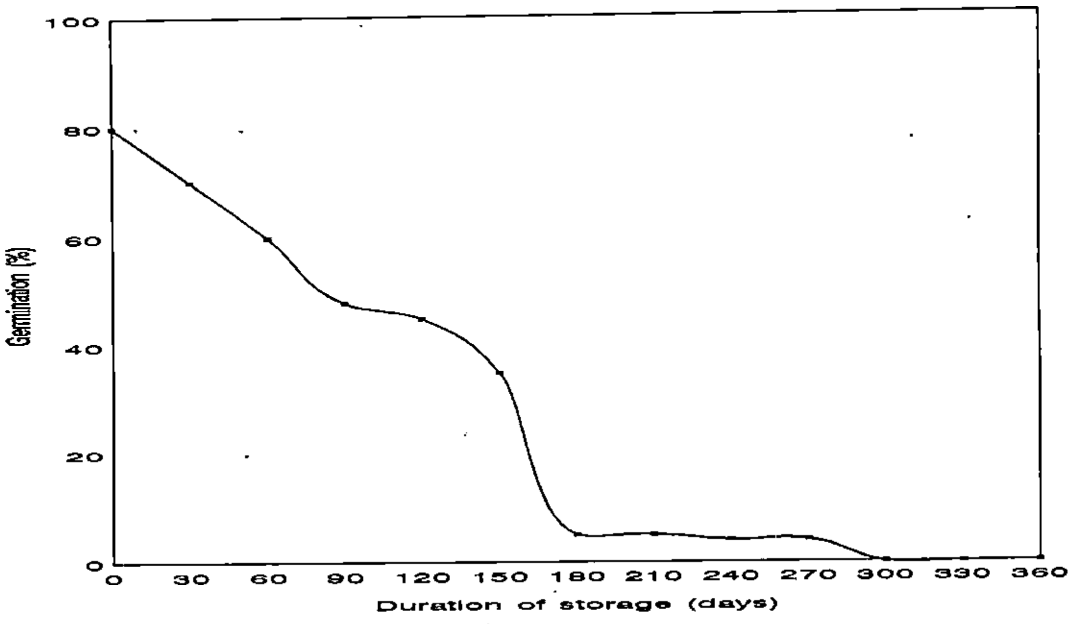
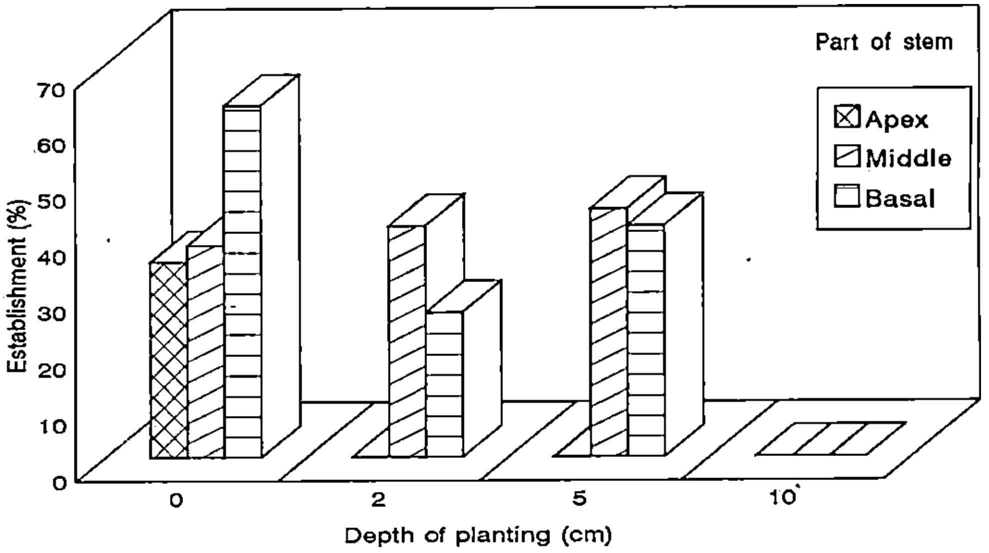


Fig.4 Effect of depth of planting and maturity of the vegetative cutting on establishment of *Mikania micrantha*



4.2.3 Reproduction of *Mikania*

4.2.3.1 From cuttings

Data on the establishment of different portions of stem at different depth of planting is given in Table 5 and Fig.4. Germination percentage and dry matter production (DMP) of *Mikania* were recorded at 30 days after planting. Maximum establishment was from the cuttings from the basal portion of stem planted at zero depth of planting (62.66 per cent cuttings established and produced 5.25 g dry matter per plant), eventhough the differences between treatments were non-significant. No sprouts was produced from the apex portion of stem planted at 2.5 and 10 cm depth, middle and basal portions at 10 cm depth and internodes at all depths. Comparing different portions of stem, apex portion gave the least establishment with zero germination even at a depth of 2 cm. Planting deeper than 5 cm suppressed the sprouting from all portions of stem. Eventhough internodal cuttings produced roots and no shoots emerged.

4.2.3.2 Leaves

Leaves did not sprout, but the leaf petioles with axillary bud produced sprouts.

4.2.3.3 Seeds

Seeds on the soil surface gave 35 per cent germination. Lack of germination was noted below the soil surface.

4.3 Crop weed competition

The effect of competition of *Mikania* on the growth and yield of pineapple, banana, cocoa, rubber, coconut and teak seedlings are given in Tables 6,7,8,9,10,11 and Plates 2a, 2b,2c,2d. In pineapple, the height and girth of the plants were not

Table 5 Effect of different parts of stem and depths of planting on sprouting percentage and dry matter production of *Mikania* at 30 DAP

Part of stem	Depths of planting	Sprouting (%)	Dry weight (g m^{-2})
Apex	0 cm	34.66 (35.96)*	3.150
	2 cm	-	-
	5 cm	-	-
	10 cm	-	-
Middle	0 cm	37.66 (37.47)	4.203
	2 cm	41.00 (39.42)	4.833
	5 cm	44.00 (41.38)	3.200
	10 cm	-	-
Base	0 cm	62.66 (52.41)	5.250
	2 cm	25.66 (29.97)	2.630
	5 cm	41.00 (39.83)	4.000
	10 cm	-	-
Internodes	No sprouting at any depth of planting		
SEm±		5.57	0.683
CD (0.05)		NS	NS

* Arcsine transformed values

Table 6 Effect of competition from *Mikania* on growth and yield of pineapple

Treatments	Height of plant (cm)	Girth of plant (cm)	Days to flowering (DAP)	Dry weight of plant (kg)	Fresh weight of fruits (kg)	Dry weight of *Mikania* (g)
Competition from one *Mikania*	94.8	14.8	330	0.89	0.9	129.06
Competition from two *Mikania*	100.4	15.2	319	0.95	0.87	130.50
Competition from four *Mikania*	108.4	15.4	329	0.95	0.86	126.60
Control	114.8	17.2	212	1.30	1.24	-
SEm±	8.3	2.1	13.9	0.067	0.073	2.6
CD (0.05)	NS	NS	42.8	0.217	0.225	NS

Table 7 Effect of competition from *Mikania* on growth and yield of banana

Treatments	Height of plant (cm)	Girth of plant (cm)	Days to flowering (DAP)	Dry weight of plant (kg)	Fresh weight of fruits (kg)	Dry weight of *Mikania* (g)
Competition from one *Mikania*	351	66.4	229	5.40	5.84	153.54
Competition from two *Mikania*	348.8	64.2	225	5.90	5.82	144.42
Competition from four *Mikania*	350.6	64.2	223	6.14	5.64	153.74
Control	401	69.2	193	9.36	8.38	-
SEm±	12.74	1.15	5.1	0.66	0.38	6.97
CD (0.05)	39.25	3.54	15.8	2.14	1.83	NS

Table 8 Effect of competition from *Mikania* on the growth of cocoa seedlings

Treatment	Height (cm)	Girth (cm)	Dry weight of plant (g)	Dry weight of *Mikania* (g)
Competition from one *Mikania*	38.0	1.12	7.72	113.00
Competition from two *Mikania*	38.2	1.12	7.76	115.00
Competition from four *Mikania*	38.0	1.14	6.88	116.80
Control	74.6	2.10	30.00	-
SEm±	5.72	0.156	3.84	10.91
CD (0.05)	17.62	0.481	11.83	NS

Table 9 Effect of competition from *Mikania* on the growth of rubber seedlings

Treatment	Height (cm)	Girth (cm)	Dry weight of plant (g)	Dry weight of *Mikania* (g)
Competition from one *Mikania*	85.8	4.6	58.8	147.32
Competition from two *Mikania*	73.2	5.0	62.2	152.38
Competition from four *Mikania*	85.0	5.2	80.6	148.62
Control	328.8	9.7	643.8	-
SEm±	35.99	1.26	48.12	7.08
CD (0.05)	110.89	3.882	148.26	NS

Table 10 Effect of competition from *Mikania* on the growth of coconut seedlings

Treatment	Height (cm)	Girth (cm)	Dry weight of plant (kg)	Dry weight of *Mikania* (g)
Competition from one *Mikania*	129.6	11.0	1.61	176.20
Competition from two *Mikania*	130	10.4	1.94	171.66
Competition from four *Mikania*	133.8	10.2	1.48	165.64
Control	196.4	14.0	2.92	-
SEm±	6.32	0.61	0.22	8.33
CD (0.05)	19.47	1.88	0.69	NS

Table 11 Effect of competition from *Mikania* on the growth of teak seedlings

Treatments	Height (cm)	Girth (cm)	Dry weight of plant (g)	Dry weight of *Mikania* (g)
Competition from one *Mikania*	87.6	3.02	28.6	167.64
Competition from two *Mikania*	78.4	3.54	27.6	153.78
Competition from four *Mikania*	87.8	2.96	26.8	161.02
Control	287.8	10.00	269.0	-
SEm±	19.08	0.667	21.23	12.9
CD (0.05)	58.79	2.055	65.41	NS

a. Pineapple & Rubber seedling

b. Cocoa seedling

c. Teak seedling

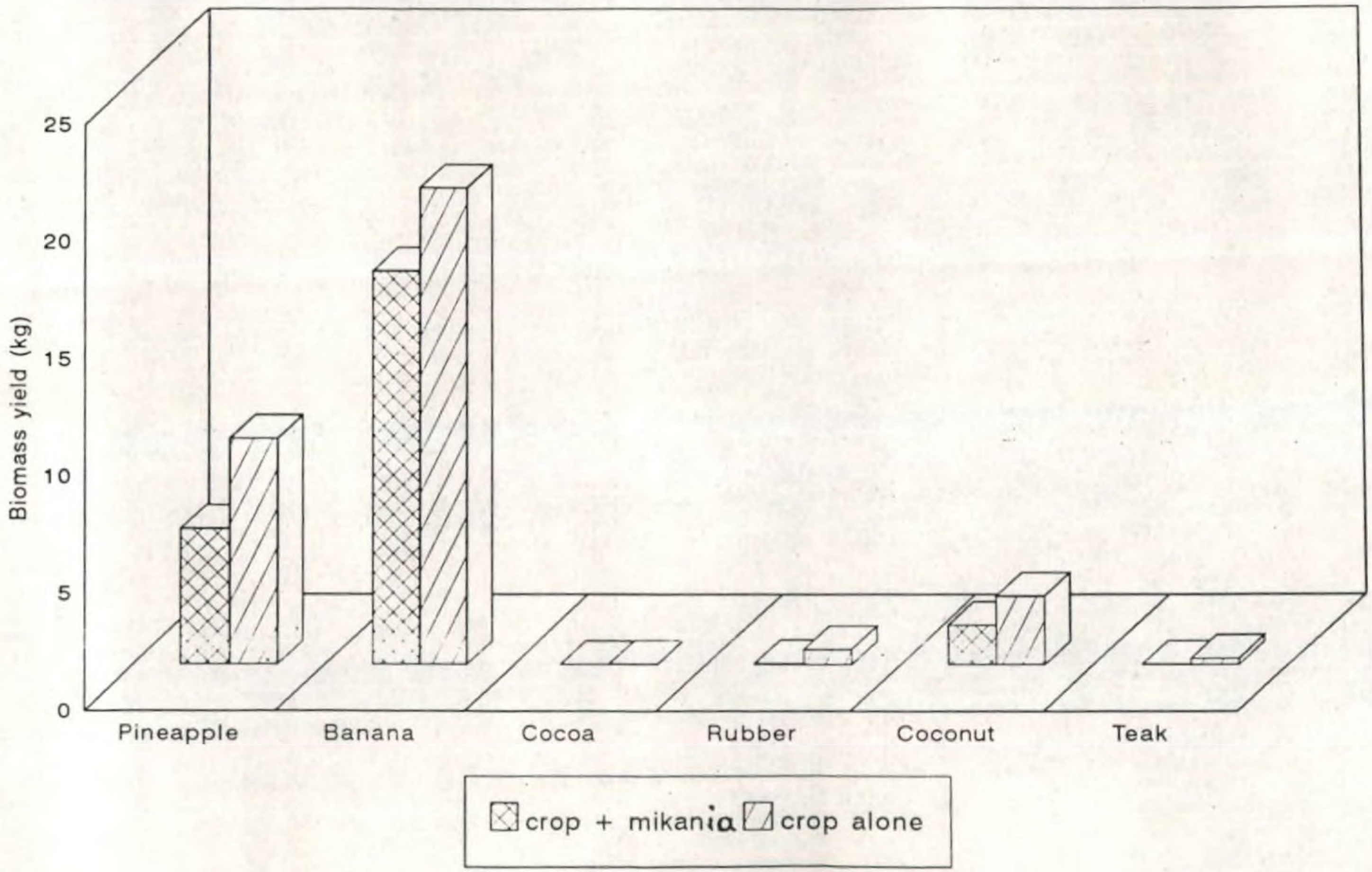
d. Coconut seedling

significantly affected by competition from *Mikania,* irrespective of number of *Mikania* plants competing. However the pineapple plants under competition from *Mikania* took more time for flowering (about 11 months) compared to pineapple without any competition which flowered by seven months after planting. The dry weight of pineapple plants as well as the fresh weight of the fruits were significantly higher in the control pineapple plant without any competition from *Mikania*. The number of *Mikania* plants competing with pineapple did not have any significant influence on its performance. Similarly the dry weight of *Mikania* growing over the pineapple did not vary significantly with increasing number of *Mikania* plants.

The height, girth and dry weight of banana plants and the bunch yield were significantly higher in plants without competition from *Mikania*. As in the case of pineapple, competition from *Mikania* delayed the flowering in banana also. The control plants flowered one month earlier than the plants which competed with *Mikania*. The number of competing *Mikania* plants did not have much effect on the different characters of the crop or on the dry weight of *Mikania*.

The height, girth and dry weight of seedlings of cocoa, rubber, coconut and teak were significantly reduced due to competition from *Mikania*. Figure 5 shows the average dry matter yield of crop plants in competition with one, two and four *Mikania* plants in comparison with the control plants free from competition. In all these cases, dry matter production of *Mikania* was the same irrespective of the number of *Mikania* seedlings growing on the crops.

Fig.5 Effect of competition from *Mikania* on dry matter production of different crops



4.5 Control methods

4.5.1 Physical methods

Results showed that all the treatments tested were significantly effective in reducing the weed population compared to the control (Table 12 and Fig.6). Sickle weeding given at monthly interval or bimonthly interval was not sufficient to kill the weed, eventhough there was reduction in the number of shoots produced (Plate 3a). Digging at monthly interval resulted in complete control of the weed without any regrowth from January to August. But again shoots were produced during September-December. When digging was given at bimonthly interval, complete destruction of the weed was not possible during the study period (Plate 3b).

Dry matter production pattern of the regrowing *Mikania* is given in Table 13. As the number of shoots produced in the treatment, digging at monthly interval, was none from January-August, the dry matter production was also nil. Dry matter production of the weed was in the same trend of the number of shoots produced.

4.5.2 Chemical methods

4.5.2.1 Effect of pre-emergence herbicides

All the herbicides tested significantly reduced the germination of *Mikania* seeds (Table 14, Fig.7 and Plate 4). Among them, diuron (1.5 kg ha^{-1}) and oxyflourfen (0.20 kg ha^{-1}) resulted in complete control of the germination and establishment of *Mikania*. Other herbicides in the order of effectiveness for controlling *Mikania* were atrazine, butachlor, metolachlor, alachlor, pretilachlor and fluochloralin. Germination of *Mikania* seeds in untreated plot was 42 per cent. Dry matter production of *Mikania* in all herbicide treatments were on par and were significantly lower than the same in control. Dry matter production of *Mikania* in herbicide treated plots

Table 12 Effect of digging and sickle weeding on the dry matter production of surviving *Mikania micrantha* (started in September, 1996)

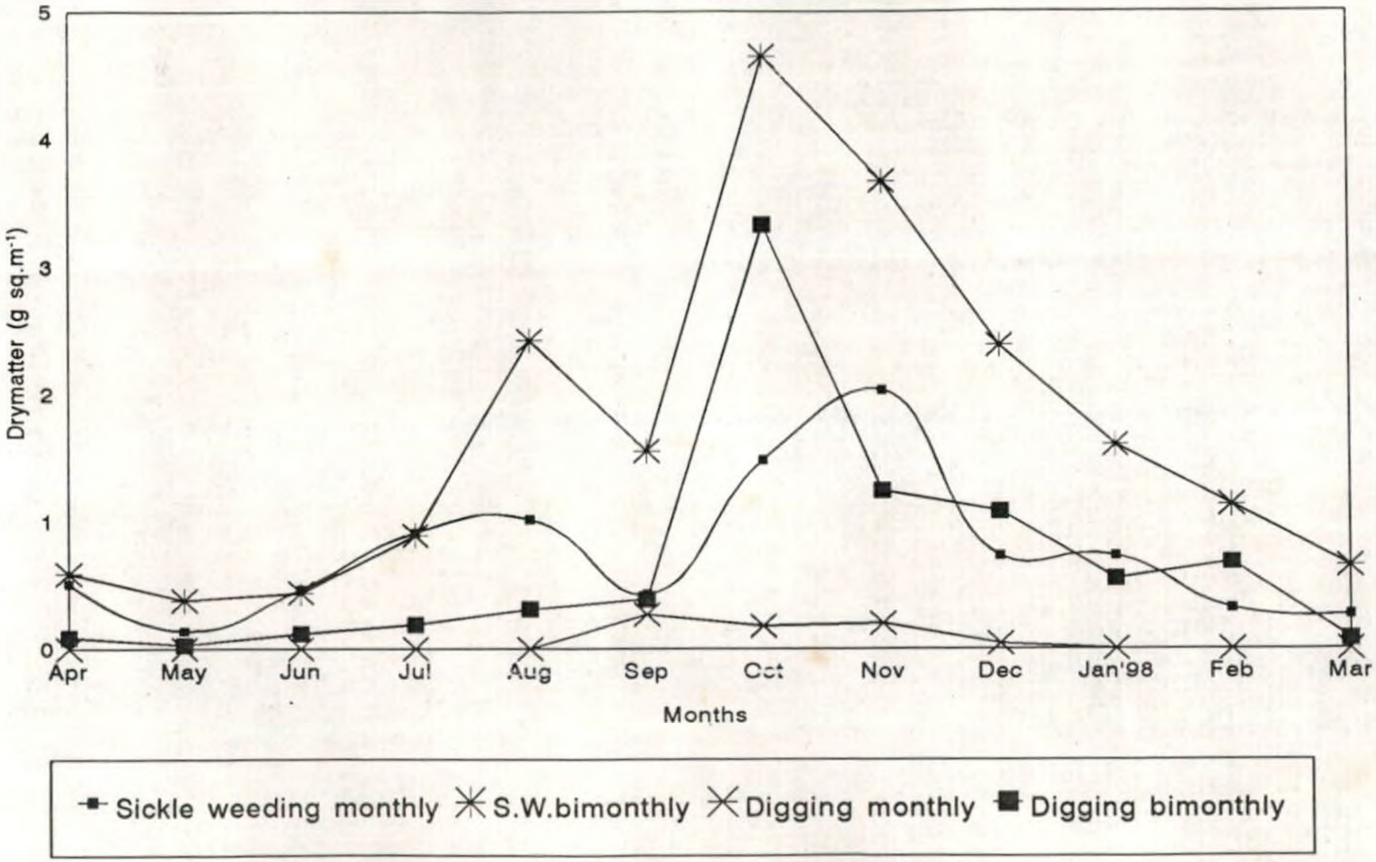
Treatment	Dry matter (g m^{-2})																	
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Sickle weeding at monthly interval	33.5^{b}	33.1^{bc}	19.0^{c}	14.59	3.62	1.74	0.51	0.14	0.47	0.91	1.014	0.43	1.48	2.03	0.73	0.73	0.32	0.27
Sickle weeding at bimonthly interval	35.0^{b}	63.0^{b}	57.0^{b}	58.1	3.58	4.10	0.59	0.38	0.44	0.89	2.42	1.55	4.65	3.67	2.38	1.60	1.13	0.65
Digging and removing stubbles at monthly interval	7.88^{b}	7.0^{c}	0.38^{c}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.18	0.20	0.04	0.00	0.00	0.00
Digging and removing stubbles at bimonthly interval	7.7^{b}	30.0^{bc}	1.93^{c}	6.24	0.26	0.16	0.09	0.03	0.12	0.19	0.31	0.39	3.33	1.24	1.08	0.55	0.68	0.08
Control	298.7^{a}	251.5^{a}	116^{a}	94.75^{a}	69.25^{a}	35.75^{a}	8.78^{a}	10.63^{a}	19.2^{a}	31.4^{a}	61.6^{a}	106.7^{a}	214^{a}	163.5^{a}	95.25^{a}	71.25^{a}	50.25^{a}	26.25^{a}
SEm±	20.14	7.85	7.72	6.67	4.20	1.98	0.604	0.662	0.93	1.54	1.167	2.10	1.80	2.99	2.33	2.98	1.99	2.22
CD	87.0	33.91	33.34	25.23	16.19	7.56	2.29	2.51	3.63	5.92	4.58	9.07	7.78	12.92	10.06	11.57	10.67	8.55

Table 13 Effect of digging and sickle weeding on the survival of *Mikania micrantha* (started in September, 1996)

Treatments	No. of shoots m^{-2}																	
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Sickle weeding at monthly intervals	■21.25 (4.606)	■18.00 (4.24)	*18.25 (4.38)	*18.75 (4.44)	*14.75 (3.97)	*4.75 (2.38)	*1.50 (1.57)	*1.50 (1.59)	*1.75 (1.64)	*1.75 (1.64)	*2.50 (1.87)	*2.75 (1.93)	■9.00 (2.998)	■7.00 (2.64)	*4.50 (2.34)	*6.50 (2.74)	*4.25 (2.28)	*4.00 (2.23)
Sickle weeding at bimonthly intervals	22.00 (4.68)	26.75 (5.16)	25.00 (5.09)	28.00 (5.36)	14.25 (3.90)	15.25 (4.03)	1.75 (1.65)	4.00 (2.23)	2.00 (1.707)	5.00 (2.45)	4.00 (2.23)	7.75 (2.92)	10.50 (3.23)	41.00 (3.63)	9.75 (3.28)	7.50 (2.89)	5.75 (2.59)	8.00 (2.998)
Digging and removing stubbles at monthly intervals	17.25 (4.152)	2.75 (1.65)	2.50 (2.93)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.50 (1.21)	1.00 (1.00)	1.00 (1.00)	0.75 (1.29)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Digging and removing stubbles at bimonthly intervals	15.50 (3.933)	18.50 (4.29)	4.25 (2.27)	4.25 (2.104)	1.25 (1.47)	0.00 (1.00)	0.50 (1.21)	0.25 (1.10)	0.50 (1.21)	1.00 (1.37)	1.25 (1.47)	2.00 (1.69)	3.50 (1.860)	3.00 (1.699)	3.00 (1.99)	0.75 (1.31)	0.50 (1.20)	0.25 (1.104)
Control	24.00 (4.895)	22.00 (4.69)	20.25 (4.61)	19.00 (4.47)	15.50 (4.05)	10.00 (3.29)	8.25 (3.02)	10.75 (3.39)	45.50 (6.81)	40.50 (6.43)	36.00 (6.07)	28.50 (5.43)	23.75 (4.864)	22.25 (4.71)	18.50 (4.405)	14.75 (4.02)	8.75 (3.098)	6.25 (2.622)
SEm±	0.95	0.97	1.05	0.81	0.75	1.34	0.58	0.96	1.77	1.30	1.26	1.04	0.85	0.68	0.78	1.01	0.72	1.08
CD	4.10	4.19	4.53	2.59	2.39	4.28	1.86	3.07	5.66	4.16	4.03	4.49	3.67	2.08	3.37	3.23	2.30	3.46

■ $\sqrt{x}$ transformed values and * $\sqrt{x+1}$ transformed values are given in the parenthesis

Fig.6 Effect of digging and sickle weeding on survival of *Mikania micrantha*



The trial started in Oct.'96. Data are for the period six months from start.

Plate 3 Effect of digging and sickle weeding for control of *Mikania*

a) Sickle weeding monthly (right) gives better control than sickle weeding bimonthly (left)

b) Digging monthly (right) gives better control than digging bimonthly (left)

Table 14 Effect of pre-emergence herbicides on germination and growth of *Mikania*

Treatment	Seed germination (%)	Dry weight at 60 DAS (g/pot)
1. Atrazine 1.5 kg ha^{-1}	2.66 (9.27*)^{c}	1.47^{b}
2. Diuron 1.5 kg ha^{-1}	-	-
3. Oxyflourfen 0.2 kg ha^{-1}	-	-
4. Fluochloralin 1.0 kg ha^{-1}	24.00 (28.19*)^{ab}	5.57^{b}
5. Butachlor 1.5 kg ha^{-1}	8.66 (14.75*)^{bc}	4.00^{b}
6. Alachlor 1.5 kg ha^{-1}	12.00 (19.32*)^{bc}	3.93^{b}
7. Pretilachlor 0.5 kg ha^{-1}	14.62 (22.14*)^{bc}	3.93^{b}
8. Metolachlor 1.0 kg ha^{-1}	10.00 (18.21*)^{bc}	2.60^{b}
9. Control	42.00 (40.40*)^{a}	15.43^{a}

* Angular transformed values.

In a column, means followed by a common letter are not significant at 5% level by DMRT.

Fig.7 Effect of pre-emergence herbicides on germination of *Mikania* seeds

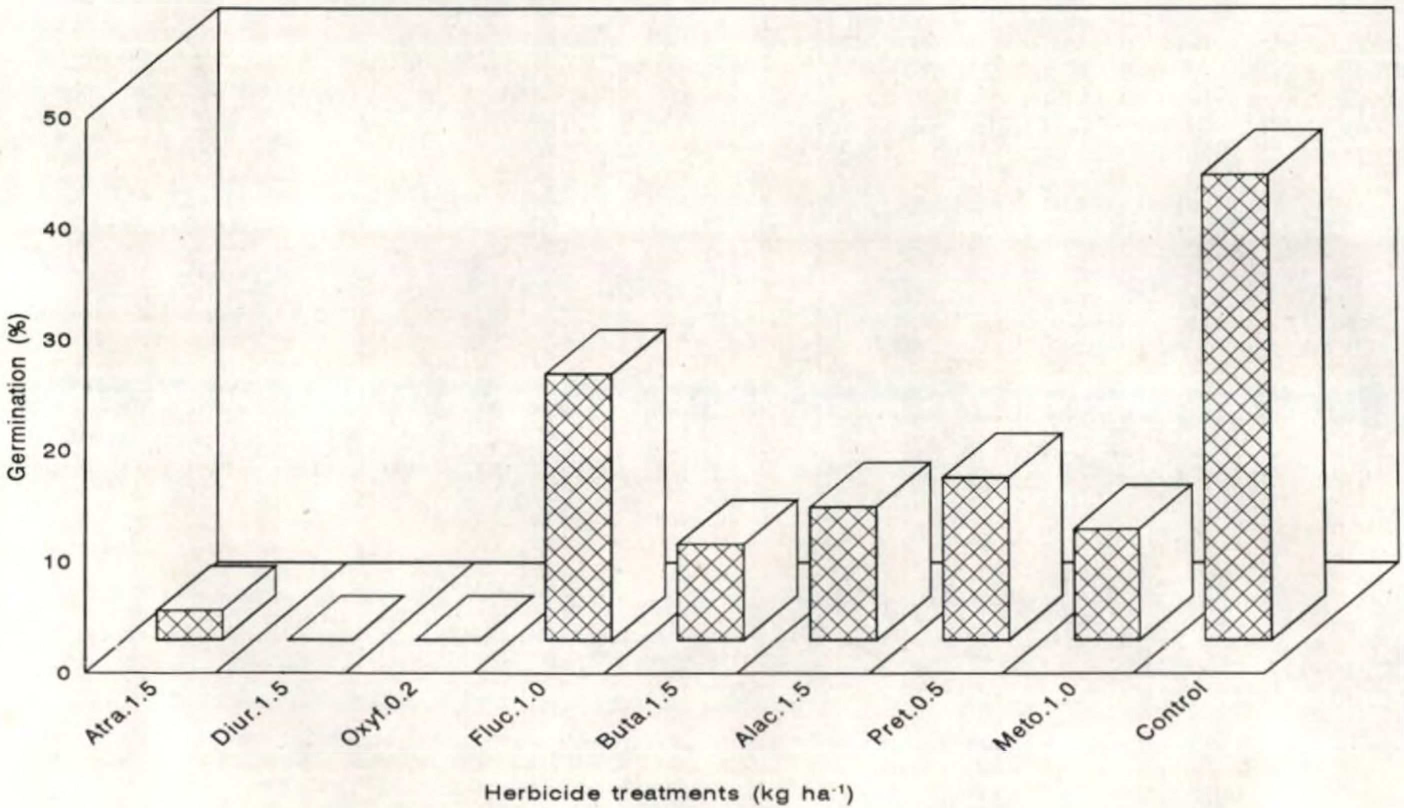
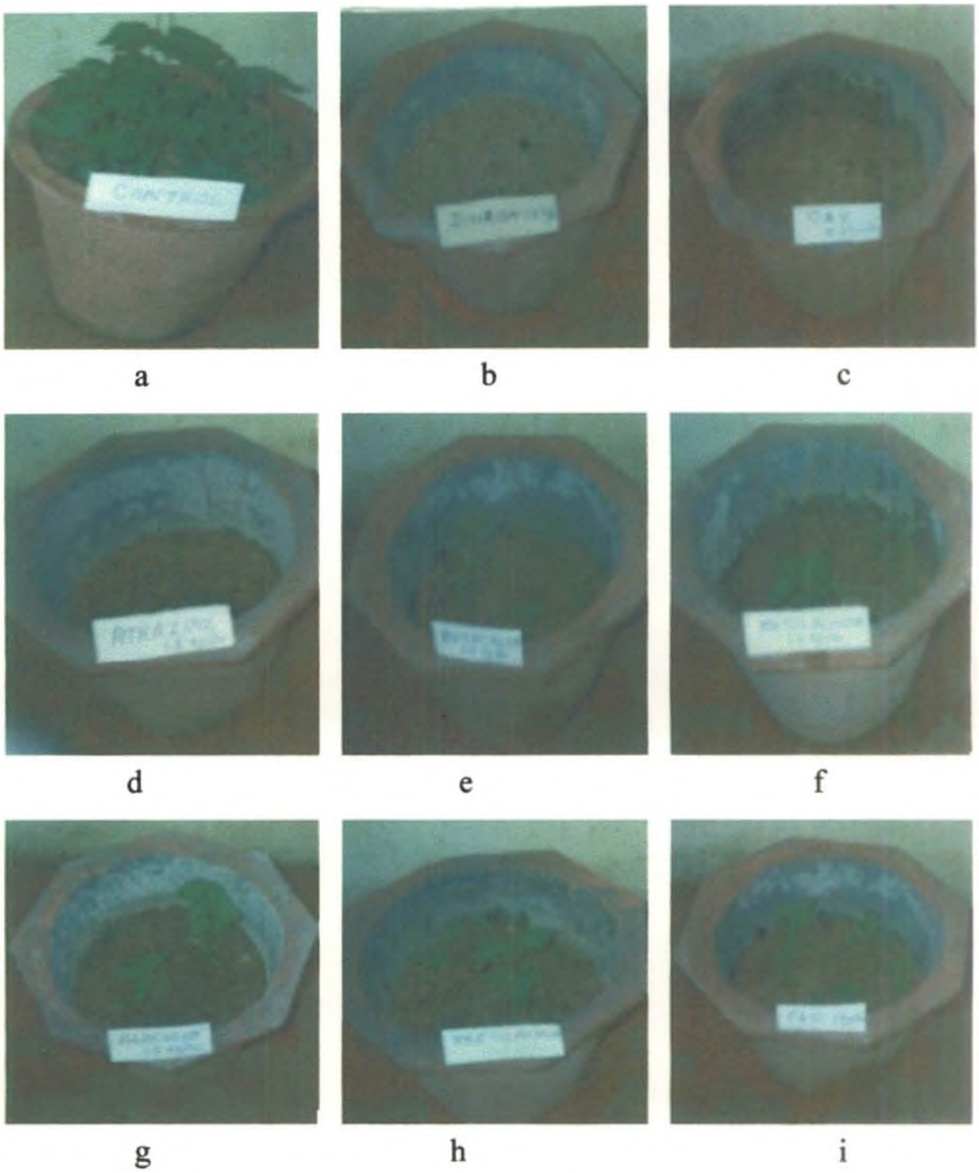


Plate 4. Effect of pre-emergence herbicides on germination and establishment of *Mikania*



a. Control b. Diuron : 1.5kg ha^{-1} c.Oxyflourfen 0.2kg ha^{-1}

d. Atrazine 1.5kg ha^{-1} e. Butachlor 1.5kg ha^{-1} f. Metolachlor 1.0kg ha^{-1}

g. Alachlor 1.5kg ha^{-1} h. Pretilachlor 0.5kg ha^{-1} i. Fluochloralin 1.0kg ha^{-1}

ranged from 1.47 - 5.57 g pot^{-1} whereas the weed dry matter in the untreated control was 15.43 g pot^{-1}.

4.5.2.2 Effect of post-emergence herbicides

Table 15 and Plate 5 shows the percentage control of *Mikania* by post emergence herbicides at 30,60 and 90 days after spraying. It was observed that more than 40 per cent control was obtained even at 90 days after spraying by the lower dose of paraquat (0.4 kg ha^{-1}) tested. Other herbicides resulted in better control than paraquat. Among them 2,4-D was the best resulting in 100 per cent control at all the doses tested without any shoots even at 90 DAS (Plate 5b). Phytotoxic symptoms produced on *Mikania* by the different herbicides tested are given in Table 16.

Data on the effect of post-emergence herbicides on the number of shoots at 30, 60 and 90 days after spraying is given in Table 17. Results show that all the doses of 2,4-D resulted in complete drying of *Mikania* in both the years of study. There was no regrowth even at 90 days after application. Among the other herbicide, glyphosate was the best in reducing the regrowth of *Mikania*. Glyphosate at 1.2 kg ha^{-1} resulted in complete drying of the weed without any regrowth upto 90 days. Paraquat and gluflosinate ammonium also reduced the growth of *Mikania* considerably. The effect was greater at higher doses for all the herbicides.

Dry matter production pattern of the regrowing *Mikania* is presented in Table 18 and Fig.8. As there was no regrowth in plots sprayed with 2,4-D (all doses) and glyphosate (1.20 kg ha^{-1}), the dry matter production was also nil. Though there was no significant difference between the other herbicides on the number of shoots produced after spraying the herbicides, dry matter production differed significantly.

Table 15 Control of *Mikania* at different periods after application of post-emergence herbicides

Treatment	Per cent control (visual rating)			
	15 DAS	30 DAS	60 DAS	90 DAS
1. 2,4-D Na 1.0 kg ha^{-1}	100	100	100	100
2. 2,4-D Na 2.0 kg ha^{-1}	100	100	100	100
3. 2,4-D Na 3.0 kg ha^{-1}	100	100	100	100
4. Glyphosate 0.4 kg ha^{-1}	75	95	90	85
5. Glyphosate 0.8 kg ha^{-1}	95	98	95	95
6. Glyphosate 1.2 kg ha^{-1}	100	100	100	100
7. Paraquat 0.4 kg ha^{-1}	70	50	40	40
8. Paraquat 0.8 kg ha^{-1}	90	60	60	60
9. Paraquat 1.2 kg ha^{-1}	95	85	80	80
10. Glu. ammonium 0.15 kg ha^{-1}	70	70	50	50
11. Glu. ammonium 0.30 kg ha^{-1}	90	90	80	70
12. Glu. ammonium 0.45 kg ha^{-1}	95	90	90	80

Plate 5. Post - emergence herbicides for controlling *Mikania*

a. View of the experimental site - spraying of herbicides in progress.

b. 2,4-D Na 1.0kg ha^{-1} - 100% control (30 DAS)

c. Glyphosate 0.8kg ha^{-1}(foreground)
Glyphosate 1.2kg ha^{-1}(background)-100% control (30 DAS)

d. Paraquat 0.4kg ha^{-1} - Regrowth of *Mikania* (30 DAS)

Table 16 Phytotoxic symptoms of post-emergence herbicides on *Mikania*

Herbicide	Phytotoxic symptoms
2,4-D	Wilting, twisting and curling of plants followed by callus formation, thickening and splitting of stem and finally drying of the plant
Glyphosate	Whitish discolouration of the growing point within a few days after application, followed by yellowing of the leaves and drying of the plant. Surviving plants produced multiple shoots at nodes.
Paraquat	Drying of leaves and tender green parts within 24 hours. Regrowth started by two weeks
Glu. ammonium	Yellowing and drying of plants within 24 hours. Regrowth started after four weeks.

Table 17 Effect of herbicides on the population (No/m^2) of *Mikania micrantha*

Treatments	Count of *Mikania* (No/m^2)					
	30 DAS		60 DAS		90 DAS	
	1996	1997	1996	1997	1996	1997
2,4-D 1.0 kg/ha	-	-	-	-	-	-
2,4-D 2.0 kg/ha	-	-	-	-	-	-
2,4-D 3.0 kg/ha	-	-	-	-	-	-
Glyphosate 0.4 kg/ha	26.0^{c} (5.18)	47.8^{ab} (6.94)	30.0^{c} (5.51)	37.0^{c} (6.16)	12.5^{def} (3.53)	44.0^{ab} (6.68)
Glyphosate 0.8 kg/ha	2.5^{c} (1.72)	22.3^{d} (4.71)	1.0^{cd} (1.31)	19.0^{f} (4.30)	12.0^{def} (3.21)	36.0^{ab} (5.98)
Glyphosate 1.2 kg/ha	0.00^{c} (1.00)	7.50^{e} (2.48)	0.00^{f} (1.00)	5.00^{g} (2.12)	0.00^{g} (1.00)	8.00^{d} (2.49)
Paraquat 0.4 kg/ha	83.00^{a} (9.15)	63.00^{a} (7.99)	95.30^{a} (9.80)	102.20^{b} (10.15)	99.00^{a} (9.98)	36.00^{ab} (6.09)
Paraquat 0.8 kg/ha	46.00^{b} (6.78)	32.00^{bcd} (5.57)	53.00^{b} (7.32)	138.00^{a} (11.78)	54.00^{b} (7.25)	17.00^{c} (4.18)
Paraquat 1.2 kg/ha	12.00^{d} (3.28)	28.80^{bcd} (5.41)	18.00^{d} (3.97)	63.80^{c} (7.98)	20.00^{cde} (4.48)	5.00^{d} (2.12)
Glu. ammonium 0.15 kg/ha	27.00^{c} (5.24)	41.80^{abc} (6.51)	30.00^{c} (5.55)	51.00^{cd} (7.14)	31.00^{bc} (5.65)	42.00^{ab} (6.54)
Glu. ammonium 0.30 kg/ha	23.90^{c} (4.86)	45.00^{bcd} (5.98)	25.01^{cd} (5.07)	42.00^{de} (6.54)	26.00^{cd} (5.19)	39.00^{ab} (6.28)
Glu. ammonium 0.45 kg/ha	4.00^{de} (2.00)	20.50^{d} (4.59)	6.00^{e} (2.46)	32.00^{e} (5.72)	4.00^{fg} (2.0)	31.00^{b} (5.63)
Control	24.50^{c} (5.04)	24.50^{cd} (5.04)	18.5^{cd} (4.30)	64.00^{c} (8.05)	11.30^{ef} (3.33)	50.07^{a} (7.14)

Values in parentheses are $\sqrt{x}$ and $\sqrt{x+1}$ transformed values

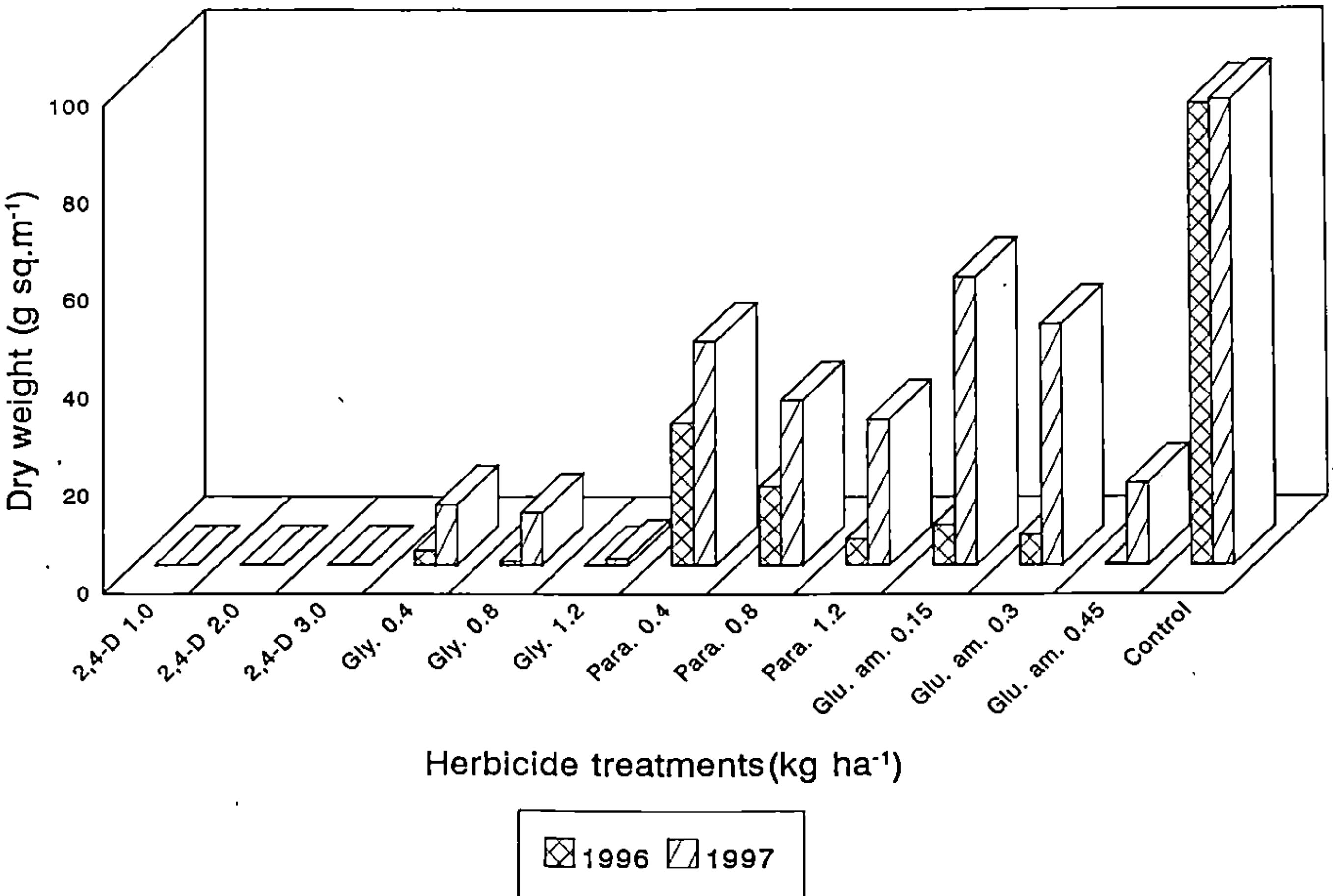
In a column, means followed by a common letter are not significant at 5% level by DMRT

Table 18 Effect of herbicides on the dry matter production of *Mikania micrantha*

Treatments	Dry matter production (g m^{-2})					
	30 DAS		60 DAS		90 DAS	
	1996	1997	1996	1997	1996	1997
2,4-D 1.0 kg ha^{-1}	-	-	-	-	-	-
2,4-D 2.0 kg ha^{-1}	-	-	-	-	-	-
2,4-D 3.0 kg ha^{-1}	-	-	-	-	-	-
Glyphosate 0.4 kg ha^{-1}	1.15^{d}	4.38^{d}	2.99^{d}	7.78^{d}	3.00^{d}	12.40^{f}
Glyphosate 0.8 kg ha^{-1}	0.14^{d}	0.53^{d}	0.19^{d}	3.13^{d}	0.67^{d}	10.73^{f}
Glyphosate 1.2 kg ha^{-1}	0.00^{d}	0.03^{d}	0.00^{d}	0.98^{d}	0.00^{d}	1.30^{f}
Paraquat 0.4 kg ha^{-1}	23.05^{b}	36.03^{bc}	30.60^{b}	36.80^{bc}	29.14^{b}	45.85^{bcd}
Paraquat 0.8 kg ha^{-1}	16.00^{bc}	18.58^{bcd}	17.65^{c}	13.23^{d}	16.1^{c}	33.80^{cd}
Paraquat 1.2 kg ha^{-1}	8.30^{cd}	7.65^{d}	3.85^{d}	8.95^{d}	5.41^{d}	29.95^{de}
Glu. ammonium 0.15 kg ha^{-1}	3.70^{d}	42.35^{b}	9.08^{cd}	53.65^{b}	8.26^{cd}	59.10^{b}
Glu. ammonium 0.30 kg ha^{-1}	3.35^{d}	20.15^{bcd}	4.30^{d}	19.38^{cd}	6.15^{d}	49.35^{bc}
Glu. ammonium 0.45 kg ha^{-1}	0.07^{d}	16.20^{cd}	1.80^{d}	9.40^{d}	0.30^{d}	16.80^{ef}
Control	215.50^{a}	163.50^{a}	116.00^{a}	112.25^{a}	94.75^{a}	95.50^{a}

In a column, means followed by a common letter are not significant at 5% level by DMRT

Fig.8 Effect of post-emergence herbicides on drymatter production of *Mikania* at 90 days after spraying



Among them, glyphosate (all the doses) recorded significantly lower dry matter production Paraquat and glufosinate ammonium also produced significantly lower dry matter than the unsprayed control. Between them the latter was better at the corresponding doses.

4.5.2.3 Effect of 2,4-D in controlling *Mikania*.

Visual observations on control of *Mikania* by different forms and doses of 2,4-D are given in Table 19. Results showed that all forms of 2,4-D at the lowest dose tested (0.25 kg ha^{-1}) gave more than 60 per cent control at 15 days indicating the high sensitivity of *Mikania* to 2,4-D. Observations at 30 days showed that a few vines produced new shoots (though not healthy) at doses of 0.25 and 0.5 kg ha^{-1} in all forms of 2,4-D (Table 19a). However, the number of shoots as well as their dry weight were negligible compared to the unsprayed control.

4.5.3 Biological methods

4.5.3.1 Indigenous pests on *Mikania*

4.5.3.1.1 Identification of insects

Different species of insect pests encountered during the survey were identified by taxonomists. Table 20 and Plate 6 gives the details of the insect pests identified. Twenty insect pests belonging to 15 families and eight orders were identified. Among them nine insect pests were belonging to the order coleoptera.

4.5.3.1.2 Nature of damage

The nature and extent of damage caused by the different insect pests on *Mikania* is given in Table 21. Tea mosquito bug (*Helopeltis theivora*), caused serious damage on *Mikania* (Plate 7b). Wide spread occurrence of aphids (*Aphis citricola*), thrips (*Microcephalothrips abdominales)* and lipidopterans (*Spilosoma obliqua, Spodoptera litura* and *Pericallia ricini*) were observed (Plates 7a, 7c, 7d).

Table 19 Effect of 2,4-D on control of *Mikania* at different periods after application

Treatment (Herbicide kg ha^{-1})	Per cent control			
	15 DAS	30 DAS	60 DAS	90 DAS
1. 2,4-D Na 0.25	80	99	99	99
2. 2,4-D Na 0.50	100	100	100	100
3. 2,4-D Na 1.00	100	100	100	100
4. 2,4-D Na 2.00	100	100	100	100
5. 2,4-D Na 3.00	100	100	100	100
6. 2,4-D E.A. 0.25	60	98	99	99
7. 2,4-D E.A. 0.50	70	99	100	100
8. 2,4-D E.A. 1.00	100	100	100	100
9. 2,4-D E.A. 2.00	100	100	100	100
10. 2,4-D E.A. 3.00	100	100	100	100
11. 2,4-D E.E. 0.25	60	98	99	99
12. 2,4-D E.E. 0.50	80	99	100	100
13. 2,4-D E.E. 1.00	100	100	100	100
14. 2,4-D E.E. 2.00	100	100	100	100
15. 2,4-D E.E. 3.00	100	100	100	100

Table 19a Effect of 2,4-D on the survival of *Mikania micrantha*

Treatments (Herbicide kg ha^{-1})	Count of Mikania (No/m^2)			Dry matter production (gm^{-2})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
1. 2,4-D Na 0.25	2	2	1	0.8	0.48	0.4
2. 2,4-D Na 0.5	1	1	-	0.5	0.04	-
3. 2,4-D Na 1.00	-	-	-	-	-	-
4. 2,4-D Na 2.00	-	-	-	-	-	-
5. 2,4-D Na 3.00	-	-	-	-	-	-
6. 2,4-D E.A 0.25	3	3	1	0.8	0.36	0.08
7. 2,4-D E.A 0.5	2	1	-	0.2	0.12	-
8. 2,4-D E.A 1.00	-	-	-	-	-	-
9. 2,4-D E.A 2.00	-	-	-	-	-	-
10. 2,4-D E.A 3.00	-	-	-	-	-	-
11. 2,4-D E.E 0.25	4	4	1	0.6	0.36	0.12
12. 2,4-D E.E 0.5	3	1	-	0.2	0.04	-
13. 2,4-D E.E 1.00	-	-	-	-	-	-
14. 2,4-D E.E 2.00	-	-	-	-	-	-
15. 2,4-D E.E 3.00	-	-	-	-	-	-
16. Control	24.5	64	50.7	163.5	112.25	95.5

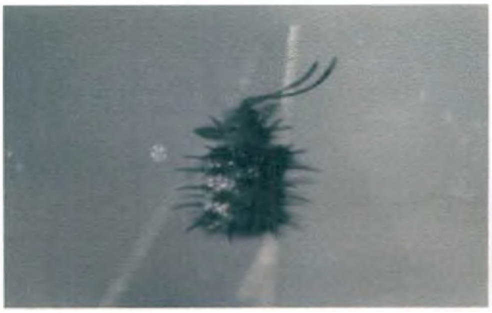
Values are average of four replications

Table 20 Natural enemies of *Mikania*

Insect pests	Family	Order
1. *Tetranychus neocaledonicus* (Andre)	Tetranychidae	Acari
2. *Eurommaticera vittata* Wlitr.	Cerambicidae	Coleoptera
3. *Apophylia viridis* (Jac.)	Chrysomelidae	Coleoptera
4. *Derectina collina* (Weise)	Chrysomelidae	Coleoptera
5. *Diapromorpha turcica* (E)	Chrysomelidae	Coleoptera
6. *Hipsa armigera* (Oliv)	Chrysomelidae	Coleoptera
7. *Lacoptera quadrimaculata*	Chrysomelidae	Coleoptera
8. *Luperomorpha bombayensis* (Jac.)	Chrysomelidae	Coleoptera
9. *Myllocerus blandus* Fst.	Curculionidae	Coleoptera
10. *Platybolium alvearium* Blair.	Tenebrionidae	Coleoptera
11. *Aphis citricola* Vander Goot	Aphididae	Hemiptera
12. *Krishna strigicollis* Spinola	Cercopidae	Hemiptera
13. *Cofana unimaculata* (Sign.)	Cicadellidae	Hemiptera
14. *Centrotyphus sp.*	Membracidae	Hemiptera
15. *Helopeltis theivora* (Waterch)	Miridae	Heteroptera
16. *Pericallia ricini* F.	Arctiidae	Lepidoptera
17. *Spodoptera litura* F.	Noctuidae	Lepidoptera
18. *Catantops sp.* (Annexus) Bol.	Acrididae	Orthoptera
19. *Kolla sp.*	Cicadellidae	Orthoptera
20. *Microcephalothrips abdominalis* (Crawford)	Phloeothripidae	Thysanoptera

Plate 6. Insect pests on *Mikania*

a. Diapromorpho turcica



b. Hipsa armigera

c. Myllocerus blandus

d. Platybolium alvearium

e. Aphis citricola (100

f. Krishna strigicollis

g. Centrotyphus sp.

h. Helopeltis theivora

i. Spilosoma obliqua

j. Pericallia ricini

k. Spodoptera litura

l. Kolla sp.

m. Catantops sp.

n. Microcephalothrips abdominalis (100x)

Table 21 Nature and extent of damage by insect pests

Insect Sp.	Nature of damage	Extent of damage
a) Acarinae		
1. *Tetranychus neocaledonicus* (Anedre)	Nymphs and adults feed by remaining inside the web on the undersurface of leaf resulting in the yellowing of leaves. The leaves later appear crinkled and curled downwards	Negligible
b) Hemipterans		
1. *Aphis citricola* Vander Goot	Nymphs and adults suck sap from leaves and petiole and cause crinkling	Wide spread
2. *Centrotyphus* sp.	"	Negligible
3. *Cofana unimaculata* (Sign.)	"	Negligible
4. *Krishna strigicollis* (Spinola)	"	Negligible
c) Heteropterans		
1. *Helopeltis theirora* (Waterh)	Nymphs and adults suck sap from the leaves and petioles, due to which brown spots develop which later turn necrotic	Serious
d) Thysanoptqran		
1. *Microcephalothrips abdominalis* (Crawford)	Suck sap from the flowers and cause drying of the flowers	Wide spread
e) Coleopterans		
1. *Apophylia viridis* (Jac.)	Cause defoliation by making small holes on leaf lamina	Negligible
2. *Derectina collina* (Weise)	"	Negligible
3. *Diapromorpha turcica* (F.)	"	Negligible
4. *Eurommaticera vittata* Wlitr.	"	Negligible

Table 21 contd...

5. *Hipsa armigera* (Oliv.)	"	Negligible
6. *Lacoptera quadrimaculata*	"	Negligible
7. *Myllocerus blandus* Fst.	"	Negligible
8. *Platybolium alvearium* (Blair.)	"	Negligible
9. *Luperomorpha bombayensis* (Jac.)	"	Negligible
f) **Orthopterans**		
i. *Catantops sp.* (Annexus) Bol.	Caused defoliation by making small holes on leaf lamina	Negligible
2. *Kolla sp.*		Negligible
g) **Lepidopterans**		
1. *Pericallia ricini* F.	Caterpillar feeds on the leaves voraciously causing defoliation reducing the leaves to mere veins	Sporadic
2. *Spilosoma obliqua* Walk.		
3. *Spodoptera litura* F.		Sporadic

4.5.1.3 Intensity of tea mosquito attack

Percentage intensity of the tea mosquito attack is given in Table 22. Tea mosquito bug caused an average intensity of attack of 18.1 per cent on *Mikania*.

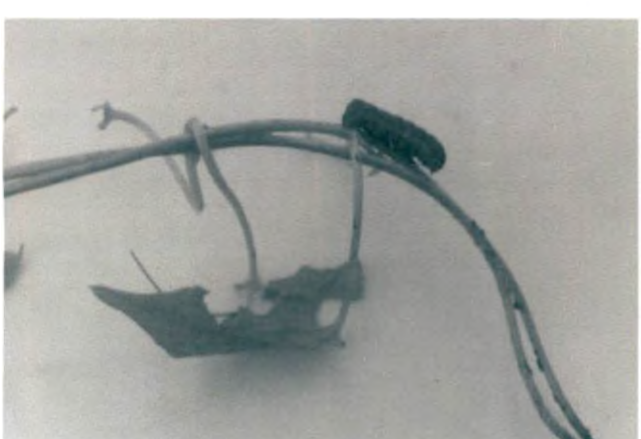
Table 22 Intensity of attack of tea mosquito bug on *Mikania*

Sample No.	Total No. of leaves in one sq.m.(b)	No. of leaves damaged (a)	Intensity of attack (I=a/b x 100)
1	530	118	22.3
2	680	164	24.0
3	746	104	13.9
4	620	74	11.9
	Mean	115	18.1

Plate 7. Nature of damage by insect pests on *Mikania*

a. Aphis citricola

b. Helopeltis theivora



c. Spodoptera litura

d. Spilosoma obliqua

4.5.3.1.4 Feeding capacity of Lepidopteran pests

Average leaf area consumed by 3rd and 4th instar larvae of *Spilosoma obliqua* was 105 sq.cm. and 156 sq.cm and that of *Spodoptera litura* was 86 sq.cm and 132 sq.cm respectively (Table 23).

Table 23 Leaf area consumed by caterpillars of Lepidopteran pests (cm^2) in 120 hours

Insect sp.	Stage of caterpillar	
	Third instar	Fourth instar
Spilosoma obliqua	105	156
Spodoptera litura	86	132

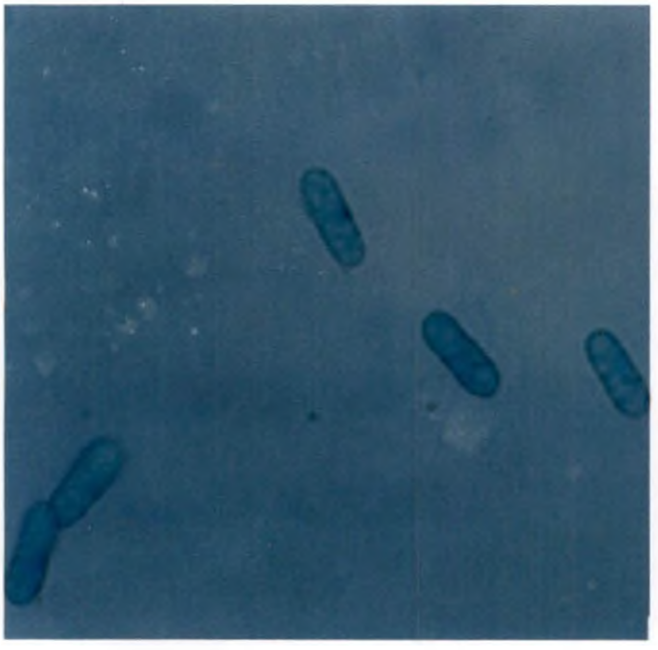
At both the stages, larvae of *Spilosoma* consumed more leaf area than the larvae of *Spodoptera*.

4.5.3.2 Indigenous pathogens on *Mikania*

4.5.3.2.1 Identification of pathogen

Different types of leaf spots were found in different locations surveyed. The pathogens causing the leaf spots were identified at the Indian type culture collection, Division of Plant Pathology, IARI, New Delhi - 110002 as *Colletotrichum gloeosporioides* (Penz) Sacc. (Plate 8a), *Alternaria alternata* Fries (Keissler) (Plate 8b), *Curvularia lunata* (Wakker) Boediin (Plate 8d) and *Corynespora cassicola* var. *aeria* (Burk. and Curt.) (Plate 8c). The intensity of infection due to all the above organisms were more severe during monsoon season (July to September).

Plate 8. Fungal pathogens inciting diseases on *Mikania*



a. *Colletotrichum gloeos porioides* (400x)

b. *Alternaria allternata* (400x)

c. *Corynespora cassicola* (400x)

d. *Curvularia lunata* (400x)

Symptoms produced by the pathogens

i) Leaf spot caused by *Colletotrichum gloeosporioides*

The disease appeared as tiny brown to dark brown circular spots with a yellow halo. The spots soon developed and became dark brown to black in colour and circular to irregular in shape. In mature spots, the holoneocrotic area was amber white and papery with brown raised margins often developing shot-hole symptoms (Plate 9a).

ii) Leaf spot caused by *Alternaria alternata*

Circular to angular, dark brown to black spots developed on the leaf. Concentric zonations were found in the necrotic tissue surrounded by narrow yellow zones. Large number of spots were formed which later coalesce resulted in blighting of leaf (Plate 9b).

iii) Leaf spot caused by *Curvularia lunata*

Irregular, brown to black coloured, water soaked lesions were formed on leaf. Later it spread and blighting of leaf occurred.

iv) Leaf spot caused by *Corynespora cassicola*

Circular spots were produced on the leaf. The fully developed mature spots exhibited concentric striations which were brown in colour. The centre was papery white surrounded by an yellow halo. In due course, the centre necrotic tissue distengrated resulting in shot-hole symptom (Plate 9c).

Pathogenicity test

Inoculation of the organisms on healthy *Mikania* plant produced the same characteristic symptoms as observed in natural infection. The reisolation of these

plate 9. Symptoms produced by the pathogens on *Mikania*

a. Colletotrichum gloeosporioides

b. Alternaria alternata

c. Corynespora cassicola

organisms from the artificially inoculated plants gave the same morphological characters of the organism.

4.5.3.2.2 Effect of toxic metabolites of *Colletotrichum* and *Alternaria* on *Mikania*

i) On excised leaf

Exotoxic and endotoxic metabolites of both the fungi produced symptoms on *Mikania* within 3 to 5 hours of inoculation. The symptom appeared as necrotic spots (Plate 10). The necrotic spots produced on treatment with both the toxic metabolites were identical in appearance and were similar to those observed in infection under natural field conditions. Diameter of spots increased with time, leading to complete drying of the leaf after four days. The results are presented in Table 24.

ii) On potted plant

The endotoxin and exotoxin of both *Colletotrichum* and *Alternaria* produced drying symptoms on leaf, leaf petioles and tender shoot tip, but not on mature shoot. But gradually it could kill the plant completely. Symptoms were produced after 3 to 5 hours of treatment.

4.5.3.2.2.1 Thermostability of toxic metabolites

The thermostability test of the toxic metabolite showed that the toxic quality was retained in cell free culture filtrate even after boiling and autoclaving. The toxic metabolite after thermostable test produced the same symptom when bioassayed on healthy host tissue.

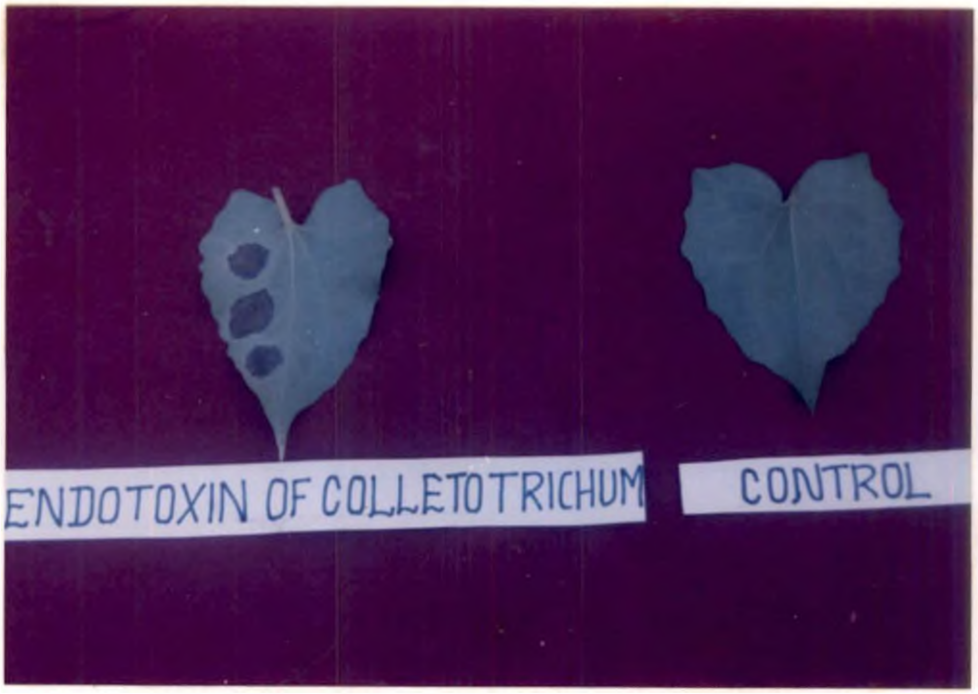


Plate 10 Symptoms produced by endotoxin of *Colletotrichum gloeosporioides*

Table 24 Effect of duration on size of the leaf spots produced by the toxic metabolites of *C. gloeosporioides* and *A. alternata* on *Mikania*

Duration after application (h)	Diameter of spots (cm)			
	A. alternata		*C. gloeosporioides*	
	Endotoxin	Exotoxin	Endotoxin	Exotoxin
4	0.40	0.30	0.35	0.35
12	1.10	1.00	0.70	0.50
24	2.40	2.20	2.00	1.80
48	3.60	3.50	2.80	2.20
72	4.80	4.80	3.90	3.60

4.6 Alternative uses

4.6.1 Utility as green manure

4.6.1.1 Biomass yield and growth rate

Table 25 gives the data on the biomass yield and growth rate of 10 *Mikania* plants separately grown for this purpose.

Six month old *Mikania* plants produced an average of 2.2 kg fresh weight. Thus the average biomass production per day was 12 g per plant.

Average rate of growth of *Mikania* shoots was 6.29 cm in 24 hours. It ranged from 5.33 to 7.3 cm.

Biomass yield estimated under natural field condition was 2012 g fresh weight from one square meter.

4.6.1.2 Nutrient content in *Mikania*

Nutrient content of different parts of *Mikania* (old stem, young stem, old leaf, young leaf) collected from various districts are presented in Table 26,27 and 28. The mean content of different nutrients in *Mikania* (average of the values for different parts of *Mikania* collected from different regions of the state) was 2.35 per cent N, 0.39 per cent P, 3.58 per cent K, 0.82 per cent Ca, 0.42 per cent Mg, 0.013 per cent Mn, 0.167 per cent Fe, 0.0045 per cent Cu and 0.022 per cent Zn. The nutrients N, P and Cu were highest in young leaf; K was highest in young stem; whereas Ca, Mg, Mn, Fe and Zn content was highest in old leaf.

4.6.1.3 Rate of decomposition

Decomposition increased with increasing time. Hundred per cent decomposition of *Mikania* fresh matter occurred by about one year (Table 29 and Fig.9). The rate of decomposition was higher during the initial periods and decreased

Table 25 Biomass yield and growth rate of *Mikania*

Plant No.	Biomass yield plant^{-1} (g)	Growth rate day^{-1} (cm)
1	1950	5.33
2	2050	6.33
3	2600	6.00
4	2100	6.50
5	2800	6.00
6	2050	6.80
7	1900	7.00
8	2850	7.30
9	1920	5.33
10	2300	6.30
Mean	2252	6.29

Table 26 Mineral nutrient content of *Mikania* from different locations

Districts	Nutrient content (%)											
	N				P				K			
	SO	SY	LO	LY	SO	SY	LO	LY	SO	SY	LO	LY
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Cannanore	1.11 (6.04)	2.25 (8.60)	1.27 (6.47)	4.87 (12.76)	0.36 (3.46)	0.25 (2.86)	0.19 (2.43)	0.35 (3.10)	5.20 (13.19)	3.73 (11.15)	2.90 (9.81)	3.57 (10.87)
Trichur	0.57 (4.33)	2.49 (9.06)	2.53 (9.16)	3.83 (11.29)	0.28 (2.85)	0.396 (3.47)	0.49 (3.97)	0.50 (4.02)	3.63 (10.96)	5.50 (13.57)	3.57 (10.89)	4.37 (12.07)
Ernakulam	0.93 (5.52)	2.49 (9.09)	2.84 (9.71)	4.84 (12.72)	0.40 (3.49)	0.44 (3.79)	0.51 (3.98)	0.65 (4.49)	2.73 (9.48)	3.37 (10.58)	2.80 (9.63)	3.23 (10.36)
Alappuzha	1.04 (5.86)	1.86 (7.84)	2.87 (9.76)	2.96 (9.91)	0.23 (2.77)	0.37 (3.46)	0.42 (3.71)	0.52 (4.12)	2.47 (9.04)	4.30 (11.97)	2.87 (9.75)	2.37 (8.84)
Idukki	0.87 (5.34)	1.62 (7.32)	2.29 (8.72)	3.40 (10.64)	0.17 (2.36)	0.496 (4.01)	0.28 (3.05)	0.47 (3.95)	2.53 (9.16)	3.96 (11.43)	4.00 (11.54)	4.53 (12.30)
Mean	**0.90**	**2.14**	**2.36**	**3.98**	**0.29**	**0.39**	**0.38**	**0.49**	**3.31**	**4.17**	**3.23**	**3.61**
SEm±	0.24	0.24	0.05	0.11	0.46	0.37	0.40	0.44	0.73	0.44	0.15	0.29
CD	0.756	0.756	0.158	0.346	NS	NS	NS	NS	2.29	1.386	0.473	0.914

Sinearc transformed values are given in the parentheses
SO - Stem old, SY - Stem young, LO - Leaf old, LY - Leaf young

Table 27 Mineral nutrient content of *Mikania* from different locations

Districts	Nutrient content (%)											
	Ca				Mg				Mn			
	SO	SY	LO	LY	SO	SY	LO	LY	SO	SY	LO	LY
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
Cannanore	(4.12) 0.52	(4.10) 0.51	(3.96) 0.49	(5.57) 0.96	(2.80) 0.24	(2.71) 0.222	(2.33) 0.167	(3.17) 0.312	(0.90) 0.030	(0.59) 0.012	(0.27) 0.002	(0.23) 0.012
Trichur	(3.39) 0.34	(3.19) 0.31	(4.74) 0.69	(3.99) 0.48	(2.58) 0.22	(3.07) 0.298	(3.97) 0.48	(3.26) 0.320	(0.42) 0.006	(0.28) 0.002	(0.57) 0.010	(0.43) 0.006
Ernakulam	(4.98) 0.84	(6.76) 1.38	(2.04) 1.073	(5.26) 0.86	(2.69) 0.28	(5.34) 0.87	(4.77) 0.69	(3.95) 0.475	(0.64) 0.012	(0.73) 0.016	(0.63) 0.92	(0.51) 0.009
Alappuzha	(5.75) 1.07	(4.11) 0.51	(7.61) 1.75	(0.91) 1.45	(2.41) 0.18	(2.81) 0.24	(4.25) 0.55	(3.75) 0.430	(0.25) 0.002	(0.36) 0.004	(0.80) 0.024	(1.06) 0.034
Idukki	(2.96) 0.27	(3.55) 0.39	(7.38) 1.65	(5.35) 0.87	(2.89) 0.25	(2.37) 0.35	(5.99) 1.087	(4.67) 0.650	(0.54) 0.009	(0.39) 0.005	(1.07) 0.035	(0.61) 0.011
Mean	**0.61**	**0.62**	**1.13**	**0.92**	**0.234**	**0.396**	**0.59**	**0.44**	**0.012**	**0.008**	**0.017**	**0.014**
SEm±	0.72	0.14	0.31	0.38	0.49	0.24	0.12	0.23	0.15	0.08	0.04	0.09
CD	NS	0.44	0.977	1.197	NS	0.756	0.378	0.725	NS	0.252	0.126	0.284

Sinearc transformed values are given in the parentheses

Table 28 Mineral nutrient content of *Mikania* from different locations

Districts	Nutrient content (%)											
	Fe				Cu				Zn			
	SO	SY	LO	LY	SO	SY	LO	LY	SO	SY	LO	LY
	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)
Cannanore	(1.68) 0.099	(0.51) 0.008	(1.45) 0.088	(0.43) 0.006	(0.26) 0.0022	(0.18) 0.0011	(0.23) 0.0014	(0.33) 0.003	(1.41) 0.099	(0.45) 0.006	(0.96) 0.028	(0.96) 0.029
Trichur	(1.27) 0.054	(1.95) 0.123	(1.71) 0.092	(1.65) 0.083	(0.21) 0.0014	(0.42) 0.0082	(0.33) 0.0034	(0.28) 0.0022	(0.31) 0.003	(0.56) 0.009	(1.63) 0.110	(0.82) 0.020
Ernakulam	(3.16) 0.322	(2.21) 0.151	(2.36) 0.182	(2.42) 0.196	(0.32) 0.0032	(0.41) 0.0051	(0.39) 0.0044	(0.33) 0.0033	(0.43) 0.006	(0.71) 0.015	(0.72) 0.016	(0.48) 0.0073
Alappuzha	(2.06 0.129	(2.30) 0.186	(3.24) 0.319	(4.08) 0.510	(0.18) 0.0008	(0.26) 0.0018	(0.26) 0.0021	(0.33) 0.004	(0.65) 0.013	(0.72) 0.016	(0.59) 0.011	(0.59) 0.010
Idukki	(2.50) 0.190	(1.49) 0.068	(3.60) 0.390	(2.15) 0.140	(0.26) 0.016	(0.31) 0.003	(0.40) 0.0052	(0.49) 0.0074	(0.75) 0.170	(0.58) 0.016	(0.44) 0.0067	(0.61) 0.012
Mean	**0.160**	**0.107**	**0.210**	**0.19**	**0.0047**	**0.0038**	**0.0033**	**0.0064**	**0.027**	**0.011**	**0.034**	**0.016**
SEm±	0.35	0.34	0.38	0.28	0.03	0.09	0.04	0.04	0.36	0.12	0.31	0.09
CD	NS	1.071	1.197	0.882	NS	NS	0.126	0.126	NS	NS	NS	0.283

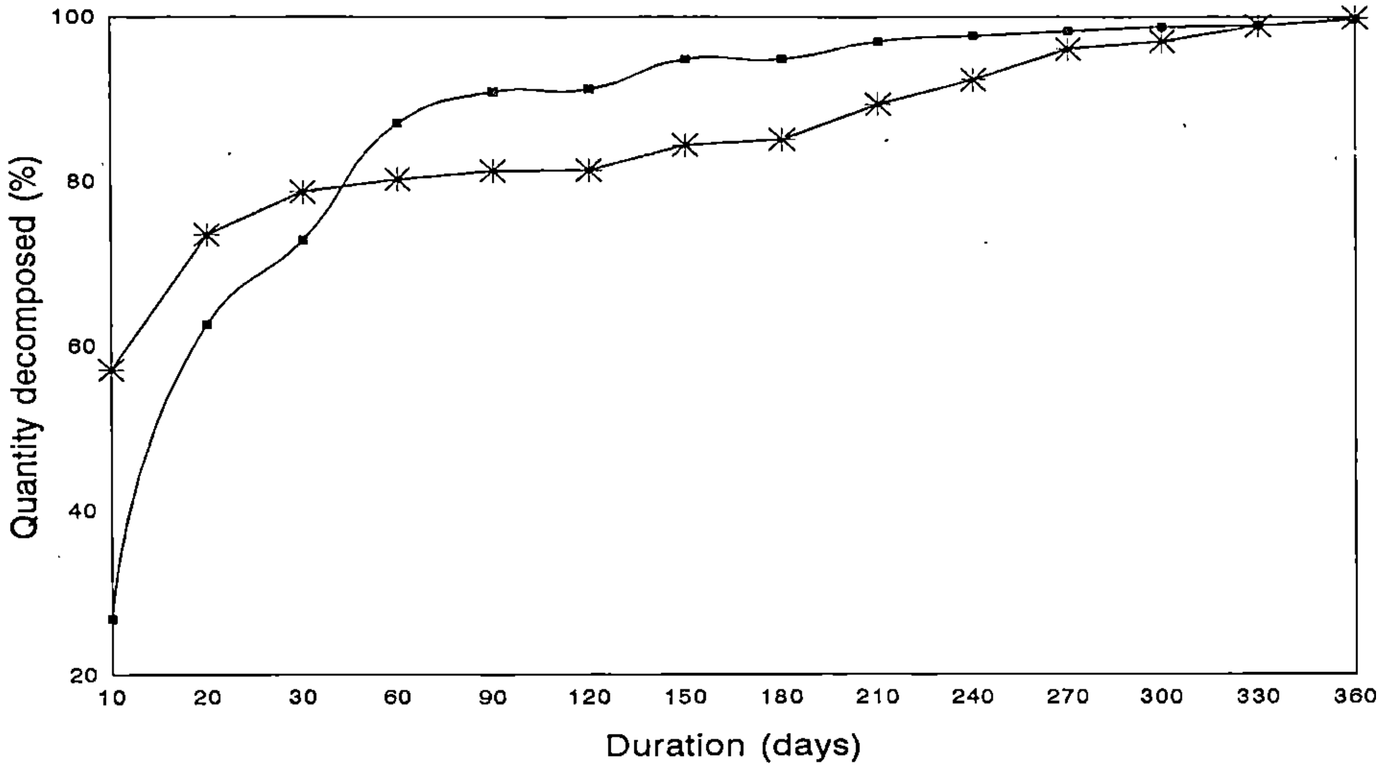
Sinearc transformed values are given in the parentheses

Table 29 Decomposition of *Mikania* at different duration in the field

Duration in field (days)	Decomposition (%)	
	Fresh *Mikania*	Partially dried *Mikania**
10	26.75[h]	57.06[h]
20	62.64[g]	73.53[fg]
30	72.92[f]	78.82[efg]
60	87.06[e]	80.29[g]
90	90.88[d]	81.28[def]
120	91.24[d]	81.39[def]
150	94.88[bc]	84.45[cde]
180	94.88[bc]	85.12[cde]
210	97.04[ab]	89.39[bcd]
240	97.71[ab]	92.42[abc]
270	98.26[ab]	96.12[ab]
300	98.79[a]	97.03[ab]
330	98.98[a]	98.94[ab]
360	99.64[a]	99.86[a]

DAP - Days after planting.
* Oven dried at 80°C for 12 hours

Fig.9 Decomposition of *Mikania* in field condition



Fresh Mikania Partiallydried Mikania

towards the end of the study. For fresh *Mikania*, the maximum significant decomposition (97.04%) is at 210 days and for partially dried *Mikania*, the maximum significant decomposition (92.42%) is at 240 days. Partially dried *Mikania* decomposed more rapidly than fresh *Mikania*. Partially dried *Mikania* lost about 57.06 per cent of the initial weight during the first 10 days while fresh *Mikania* lost only 26.75 per cent during the same time.

4.6.2 Utility of *Mikania* as a fodder

Chemical composition and fibre fractions of *Mikania* collected from four districts are given in Table 30. The plant contains only 16.68 per cent dry matter. It was found that *Mikania* contains an average value of 14.63 per cent crude protein, 2.36 per cent fat, 23.21 per cent crude fibre, 48.75 per cent nitrogen free extract, 8.92 per cent ash, 0.87 per cent Ca and 0.42 per cent P. Average potassium : calcium + magnesium ratio (K/Ca+Mg ratio) of *Mikania* was 2.86.

The fibre fractions contain 42.42 per cent neutral detergent fibre (NDF), 33.22 per cent acid detergent fibre (ADF), 0.096 per cent cellulose, 9.20 per cent hemicellulose and 10.84 per cent lignin. Variation between districts was found in the case of crude protein, ether extract, total ash, calcium, NDF and lignin content. Acid insoluble ash was almost negligible in *Mikania*. The antinutritional factor, hydrocyanic acid also recorded negative result (qualitative test).

4.6.3 Allelopathic effects of *Mikania*

4.6.3.1 Allelopathic effect of fresh *Mikania*

4.6.3.1.1 When used as mulch and incorporated

The data on effect of fresh *Mikania* on height and dry weight of seedlings of cowpea, rubber and rice is given in Table 31. The three test crops behaved

Table 30 Chemical composition of *Mikania* from different districts (DM basis)

Districts	Crude protein (%)	Ether extract (%)	Crude fibre (%)	Nitrogen free extract (%)	Total ash (%)	Calcium (%)	Phos-phorus (%)	NDF (%)	ADF (%)	Hemicel lulose (%)	Cellu-lose (%)	Lignin (%)
Trichur	14.71 (22.75)	2.59 (9.25)	24.67 (29.69)	50.49	7.44 (15.84)	0.46 (3.88)	0.42 (3.71)	35.72 (36.72)	29.49 (32.91)	6.23 (14.45)	0.025 (0.90)	2.20 (8.36)
Ernakulam	17.33 (24.62)	2.76 (9.56)	23.48 (29.00)	46.43	10.00 (18.43)	1.04 (5.84)	0.49 (4.01)	40.88 (39.72)	32.60 (34.75)	8.28 (16.35)	0.03 (0.98)	3.23 (10.11)
Alappuzha	13.67 (21.71)	2.13 (8.40)	22.92 (28.61)	51.99	9.29 (17.75)	1.20 (6.28)	0.39 (3.57)	42.25 (40.56)	33.05 (35.10)	9.196 (17.56)	0.156 (2.25)	18.78 (25.37)
Idukki	12.82 (20.99)	1.95 (8.03)	21.75 (27.81)	46.08	8.93 (17.4)	0.79 (5.11)	0.36 (3.42)	50.84 (45.51)	3773 (37.85)	13.11 (20.73)	0.171 (2.16)	19.15 (24.98)
Mean	**14.63**	**2.36**	**23.21**	**48.75**	**8.92**	**0.87**	**0.42**	**42.42**	**33.22**	**9.204**	**0.096**	**10.84**
SEm ±	0.17	0.27	0.97	2.55	0.40	0.17	0.21	0.33	1.43	2.36	0.37	3.51
CD (0.05)	0.55	0.88	NS	NS	1.30	0.55	NS	1.08	NS	NS	NS	11.45

Sinearc transformed values are given in the parentheses

Table 31 Allelopathic effect of mulching and incorporation of *Mikania* on growth of cowpea, rubber and rice seedlings

Concentration	Cowpea		Rubber		Rice	
	Height (cm)	Dry weight (g)	Height (cm)	Dry weight (g)	Height (cm)	Dry weight (g)
Mulch						
1 per cent	20.00^{bc}	1.18^{bc}	37.75^{a}	1.30^{a}	42.24^{ab}	0.35^{ab}
2 per cent	15.75^{c}	0.78^{c}	21.50^{c}	0.33^{d}	40.75^{ab}	0.25^{ab}
4 per cent	24.00^{bc}	2.48^{ab}	19.00^{c}	0.42^{d}	35.00^{bc}	0.29^{ab}
Incorporation						
1 per cent	17.50^{c}	1.16^{bc}	30.75^{b}	1.00^{b}	39.25^{abc}	0.36^{ab}
2 per cent	26.25^{b}	1.05^{c}	29.00^{b}	0.75^{c}	34.50^{bc}	0.26^{ab}
4 per cent	34.25^{a}	3.05^{a}	17.50^{c}	0.41^{d}	45.50^{a}	0.39^{a}
Control (0%)	37.25^{a}	1.80^{abc}	39.75^{a}	1.26^{a}	29.70^{c}	0.16^{b}

differently in response to the effect of *Mikania* as mulch or incorporation (Fig.10). The height and dry weight of cowpea seems to be reduced by lower dose of *Mikania* either as mulch or incorporation (1 and 2 per cent) whereas the higher dose of incorporation (4 per cent) resulted in higher in values of these parameters. On the contrary, rubber appears to be very sensitive to the allelopathic effect of *Mikania* (Plate 11), resulting in reduction in height and dry weight of the seedlings with increase in the concentration of *Mikania* as mulch or as incorporation. The growth of rice seedling was favoured by the addition of *Mikania* (both as mulch or incorporation) resulting in more height and dry matter production than the control, though difference was not significant in all the cases.

4.6.3.2 Allelopathic effect of water extract

4.6.3.2.1 Effect of water extracts on seed germination

Treatment with *Mikania* extract did not have any influence on germination and radicle length of rice where as in cowpea, the allelopathic effect was very much pronounced (Table 32). When 80 per cent cowpea seeds germinated within 24 hours in control, the germination was only 20 per cent in seeds treated with *Mikania* extract. Eventhough the germination improved by 48 hours, the radicle length was much lower in the seedlings treated with *Mikania* extract. At 72 hours, the seedlings from the treated seeds had an average radicle length of 1.51 cm compared to 4.68 cm in the untreated seedlings.

4.6.3.2.2 Effect of water extracts on seedling growth

Response to water extracts of *Mikania* varied among the test sp., cowpea, rubber and rice (Table 33 and Fig.10). Growth of cowpea and rubber seedlings were significantly decreased by the *Mikania* extract. The highest concentration of

Fig.10 Allelopathic effect of *Mikania* on crop plants

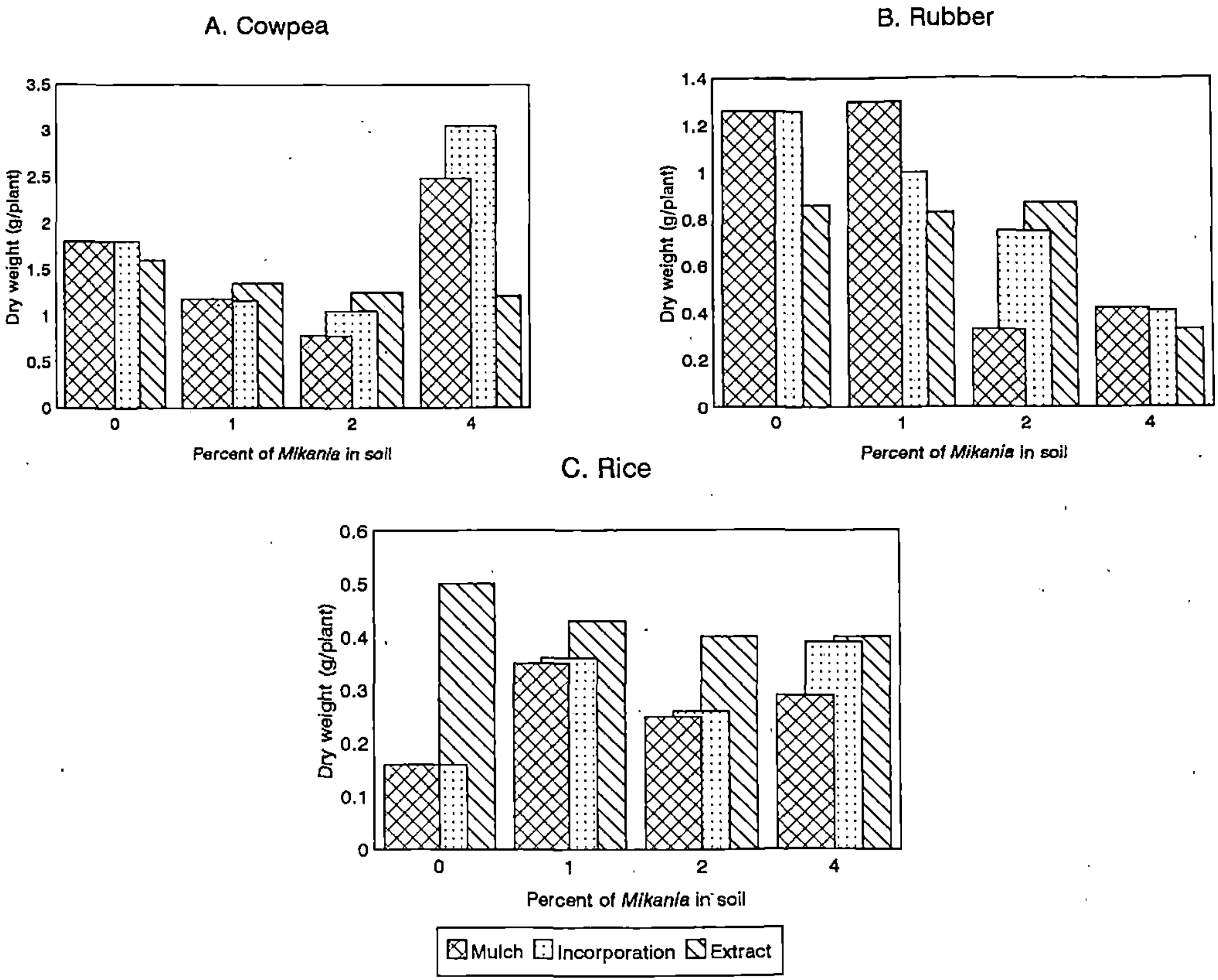


Plate 11 Allelopathic effect of *Mikania* on rubber seedlings (right) compared with control (left)

Table 32 Effect of *Mikania* extract on germination and radicle length of cowpea and rice

Treatment	Cowpea						Rice					
	Germination (%)			Radicle length (cm)			Germination (%)			Radicle length (cm)		
	24h	48h	72h	24h	48h	72h	24h	48h	72h	24h	48h	72h
Mikania extract (4%)	20	80	80	-	0.72	1.51	-	-	90	-	-	0.35
Control (0%)	80	80	80	-	1.91	4.68	-	-	90	-	-	0.35

Table 33 Effect of water extracts of *Mikania* on growth of test sp.

Concentration of the extract	Cowpea		Rubber		Rice	
	Height (cm)	Dry weight (g)	Height (cm)	Dry weight (g)	Height (cm)	Dry weight (g)
1. 1 per cent	41.25^{a}	1.35	38.75^{a}	0.83^{a}	46.50	0.43
2. 2 per cent	34.5^{a}	1.25	38.00^{a}	0.87^{a}	45.75	0.40
3. 4 per cent	25.0^{b}	1.21	16.75^{b}	0.33^{b}	47.25	0.40
4. Control	40.0^{a}	1.60	39.00^{a}	0.86^{a}	48.00	0.50
SEm±	3.24	0.29	1.22	0.07	3.57	0.07
CD (0.05)	9.98	NS	3.76	0.216	NS	NS

four per cent extract significantly reduced height of cowpea and height and dry weight of rubber seedlings. The lower two concentrations of one and two per cent did not significantly affect these crops. The extract did not have any influence on growth of rice.

Discussion

DISCUSSION

5.1 Distribution of *Mikania* in Kerala

Mikania is a serious problem in most of the southern and central region of Kerala (Table 2). From the Fig.1 it is clear that the infestation is concentrated mainly around Ernakulam. Probably it might have been first introduced to Ernakulam through the rail transport from the North-eastern regions of the country where the weed has been reported almost half a century back (Choudhury, 1972). From Ernakulam, *Mikania* is spreading fast to the surrounding areas. Already its infestation is very severe in a region of about 100 km radius around Ernakulam.

In areas where mild or isolated infestation is noticed, the weed was noticed in the roadsides (Dharmadom, Meenchanda, Quilandi, Pulpalli, Thirunelli, Anchal and Adoor) or near railway lines (Aryankavu, near the Kerala-Tamil Nadu boarder in Kollam district) indicating that the long distance spread is aided by vehicular traffic. The effective dispersal mechanism (parachute like seeds) and the light weight of seeds can facilitate dispersal through wind to nearby areas only (Sasikumar and Prakash, 1998).

Dense occurrence near water bodies indicate its affinity to high soil moisture and also the possible distribution of seed through water. This is evident from the infestation of *Mikania* all along the sides of Achamkovil river in the eastern side of Pathanamthitta district, where the weed is yet to spread to surrounding areas. Dutta (1977) also reported its seriousness in tea plantations of North-eastern India in areas with high soil moisture.

Mikania was not found in high attitude areas such as Moonnar and Devikulam (3500-4000 above MSL) in Idukki district and at Ambalavayal (1000 m above MSL) in Wynad district. This might be due to its intolerance to low temperature. Wirjahadja (1975) and Borthakur (1977) reported that in Indonesia, *Mikania* was confined to lower regions upto an elevation of around 1000 metres.

Isolated occurrence of *Mikania* was noticed at Thirunelly and Panamaram in Wynad, Dharmadam and Valapattanam in Kannoor and at Kanjangad in Kasargod. Spread to Thirunelly may be from the tourist vehicles which stops for rest and water near the spring where the isolated case of *Mikania* was noticed in the Thirunelli forest. Introduction to the other places may be by the farmers (settlers) from south and central Kerala who would have accidentally brought it along with planting materials like rubber seedlings or seeds.

Among the crops, pineapple garden in Moovattupuzha is the most severely affected (Plate 1e). Most of the pineapple cultivation is in open areas with good soil moisture status or with irrigation facility. If a single plant gets established, it rapidly spreads in the field by runners, cuttings or seeds and cuts off sunlight for the pineapple crop affecting its growth and yield.

5.2 Biology of *Mikania*

5.2.1 Morphology of *Mikania*

Three species of *Mikania* have been reported in India: *Mikania micrantha, M. cordata* and *M. scandens* (Choudhury, 1972). Choudhury has also listed out the distinguishing floral characters of each species. The characters of the specimens collected from different parts of the state tallies with the characters described for *M. micrantha* by Choudhury (1972). Thus the species of *Mikania* present in Kerala is *M. micrantha*.

The climbing nature helps the weed to spread over tall growing plants and effectively compete for sunlight. It has the capacity to produce runner shoots which help the plant to spread fast and also to circumvent the tillage operations of farmers. The variations of the green and purple coloured stem has been reported by Dutta (1977) also. However, a close watch of the plant indicated that it is not a varietal character; the stems which were purple in the early stages (vegetative) gradually turned to green in its flowering branches. Thus in the same stem, purple and green colour could be noticed. As roots and shoots are produced from the nodes, the plant can overcome tillage operations or sickling which will lead to fragmentation of stem into small pieces. Each node will be capable of regrowing as a new plant.

Perennial grasses like *Imperata cylindrica* and *Agropyron repens* which propagate through rhizome also have the ability to regenerate even from a small piece of rhizome tissue and have abundance of vegetative buds on the rhizomes and these characteristics largely compensate for their vulnerability to soil disturbance (Rao, 1992).

5.2.2 Lifecycle of *Mikania*

In field conditions, seeds start germinating during April after the receipt of first monsoon showers. Early germination is an advantage that ensures a high probability of establishment. Thus it can resist any detrimental effect of heavy monsoon in the months of June-July (S.W. monsoon).

In 1996 and 1997, flowering started from October onwards. But in 1998, flowering was delayed upto November. This may be due to the high rainfall and cloudiness during the period (Appendix 2). It starts growing in April and flowers in October. Within this short span of life, it grows well and produce large number of flowers.

Average seed output of a *Mikania* plant estimated in this study was 45,812 (50 per cent of which is viable). But Sasikumar and Prakash (1998) reported production of 4,33,500 seeds per plant. Reason for this big difference in the estimates is not clear as the workers have not clearly elaborated the procedure followed for determining the seed output. The result of this study (22,906 viable seeds per plant) is closer to the estimate of Dutta (1977), who reported 27,792 viable seeds (three fertile seeds per capitulum) per plant per year.

The seeds are light in weight with only 0.1304 g weight per 1000 seeds. The presence of pappus hairs helps in wind dispersal. These seed characters help in the quick spread of *Mikania*. The high seed production capacity with adaptations for wind dispersal is the main reason for the weediness of *Mikania*.

5.2.3 Longevity of seeds

Maximum germination for the freshly collected seeds and decline in germination percentage upon storage (Fig. 3) shows that the seeds will be viable only for the next favourable season. *Mikania* produces huge number of seeds, but fortunately 100 per cent of its viability is lost after nine months storage. Germination decreases gradually and reaches less than 10 per cent by six months. This explains the higher intensity of infestation of these weeds in moist areas like those adjoining areas of rivers, canals, low lying lands etc. In these areas, the freshly produced seeds get a chance to germinate immediately after dispersal from the mother plant when the germination per cent is very high. In uplands where the land remains dry for about six months between the North-eastern and South-west monsoon (from November-December to May-June), the chances for germination of the seeds produced after December is limited. They get a chance to germinate by May at the receipt of pre-monsoon showers. By this time the germination percentage would be lesser. The seeds did not show any dormancy period in its lifecycle. This observation was in agreement with Dutta (1977), but in contrast to the observation of Sasikumar and Prakash (1998).

5.2.4 Reproduction of *Mikania*

Establishment of *Mikania* decreased with increasing depth of planting (Table 5 and Fig.4). Lack of germination at deeper planting might be due to the lack of light and sufficient oxygen in the moist soil. In contrast to middle and basal portions, apex portion did not give new shoots when planted at 2, 5 and 10 cm depth. This might be due to the easy rotting of the succulent apex part which contains lower lignin in compared with hardy middle and basal portions. Ability of *Mikania* to produce sprouts from different portions of the stem when planted at surface or at deeper depth shows the aggressiveness of the weed. Internodes of *Mikania* also rooted easily, but did not give rise to new plants. Similar observations were reported by Mercado (1994) and Sasikumar and Prakash (1998) also. The results indicate that this weed cannot be controlled by ploughing the field as it is practically impossible to burry all the plant parts to deeper soil depths more than 5 cm, from where regrowth may not occur Observation also shows that it is not advisable to use fresh *Mikania* as green manure as it may help spreading the weed to new areas.

Leaves did not give rise to new plants. This observation is in contrast with those of Mercado (1994) and Sasikumar and Prakash (1998). In this study only the leaves with petioles and axillary buds sprouted. The earlier workers have not specified whether they had taken care to remove the axillary buds which usually remain attached to the petiole, when the leaf is plucked from the plant.

Germination percentage of seeds on the surface of soil was only 35 per cent (in the month of June). Lack of germination of seeds at depths more than `0' cm might be due to the non-availability of light, oxygen and optimum temperature. Germination of seeds of *Mikania* is reported to be light sensitive (Hu and But, 1994; Sasikumar and Prakash, 1998).

Eventhough the percentage of seed germination was not very high, the very high output of seeds ensures the propagation of the species. Due to the ability of the seeds to be dispersed by wind, seeds are distributed to distant places. If a few of these seeds germinate, the *Mikania* seedlings produced can get established in the new area because of its capacity for efficient vegetative propagation. Choudhury (1972) also reported that propagation of *Mikania* was more by runners than the seeds.

5.4 Crop-weed competition

Growth and yield of crop plants free of competition from *Mikania* were significantly better than those over grown by the weed (Table 6,7,8,9,10 and Fig.5). The overgrowing *Mikania* cuts off sunlight to the crop and thus suppress the growth (Plate 2). In earlier studies also, growth and yield of plantation crops such on tea, oil palm and rubber were found to be affected by *Mikania* (Weng, 1964, Dutta, 1977) Palit (1981) reported that *Mikania* caused damage in timber trees by smothering the crown and causing deformation. Some rubber plants over grown by *Mikania* were completely destroyed and the dry matter production of these plants was nil. This may be because of the competitive and allelopathic effect of *Mikania* on rubber plants. Weng (1964) reported that rubber trees grown together with *M. cordata* have shown depressed contents of nitrogen and phosphorus in their leaves as well as depressed rooting in the litter layer and A horizon and have developed relatively small canopies.

Flowering of pineapple and banana were delayed. Kasasian and Seeyave (1968) observed that the main effect of weed competition on banana is the delay in maturity.

In all the crops tried, there was no significant difference in their growth with variation in the number of *Mikania* plants allowed to grow on them. This indicates that there was competition between the *Mikania* plants resulting in reduced drymatter production of individual plants. It also indicates that even a single plant of *Mikania* is capable of covering the canopy of entire crop plants resulting in adverse effect on the crops. So the farmers should be vigilant to destroy any *Mikania* seedling found growing in their crop fields.

5.5 Control methods

5.5.1 Physical methods

All treatments tested were effective compared to the control (Table 12,13 Fig.6 and Plate 3). But the result indicates that *Mikania* could not be eradicated even by digging at monthly interval. Even though digging at monthly interval resulted in complete kill of the weed without any regrowth from January to August, again regrowth appeared from September to December. The study indicated that the weed has the capacity to regrow from the underground corm, bases and portions remaining after cutting.

Sickle weeding, the practice followed currently is not successful as the weed regenerates profusely. This observation was also made by Dutta (1977) and Sarma and Mishra (1986). They reported that *Mikania* stock was able to survive against burning or cutting and new suckers grew from the old suckers.

5.5.2 Chemical methods

5.5.2.1 Effect of pre-emergence herbicides

The observations on seed germination and dry matter production at 60 days after sowing showed that herbicides tested could effectively control *Mikania* (Table 14 and Fig.7). The herbicides, diuron and oxyflourfen resulted in cent per cent control of the germination and establishment of *Mikania* (Plate 4). The results indicate that other herbicides (except fluochloralin) also reduced the germination by more than 50 per cent compared to the control. The problems from *Mikania* can be reduced considerably in cropped field by the use of selective pre-emergence herbicides. Diuron is recommended for pre-emergence application in pineapple (KAU, 1996). The present study indicate that application of diuron can take care of the problems from *Mikania* also in the pineapple garden. Soerjani *et al.* (1976) and Ghosh and Ramakrishnan (1981) also reported the effect of different pre-emergence herbicides including diuron and oxyfluorfen for control of *Mikania*. Diuron (1.5 kg ha^{-1}) was also found to give complete control of the germination of *Chromolaena odorata* (Abraham *et al.*, 1998), another introduced problem weed belonging to compositae.

5.5.2.2 Effect of post-emergence herbicides

All the herbicide treatments resulted in reduction in the number of *Mikania* shoots and their dry matter production compared to the unsprayed control, and the effect was greater at higher doses tested (Table 17,18 and Fig.8). The herbicides in the order of effectiveness in controlling *Mikania* were 2,4-D, glyphosate, glufosinate ammonium and paraquat (Plate 5). All doses of 2,4-D (1.00, 2.00 and 3.00 kg ha^{-1}) and glyphosate at 1.2 kg ha^{-1} resulted in complete drying of *Mikania*, lasting even at 90 days after application. Longlasting control resulting from spraying glyphosate and 2,4-D is because of their systemic action. Dutta (1977) and Palit (1981) also reported the effectiveness of 2,4-D for control of *Mikania*. Prolonged control of

Mikania by spraying glyphosate was reported in rubber, tea and oil palm plantations also (Sukasman, 1979 and Hee *et al.*, 1993). Paraquat and glufosinate ammonium resulted in immediate drying of the weed. Immediate control was because of their contact action. Seth (1971) also noticed short lived action of paraquat and subsequent vigorous regrowth of *Mikania.*

The number of new shoots produced did not differ significantly, between the herbicides. But the dry matter production recorded for all doses of glyphosate was significantly lower eventhough the number of shoots was more. Hundred per cent control of *Mikania* was obtained even at the lowest dose tested for 2,4-D (1.00 kg ha^{-1}), indicating the high sensitivity of *Mikania* to the herbicide. In earlier studies, Borthakur (1977) also reported the susceptibility of *Mikania* to low doses of 2,4-D.

5.5.2.3 Effect of 2,4-D in controlling *Mikania*

Result on the effect of 2,4-D at different formulations and at different doses tested (Table 19) showed that almost complete control of *Mikania* was obtained even for the lowest dose tested (0.25 kg ha^{-1}),indicating the effectiveness of 2,4-D for controlling *Mikania.* A few shoots found green might be the ones that escaped from spraying. Observation also showed that the treatment effect increased from 30 DAS to 90 DAS. This might be due to the systemic and prolonged action of 2,4-D. Susceptibility of *Mikania* to lower doses of 2,4-D was reported by Borthakur (1977) also. The result indicated that *Mikania* infestation in crops not very sensitive to 2,4-D can be controlled by using lower doses of 2,4-D. A farm trial conducted also showed that *Mikania* growth over pineapple could be effectively controlled (94 per cent control) by spraying 2.4-D at 0.25 kg ha^{-1} without giving injury to pineapple crop (Abraham and Abraham, 1999).

5.5.3 Biological methods

5.5.3.1 Indigenous pests on *Mikania*

All the insect pests (Table 20 and Plate 6) found feeding on *Mikania* are polyphagous in nature. So further scope for utilising them as biocontrol agent is limited. However, serious damage to *Mikania* was found in the field by these insect pests, especially tea mosquito bugs, caterpillar and aphids (Plate 7). According to Cock (1982b) the reason for the mild occurrence of *Mikania* in the New World was the presence of wide range of phytophagous insects in the New World. This indicates that the chance of *Mikania* becoming a very serious menace is limited as the uncontrolled growth of *Mikania* will be checked by indigenous enemies present here which will utilise *Mikania* as their alternate host.

Cock (1982b) reported many host specific species from neotropics, the native home of *Mikania*. The host specific species reported from neotropics have not been found to occur in Kerala in this study. This indicates that there is a very good scope for introducing and utilising them as biocontrol agents. The suitability of these agents in biocontrol programme need to be subjected to detailed study.

5.5.3.2 Indigenous pathogens on *Mikania*

All the four pathogens isolated from *Mikania* (Plate 8) which are not host specific in nature are reported to infect common crop plants like tomato, brinjal, chilli, rubber etc. Being non-specific to the host plants the scope for using these as biocontrol agents is limited. However, it can be assumed that natural control of *Mikania* may occur due to the occurrence of these organisms in Kerala. Among the pathogens isolated, *Colletotrichum* and *Alternaria* were found to be the most effective in reducing the competitiveness of *Mikania*. Sharma (1976) and Dutta (1977) also reported *Alternaria sp.* as a major fungi infecting *Mikania*. There is no report of occurrence of the other pathogens (viz., *Colletotrichum gloeosporioides, Curvularia lunata* and *Corynospora cassicola* on *Mikania* and hence these pathogens infecting *Mikania* are new reports. The toxic metabolites isolated from *Colletotrichum* and *Alternaria* could produce necrotic lesions on plant (Plate 10). Necrotic lesions produced by toxic metabolites of *Colletotrichum gloeosporioides* on *Plumbago indica* was reported by Varma (1991) also. Further, since toxic metabolites were found to be thermostable, there is scope for utilising the toxin or its metabolite as a herbicide.

5.6 Alternate uses

5.6.1 Utility as green manure

5.6.1.1 Biomass yield, growth rate and nutrient content of *Mikania*

Observation on biomass production and growth rate of *Mikania* showed its fast growth rate and large biomass yield (Table 25). Thus it can be compared with the biomass production of common green manure plant dhaincha which could yield 26.3 tons ha^{-1} biomass within 45-60 days (Tandon, 1994). Growth rate of *Mikania* shoots per day as reported by Dutta (1977) was 1.8 to 2.7 cm. This observation was much lower than the results in this study (6.29 cm day^{-1}). Dutta has worked out the per day growth rate from the entire period of the *Mikania* plant including the flowering and seed production stage when the vegetative growth is almost nil. In this study the growth rate was worked out on actively growing *Mikania* for 15 days during the vegetative period. This may be the reason for the difference in estimation.

The nutrient content of *Mikania* was also comparable with common green manure plant dhaincha (Table 34). *Mikania* plant is a very good source of nutrients.

5.6.1.2 Rate of decomposition

Decomposition of *Mikania* during 12 months is shown in Table 29. Percentage of decomposition increased with time bringing about 100 per cent decomposition after one year (Fig.9). The litterbags were kept for decomposition in the month of September. More than 70 per cent of *Mikania* (both fresh and dry *Mikania*) decomposed within the first one month itself. Favourable moisture and temperature regimes during the season must have contributed towards the faster rate of decomposition.

The water soluble fraction in the plant material decomposes rapidly, immediately after incorporation and the medium persisting cellulose and hemicellulose and the most resistant fraction lignin decomposes slowly over a longer period (Tandon, 1994). After the seventh month, the rate of decomposition was slow. By the end of the year (360 days after placing the litter bags), about 99.64 and 99.86 per cent of the *Mikania* kept in the litter bags had decomposed. This implied that even after one year of exposure an average of 0.3 per cent of the original material was not decomposed. Thus the decomposition pattern had an initial rapid phase followed by a later slower phase. Similar result was obtained for *Acacia auriculiformis*, wherein 90 per cent of the litter disappeared within six months and the residual mass was remaining upto 16 months (Kunhamu *et al.*, 1994).

Table 34 Average nutrient content in *Mikania* and Dhaincha

Nutrients	Percentage of nutrient	
	Mikania	Dhaincha
N	2.91 (2.04 - 3.78)	3.5
P	0.39 (0.28 - 0.49)	0.6
K	3.41 (2.13 - 4.70)	1.2

Faster rate of decomposition during the initial period has been observed in partially dried *Mikania* compared to the fresh one. After 10 days of placement, rate of decomposition of fresh *Mikania* was 26.75 per cent while partially dried *Mikania* recorded a decomposition of 57.06 per cent. This is because the fresh *Mikania* kept for the decomposition study remained alive for a longer period in the humid and rainy condition. A few shoot pieces even produced new plants by rooting at the nodes, which peeped through the plastic net and had to be nipped off (Plate 12).

This indicate that when *Mikania* is used as a source of green manure there is a chance that it may produce new shoots and thereby helping the spread of the weed. To avoid this problem, sun drying the material for a few days or composting will have to be done.

5.6.2 Utility of *Mikania* as fodder

Data on chemical composition and fibre fractions of *Mikania* presented in Table 30 shows that *Mikania* as a fodder is comparable with common exotic grasses like guinea and setaria used for fodder purpose (Table 35). Fibre fractions showed wide variation in the samples from different locations, probably due to difference in stage of maturity of plants analysed. Hydrocyanic acid, an important antinutritional factor is not present in *Mikania*. Average protein content in *Mikania* is 14.63 per cent. As protein content of fodder increases, it will be well relished by the cattle, at the same time the forage will be more digestible and nutritious to the animals (Pillai, 1986). Thus it seems that it is a good fodder. Importance of *Mikania* as a livestock feed was reported by Arope *et al.* (1985) and Bogidarmantis (1989).

Plate 12 Sprouting from fresh *Mikania* kept for decomposition in litter bag

Table 35 . Average chemical composition and dry matter yield of *Mikania* in comparison with guinea grass and setaria grass

Plant	Crude protein (%)	Crude fibre (%)	Total ash (%)	Calcium (%)	Dry matter yield (t ha^{-1})
Mikania sp.	14.63	23.21	8.92	0.87	4.02 - 6.04
Guinea grass	8.40	32.97	10.40	0.53	7.58 - 11.51
Setaria grass	8.50	31.97	10.96	0.56	17.35 - 11.21

However reports are there from veterinary surgeons in Moovattupuzha Taluk in Ernakulam district that goats feeding on *Mikania* had developed symptoms of neurotoxicity (personal communication from Dr. Justin Adikarathil, Veterinary Surgeon, Thodupuzha). These cases responded to thiamin treatment, indicating that some antinutritional factors other than hydrocyanic acid (HCN) is present in *Mikania*. Average K/Ca+Mg ratio of *Mikania* was 2.86. The plant had slightly higher values for the ratio than the reported critical value of 2.2 for the incidence of grass tetany (hypomagnesaemia) in cattle. This is a drawback for the fodder quality. Reports are also available indicating the hepatotoxicity to animals feeding on *Mikania* which was attributed to the presence of alkaloid like materials in *Mikania* (RIAD, 1986 and Murdiate and Stoltz, 1987). So further research is needed to find out whether any other antinutritional factor is present in *Mikania* before making any conclusion about its utility as a fodder.

5.6.3 Allelopathic effects of *Mikania*

Results of the effect of leachate and fresh material of *Mikania micrantha* on germination and growth of test sp. cowpea, rubber and rice are given in Tables 31,32,33 and Fig.10. Among the test sp., rubber was very sensitive to both leachate and fresh material of *Mikania*. It caused significant reduction in height and weight of rubber seedlings (Plate 11). Weng (1964) also noticed significant depressive effects on growth of rubber seedlings by the application of *Mikania*. He also reported that *Mikania* contained substances which depressed growth of rubber and suggested that growth inhibitory substances like phenolic and flavonoid constituents may be responsible for this. Ismail and Mah (1993) reported that leachate of *Mikania* leaf caused significant reduction in radicle length and fresh weight of the seedlings of the test sp., *Paspalam conjugatum, Asystasia intrusa* and *Chrysopogon aciculatus*. Among these, only paspalam seeds showed significant decrease in germination. The study indicates that growth of *Mikania* as weed in rubber garden may have deleterious effect on growth as the weed has allelopathic effect (suppression of growth) on rubber plants. This would be the reason for the failure of the attempt to introduce these as cover crop in Malaysia (Weng, 1964). On the contrary, there was no allelopathic effect from *Mikania* on growth of rice. Growth of rice was enhanced by application of *Mikania* indicating its possible utility as a source of green manure for rice.

Summary

The weed has not yet spread to the Southern districts, with no infestation in Thiruvananthapuram and only isolated incidence in Kollam district.

In northern districts of Malappuram, Palakkad, Kozhikode, Wynadu, Cannanore and Kasaragod, only isolated infestation was noted.

Part II - Biology of *Mikania*

Morphology was studied by observing the plant samples collected from different parts of state. Life cycle of *Mikania* from germination, growth, flowering, seed production and to death were studied in natural field condition. Reproduction of *Mikania* from seeds and cuttings of different parts of stem sown/planted at different depth in soil were studied. Ability of the plant to propagation from leaves was also studied. Seed characters such as seed longevity and 1000 seed weight were studied under laboratory condition.

Mikania is a fast growing herbaceous perennial climber, the top portion of *Mikania* plant dries out every year at the onset of summer and regenerates during April-May. In the same plant some shoots are light violet in colour, some are hairy. The inflorescence is umbel of heads. Studies on floral characters revealed that the species present in Kerala is *Mikania micrantha.*

In the natural field conditions, seeds of *Mikania* germinated soon after the first receipt of rainfall during April. Normally, flowering period commences in October. After flower opening it took 9-12 days for seed maturity. Single *Mikania* produced an average of 357 inflorescence with 32 flowers (four seeds per head) per inflorescence. Average seed output per plant was 45812 number with a range of 35520-54720.

SUMMARY

Mikania micrantha H.B.K. is one of the most serious weed in agricultural and non-agricultural area of Kerala. Being a comparatively recent introduction, no work has been undertaken to develop an efficient method to manage this weed. Hence this study "Biology and control of the weed *Mikania micrantha* in Kerala" - was conducted at College of Horticulture, Vellanikkara during 1995-1999 with the intention to understand the following aspects.

1) Survey on the distribution of *Mikania* in Kerala.
2) Biology of *Mikania*
3) Competition of *Mikania* with common crops
4) Efficiency of different control methods and
5) Alternate uses of *Mikania.*

The study was undertaken in five parts as briefed below:

Part I Distribution of *Mikania* in Kerala

Distribution of *Mikania* was studied by conducting a survey at different parts of Kerala by travelling along the major terrestrial routes of the state. Extent of infestation in agricultural and non agricultural area was noted and its intensity was recorded. It was found that the infestation of the weed was severe in all parts of Ernakulam and Kottayam districts and also in some parts of Trichur, Idukki, Alappuzha and Pathanamthitta districts mainly the adjoining areas of Ernakulam and Kottayam districts.

Average weight of 1000 seeds was 0.1304 g. Seed germination decreased with duration of storage with no seeds germinating after seven months of storage.

Maximum establishment was for the cuttings from the basal portions of stem at zero depth of planting (52.4%). No sprouts was produced from the apex portion of stem planted at 2, 5 and 10 cm depth, middle and basal portions at 10 cm depth and internodes at all depths. Internodal cutting produced roots but no sprouts emerged. Seeds at `0' cm depth (kept at the surface of soil) gave 35 per cent germination. The seeds failed to germinate even by slight burial in soil. Leaves did not sprout, but the leaf petioles with axillary bud produced sprouts.

Part III Crop-weed competition

Effect of competition from *Mikania* on the growth of crop plants such as pineapple, banana, rubber, coconut, cocoa and teak was studied in a field experiment in randomised block design. The treatments were competition of crop plants with one *Mikania*, two *Mikania* and four *Mikania*. For cocoa, rubber, teak and coconut, the observations were taken after one year and for banana and pineapple, the observations were taken at the harvest of the crop. For all crops, growth was suppressed by *Mikania* infestation. Competition from *Mikania* delayed the flowering and reduced the fruit weight in pineapple and banana. Height, girth and dry weight of banana, cocoa, rubber, coconut and teak were significantly reduced due to competition. The number of *Mikania* plants competing with a single crop plant did not have much effect on the different characters of the crop or on the dry weight of *Mikania*.

Part IV Control methods

Studies on physical methods of control was conducted in the rubber plantation which had a uniform infestation of *Mikania.* The trial was started in October 1996 and continued for 18 months. Experiment on screening of pre-emergence herbicides was done in pots whereas testing of post-emergence herbicides was conducted in the field. Indigenous pests and pathogens on *Mikania* were collected during the survey and scope of using them for biological control of *Mikania* was assessed.

Among the different, physical methods of control, digging at monthly interval was found to be the best, followed by digging at bimonthly interval, sickle weeding at monthly interval and sickle weeding at bimonthly interval. All treatments significantly reduced the number and dry matter products of *Mikania* plants per unit area compared to the control. Digging at monthly interval resulted in complete control of the weed without any regrowth.

All the pre-emergence herbicides tested significantly reduced the germination of *Mikania* seeds. Among them, diuron (1.5 kg ha^{-1}) and oxyflourfen (0.20 kg ha^{-1}) resulted in complete control of the germination and establishment of *Mikania.* Other herbicides in the order of effectiveness in controlling *Mikania* were atrazine, butachlor, metolachlor, alachlor, pretilachlor and fluochloralin.

All forms of 2,4-D resulted in complete drying of *Mikania* followed by glyphosate, glufosinate ammonium and paraquat. 2,4-D, even at the lowest dose tested (0.25 kg ha^{-1}) gave 92-99 per cent control, indicating the high sensitivity of *Mikania* to 2,4-D.

Eighteen insect pests were found infesting *Mikania*. Among them, the major pests were aphids tea mosquito bug, thrips and the lepidopteran pest *Spilosoma obliqua*. But all these pests are polyphagous in nature limiting the scope to use them for biological control of *Mikania*.

Pathogens causing the leaf spots were identified as *Colletotrichum gloesporioides*, *Alternaria alternata*, *Curvularia lunata* var. aria. and *Corynespora cassicola*. The toxic metabolites (both endotoxin and exotoxin) isolated from *Colletotrichum sp.* and *Alternaria* sp. produced symptoms on *Mikania* within 3 to 5 hours of inoculation. Diameter of these necrotic spots increased with time, leading to complete drying of the leaf by four days. These toxic metabolites were found to be thermostable.

Part V Alternate uses

To study the utility of *Mikania* as green manure, biomass production, growth rate, nutrient content (major and minor) and rate of decomposition were studied.

Biomass yield of single plant was calculated from isolated single *Mikania* seedling allowed to climb on tapioca plant. Six month old *Mikania* plant could produce 2.25 kg fresh weight with an average increase in the length of vine by 6.29 cm per day. Biomass of *Mikania* grown under natural field condition was 2012 g fresh weight per square metre.

Nutrient content of different parts of *Mikania* (old stem, young stem, old leaf and young leaf) collected from various district were estimated. The mean content of different nutrients in *Mikania* was 2.35 per cent N, 0.39 per cent P, 3.58 per cent K, 0.82 per cent Ca, 0.42 per cent Mg, 0.013 per cent Mn, 0.167 per cent Fe, 0.0045 per cent Cu and 0.022 per cent Zn.

Decomposition rate of fresh and partially dried *Mikania* (oven dried at 80°C for 12 hours) were studied under natural field condition using litter bag technique. The rate of decomposition was higher during the initial periods and decreased towards the end of the study. Partially dried *Mikania* decomposed more rapidly than fresh *Mikania*. Almost 100 per cent decomposition of both type occurred by about one year.

Chemical composition and fibre fractions of *Mikania* were estimated to study the fodder value of *Mikania*. It contained an average of 14.63 per cent crude protein, 2.36 per cent fat, 23.21 per cent crude fibre, 48.75 per cent NFE, 8.92 per cent ash, 0.87 per cent Ca and 0.42 per cent P. The fibre fractions contained 42.42 per cent neutral detergent fibre, 33.22 per cent acid detergent fibre, 0.096 per cent cellulose, 9.2 per cent hemicellulose and 10.84 per cent lignin. The analysis for antinutritional factor hydrocyanic acid showed negative result. These results suggest that fodder value of *Mikania* is comparable with the common exotic grasses like guinea grass and setaria grass used for fodder purposes.

Allelopathic effects of fresh *Mikania* when used as mulch or when incorporated in soil and from water extracts of *Mikania* (0, 1, 2 and 4 per cent) were studied using the test crops (cowpea, rubber and rice). Both seed germination and growth of the test crops were observed. Among the test sp. rubber was very sensitive to both water extracts and fresh material of *Mikania*. It caused significant reduction in height and weight of rubber seedlings. On the contrary, not only there was no allelopathic effect from *Mikania* on growth of rice, but the growth of rice was also enhanced by application of *Mikania*. Treatment with *Mikania* extract did not have any influence on germination and radicle length of rice whereas in cowpea, the allelopathic effect was very much pronounced.

Conclusion

Mikania Micrantha, an introduced weed native to tropical south and central America and belonging to the family *Asteraceae* is widely distributed in Ernakulam, Kottayam, Idukki and Pathanamthitta districts. It has profuse seed production capacity in addition to effective vegetative reproduction. Competition of *Mikania* with crop plants reduces the yield and drymatter production as the weed climbs over the crop and reduces the availability of sunlight.

Physical methods like digging and sickling are not very effective as the weed has the capacity to regenerate from fragment of stem with a node. The pre-emergence herbicides diuron and oxyflourfen can be applied to control *Mikania* in annual crops like pineapple and banana. Among the post-emergence herbicides tested, 2,4-D was very effective in controlling the weed even at a low dose of 0.25 kg ha^{-1}. In pineapple garden, spraying 2,4-D (0.25 kg ha^{-1}) can control *Mikania* without giving phytotoxicity to the crop. 2,4-D can also be applied to control *Mikania* in graminaceous crops like sugarcane. In plantations directed spraying of systemic herbicides, 2,4-D and glyphosate can control the weed. A number of insects and fungi are found to attack *Mikania*. However, they are not host specific for utilize them for biological control.

Mikania can be used as a source of green manure and as feed for cattle. The weed has allelopathic or inhibitory effect on growth of rubber.

Future line of work

Infestation of *Mikania* is severe in central Kerala and decreases towards northern and southern districts. Periodical survey has to be repeated for monitoring the further spread of the weed to other areas of Kerala. Investigations are also required to understand whether soil and climatic factors are influencing the severe infestation of the weed in the districts of Ernakulam and Kottayam.

Eventhough the pathogens infecting *Mikania* are not host specific, the present study has indicated the potential of their toxin for causing phytotoxicity in this weed. Studies on synthetic analogues of these toxins may lead to develop eco-friendly herbicides.

All the insect pests found to infest *Mikania* in Kerala are polyphagous in nature and hence cannot be used for biological control purposes. Hence studies with exotic organisms for biological control should be taken up. This is important as the weed has already infesting large areas under forests and non agricultural lands, where other methods may not be practical.

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* Originals not seen

Appendices

APPENDIX 1

Details of herbicides used in the trial

Sl. No.	Common Name	Trade Name	Formulation	Manufacturing Company
1	2,4-D Sodium salt	Fernoxone	80% WP	Zeneca - ICI
2	2,4-D Ethanol amine	Agrodar 96	58% SL	Agromore Ltd.
3	2,4-D Ethyl ester	Agrodon conc.54	34% EC	Agromore Ltd.
4	Paraquat	Gramoxone	24% WSC	Zeneca - ICI
5	Gluphosate	Roundup	41% WSL	Monsanto
6	Glufosinate ammonium	Basta	15% SL	Agr. Evo
7	Diuron	Klass	80% WP	Bharat Pulverising Mills
8	Atrazine	Atrataf	50% WDP	Rallis India Ltd.
9	Oxyflourfen	Goal	23.5% EC	Bayer (India) Ltd.
10	Fluochloralin	Basalin	45% EC	BASF
11	Butachlor	Machete	50% EC	Monsanto
12	Alachlor	Lasso	50% EC	Monsanto
13	Pretilachlor	Refit	50% EC	Novartis
14	Metolachlor	Dual	50% EC	Novartis

APPENDIX 2

Mean monthly weather parameters during the study

Month	Total rainfall (mm)	Temperature Max (°C)	Temperature Min (°C)	Relative humidity FN (%)	Relative humidity AN (%)	Sunshine hours(h)	Wind speed (km h^{-1})
1996							
Jan	0	33.1	22.4	71	35	9.4	7.1
Feb	0	34.7	23.4	72	34	9.9	5.9
Mar	0	36.4	24.3	82	37	9.3	3.6
Apr	1520	34.6	25.0	87	59	8.3	3.0
May	954	32.8	25.2	91	63	7.7	2.4
Jun	4003	30.5	23.8	94	75	4.7	3.0
Jul	5887	28.8	23.1	96	83	2.7	2.7
Aug	3100	19.1	23.6	95	78	3.7	3.0
Sep	3916	29.2	23.7	94	74	4.3	2.7
Oct	2193	30.1	22.9	93	70	6.0	2.0
Nov	2210	31.5	23.6	84	59	7.1	3.7
Dec	604	30.5	21.8	80	55	6.8	6.4
1997							
Jan	0	32.0	22.9	78	45	9.6	6.9
Feb	0	33.9	23.8	82	39	9.3	3.9
Mar	0	36.7	24.0	82	37	9.6	4.0
Apr	82	35.2	24.5	83	50	9.4	3.3
May	630	34.4	24.5	87	57	6.7	3.3
Jun	7205	31.2	23.0	93	71	5.9	2.7
Jul	9792	28.1	21.8	95	84	1.9	4.6
Aug	6368	29.0	22.8	95	78	3.4	2.8
Sep	1640	30.6	23.4	93	71	6.8	2.5
Oct	1947	32.2	23.6	88	65	7.3	2.6
Nov	2113	31.6	23.2	88	67	5.3	2.9
Dec	664	31.7	23.8	83	61	7.5	5.9

Appendix 2 contd....

1998							
Jan	0	33.1	22.8	78	49	9.3	6.6
Feb	0	34.4	23.6	77	51	9.6	5.2
Mar	11.0	36.2	23.6	88	47	10.0	3.4
Apr	61.4	36.5	25.6	86	50	9.0	3.1
May	203.0	34.1	25.2	90	63	7.6	2.6
Jun	809.3	30.2	23.3	94	79	3.4	2.7
Jul	752.9	29.2	23.6	96	80	3.3	2.8
Aug	433.6	29.8	23.9	95	77	3.6	2.5
Sep	571.3	30.2	23.3	96	78	4.1	2.0
Oct	194.7	32.2	23.2	88	65	7.3	2.1
Nov	109.4	31.5	23.1	92	64	7.2	1.7
Dec	33.0	30.1	22.9	79	58	6.6	5.7

APPENDIX 3

Abstracts of analysis of variance tables

1. Biology - Reproduction from different parts of stem

Source	df	Mean square	
		Sprouting	Dry weight
Treatment	6	2.73	138.94
Error	12	1.40	91.07

2. *Competition with crop plants*

(a) Pineapple

Source	df	Height	Girth	Weight of plant	Flowering	Weight of fruit	Weight of *Mikania*
Treatment	3	387	1.12	0.18	8513	0.17	19.35
Error	12	346	0.99	0.023	1811	0.027	20.35

(b) Banana

Source	df	Height	Girth	Weight of plant	Flowering	Weight of fruit	Weight of *Mikania*
Treatment	3	3239	66	16.2	1380	8.6	141
Error	12	811	21	2.19	131	0.74	146

(c) Coconut

Source	*df*	*Height*	*Girth*	*Weight of plant*	*Weight of Mikania*
Treatment	3	5342	16	2.12	140
Error	12	199	1.8	0.25	208

(d) Teak

Source	df	Height	Girth	Weight of plant	Weight of *Mikania*
Treatment	3	51438	71	72804	240
Error	12	1821	1.29	2254	500

(e) Rubber

Source	df	Height	Girth	Weight of plant	Weight of *Mikania*
Treatment	3	76715	28.7	416025	34.5
Error	12	6476	7.9	11575	150.6

(f) Cocoa

Source	df	Height	Girth	Weight of plant	Weight of *Mikania*
Treatment	3	1.668	1.19	636	237
Error	12	163	0.12	74	357

3. Physical methods of control

Source	df	No. of shoots m^{-2}																	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Treat -ment	3	49	32458	405	379	185	73	50	88	1945	1449	1121	540	312	1627	200	132	47	45
Error	9	3.5	378	4.4	2.6	2.2	7	1.3	3.7	12.5	7	6.3	4.3	2.9	1118	2.5	4	2	4.7

Source	df	Dry weight of *Mikania*																	
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Treat -ment	3	62409	64069	51253	15163	10519	1149	70	108	267	497	151	3965	8303	9991	7101	4941	1984	672
Error	9	1622	247	238	178	70	16	1.5	1.8	3.4	9.4	5.4	17	13	36	21	35	16	20

4. Effect of pre-emergence herbicides

Source	df	Sprouting %	Dry weight
Treatment	6	306.4	65.08
Error	14	60.2	8.85

5. Effect of post-emergence herbicides

Source	df	No. of shoots						Dry weight of *Mikania*					
		1996			1997			1996			1997		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Treatment	9	24.8	28.9	27.6	9.06	30.3	12.6	17762	5047	3355	9485	4698	3180
Error	27	0.91	0.75	1.5	1.11	0.42	0.58	59	63	32	256	149	117

6. Nutrient content

(a) Old stem

Source	df	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn
Treatment	4	7.65	0.69	9.23	3.91	0.11	0.18	1.61	0.008	0.55
Error	10	0.17	0.65	1.61	1.57	0.72	0.07	0.37	0.003	0.39

(b) Young stem

Source	df	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn
Treatment	4	4.94	0.56	3.89	5.94	3.52	0.102	1.61	0.031	0.039
Error	10	0.17	0.42	0.59	0.06	0.17	0.017	0.35	0.025	0.041

(c) Old leaf

Source	df	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn
Treatment	4	5.48	1.37	2.16	7.68	5.29	0.29	2.63	0.018	0.66
Error	10	0.008	0.47	0.07	0.29	0.04	0.004	0.43	0.004	0.28

(d) Young leaf

Source	df	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn
Treatment	4	4.8	0.78	5.89	3.24	1.10	0.29	5.27	0.02	0.111
Error	10	0.04	0.59	0.26	0.44	0.16	0.02	0.23	0.051	0.023

7. Rate of decomposition

Source	df	Fresh *Mikania*	Dry *Mikania*
Treatment	13	2049	759
Error	56	6.4	49

8. Chemical composition

Source	df	C. Protein	Fat	C. Fibre	Ca	P	NDF	ADF	Cellulose	Hemi cellulose	Lignin	Ash
Treatment	3	7.39	1.52	1.9	3.3	0.19	39.8	12.4	1.59	20.8	255	3.6
Error	8	0.08	0.22	2.8	0.08	0.13	0.32	9.02	0.42	16.7	36	0.49

9. Allelopathic effect

(a) Mulch/Incorporation

Source	df	Rubber		Cowpea		Rice	
		Height	Weight	Height	Weight	Height	Weight
Treatment	6	317	0.69	270	2.83	115	0.024
Error	21	13.4	0.022	28.8	0.71	36.14	0.16

(a) Extract

Source	df	Rubber		Cowpea		Rice	
		Height	Weight	Height	Weight	Height	Weight
Treatment	3	477	0.28	219	0.12	3.75	0.009
Error	12	5.96	0.019	42	0.34	50.9	0.021

BIOLOGY AND CONTROL OF THE WEED *Mikania micrantha* H.B.K. IN KERALA

By

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ABSTRACT OF THE THESIS

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1999

ABSTRACT

Mikania micrantha is a recently introduced weed spreading fast in agricultural and non-agricultural areas of Kerala. It is commonly known as mile-a-minute weed in English and as *American vally, Padvayara* etc. in Malayalam. A study on "Biology and control of the weed *Mikania micrantha* HBK in Kerala" was undertaken at the College of Horticulture, KAU, Vellanikkara during 1995-1999 to study the distribution, biology, competition to crops and alternate uses of *Mikania* and also to develop recommendations for controlling the weed.

Infestation of *Mikania* was found to be widespread in Ernakulam and Kottayam districts and in most parts of Trichur, Idukki, Alappuzha and Pathanamthitta districts. The weed has not yet spread to the southern districts, with no infestation in Thiruvananthapuram and only isolated incidence in Kollam district. In the northern districts of Malappuram, Palakkad, Kozhikode, Wynad, Kannoor and Kasaragod, only isolated infestation was noticed.

Mikania is a fast growing herbaceous perennial climber belonging to the family Asteraceae. The weed seeds germinated in April-May, flowered in October and took 9 to 12 days for seed maturity. Inflorescence is an umbel of heads. Average seed output per plant was 45812 with an average production of 357 inflorescence, each having 32 flowers (four seeds per head). Fresh seeds gave 80 per cent germination and the viability decreased to zero after seven months of storage.

The weed can propagate by seeds and stem cuttings. Seeds kept for germination on the soil surface (0 cm depth) gave maximum germination, whereas even the slight burying of the seeds prevented germination. From the stem cuttings, maximum establishment was for the cuttings from the basal portion of stem when planted at zero depth of planting followed by middle and apex portions. Sprouting per cent decreased with depth of planting with no sprouts arising when planted at 5 cm below the surface. No sprouts were produced from internode at any depth of planting. Leaves did not sprout, but the leaf petioles with axillary bud produced sprouts.

Competition from *Mikania* suppressed the growth of pineapple, banana, rubber, coconut, cocoa and teak plants. It also delayed the flowering and reduced the fruit weight of pineapple and banana.

Among the physical methods of control, digging at monthly interval was found to be the best followed by digging at bimonthly interval, sickle weeding at monthly interval and sickle weeding at bimonthly interval.

Pre emergence herbicides, diuron (1.5 kg ha^{-1}) and oxyflourfen (0.20 kg ha^{-1}) resulted in prevention of germination and establishment of *Mikania* followed by atrazine, butachlor, metolachlor, alachlor, pretilachlor and fluochloralin.

All forms of 2, 4-D resulted in complete drying of *Mikania*. Even the lowest dose (0.25 kg ha^{-1}) tested gave 92-99 per cent control of *Mikania*. Other herbicides in the order of effectiveness were glyphosate, glufosinate ammonium and paraquat.

Eighteen insect pests were found infesting *Mikania*. The major pests were aphid, tea mosquito bug, thrips and the lepidopteran pest, *Spilosoma obliqua*. However, since all these insect pests are polyphagous in nature, their utility for biological control is limited.

Pathogens infecting the weed were identified as *Colletotrichum gloeosporioides, Alternaria alternata, Curvularia lunata* Var. *aria* and *Corynespora cassicola*. The toxic metabolites (both endotoxin and exotoxin) isolated from *Colletotrichum sp.* and *Alternaria sp.* produced necrotic symptoms on *Mikania*. Size of the leaf spot increased with time leading to complete drying of the leaf by four days.

Biomass yield of single *Mikania* plant was 2.25 kg fresh weight (18.25% dry weight). Under natural field condition biomass yield from one square metre area was 2.012 kg fresh weight. Average increase in the length of vine per day was 6.29 cm.

The mean content of different nutrients in *Mikania* was 2.35 per cent N, 0.39 per cent P, 3.58 per cent K, 0.82 per cent Ca, 0.42 per cent Mg, 0.013 per cent Mn, 0.167 per cent Fe, 0.0045 per cent Cu and 0.022 per cent Zn.

Rate of decomposition of *Mikania* was faster during the initial period and decreased towards the end of the study, reaching almost 100 per cent decomposition by one year.

Fodder value was studied by estimating the chemical composition and fibre fraction of *Mikania*. It contained an average of 14.63 per cent crude protein, 2.36 per cent fat, 23.2 per cent crude fibre, 48.75 per cent nitrogen free extract, 8.92 per cent ash, 0.87 per cent calcium and 0.42 per cent phosphorus. The fibre fractions contained 42.42 per cent neutral detergent fibre, 33.22 per cent acid detergent fibre, 0.096 per cent cellulose, 9.2 per cent hemicellulose and 10.84 per cent lignin. The analysis for anti-nutritional factor hydrocyanic acid showed negative result.

Allelopathic effect of *Mikania* when used as mulch or incorporation as well as the effect of the *Mikania* extract were studied using the test crops, rice, cowpea and rubber. *Mikania* had an inhibitory effect on growth of rubber, but the growth of rice was enhanced by its application. Treatment with *Mikania* extract did not have any influence on germination and radicle length of rice seeds where as in cowpea seeds the allelopathic effect was very much pronounced.