UNIVERSITI PUTRA MALAYSIA

THE EFFECT OF LIGHT, FERTILISER AND PLANTING DENSITY ON THE GROWTH AND FLOWERING OF ASYSTASIA GANGETICA SUBSP. MICRANTHA

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BY

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Asystasia gangetica subsp. *micrantha*, commonly known as Asystasia, is a prolific weed that has recently become problematic to the plantation industry in Malaysia. The weed's success in invading plantations over a wide geographical range is attributed to its fast establishment, rapid growth rate and early flowering.

The pot trial study of Asystasia showed the weed's life-cycle consists of four growth phases, each of about 45-days' duration: namely phase 1 - juvenile, phase 2 - initial flowering, phase 3 - intense flowering and phase 4 - senescent.

Phase 1 was characterised by rapid vegetative growth with the first flower blooming by Day 42. The

total dry weight for high-density (17 plants/pot) plants under full sunlight and high soil nutrients was 34 g/pot. The dry matter partitioning of leaves:stems:roots was 40:28:32 and the leaf index was 5.37. The weed's fast growth from seed germination is one of its outstanding characteristics and has made it highly successful in colonising exposed sites brought about by land cultivation or chemical spraying.

The second growth phase from Day 45 to 90 consisted of both vegetative and flowering. The total biomass has increased to 95 g/pot and dry matter partitioning of leaves:stems:roots has changed to 31:37:32. Emphasis of dry matter allocation has shifted from leaves to stems as the plant grew. This stage of growth could also be considered the "building phase" as the weed accumulated biomass and leaves for the next stage of high reproduction. Leaf index has more than doubled to 12.8. Inter-plant competition has affected flowering: low-density (1 plant/pot) plants have higher capsule potential of 302 capsules/pot compared to only 34 capsules/pot for high-density under open conditions with high fertiliser rates.

Phase 3 growth of Asystasia was primarily the flowering and reproduction stage and these might be considered the "climax" growth. The total dry matter of 232 g/pot has more than doubled the previous phase

but the capsule potential has increased many times. Flowering was intense. Under open conditions, capsule potential ranged from 325 to 1078 capsules/pot while under shade conditions, the potential was 285 to 820 capsules/pot. Dispersed seeds would become part of the soil seed bank and ready to germinate at the next growth opportunity and perpetuate future generations of Asystasia. Dry matter partitioning of leaves:stems:roots was 22:36:42. Leaf index has increased to 19.8.

The last phase is senescence stage. Most of the ripe capsules have dispersed their seeds and most plants were chlorotic and suffering from considerable die-back.

The noxious status of this weed is attributed mainly to its ability to absorb high amount of soil nutrients. At its "climax" growth by Day 135, the Asystasia biomass of 232 g/pot consisted of 5.4 g of nitrogen, 0.4 g of phosphorus, 4.1 g of potassium and 0.6 g of magnesium excluding the biomass produced as capsules. Thus, cultivated crops that are heavily infested with Asystasia are likely to face severe competition for soil nutrients.

Abstrak tesis dikemukakan kepada Senat Universiti Pertanian Malaysia Untuk Memenuhi Keperluan Ijazah Master Sains

KESAN CAHAYA, BAJA DAN KEPADATAN TANAMAN KE ATAS PERTUMBUHAN DAN PEMBUNGAAN *ASYSTASIA GANGETICA SUBSP. MICRANTHA*

Oleh

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Asystasia gangetica subsp. micrantha atau biasanya dikenali sebagai Asystasia adalah rumpai produktif yang bermasalah dalam industri perladangan di Malaysia pada masa kini. Kejayaan pencerobohannya ke dalam ladang ladang adalah disebabkan oleh kadar pertumbuhannya yang pantas dan kukuh serta pembungaannya yang awal.

Pengajian yang dijalankan dalam pasu menunjukkan bahawa rumpai ini mempunyai 4 peringkat pertumbuhan, iaitu peringkat 1- muda, peringkat 2- permulaan membunga, peringkat 3- giat membunga dan peringkat 4- layu. Jangka masa setiap peringkat tersebut adalah lebih kurang 45 hari.

Peringkat 1 menandakan pertumbuhan tampang yang cepat dengan bunga pertama berkembang pada hari ke

42. Di bawah cahaya penuh dan kandungan nutrien tanah yang tinggi, pokok-pokok yang ditanam dengan kepadatan tinggi (17 pokok/pasu) memperolehi jumlah berat kering sebanyak 34 g/pasu. Nisbah bahan kering daun:batang :akar adalah 40:28:32 dan indeks daun adalah 5.37. Pertumbuhan yang cepat selepas percambahan adalah salah satu sifat luar biasa yang membolehkan rumpai ini berjaya menduduki kawasan kawasan yang terdedah akibat dari cucuk tanam dan penggunaan racun kimia.

Peringkat kedua adalah di antara hari ke 45 dan ke 90. Peringkat ini melibatkan pertumbuhan tampang dan pembungaan. Jumlah biomas bertambah ke 95 g/pasu dan nisbah bahan kering untuk daun:batang:akar bertukar ke 30:37:32. Keutamaan peruntukan berat kering berpindah dari daun ke batang dalam proses pertumbuhan. Peringkat ini boleh juga dikenali sebagai "fasa pembinaan" di mana rumpai ini mengumpulkan biomas untuk pertumbuhan giat seterusnya. Indeks daun meningkat ke 12.8. Persaingan antara pokok telah memberi kesan kepada pembungaan: pokok-pokok yang ditanam dengan kepadatan rendah (1 pokok/pasu) mempunyai potensi sebanyak 302 kapsul/pasu berbanding dengan hanya 34 kapsul/pasu untuk pokok-pokok dalam kepadatan tinggi di bawah keadaan terbuka dan kadar pembajaan yang tinggi.

Peringkat 3 pertumbuhan Asystasia adalah pada asalnya peringkat pembungaan dan penghasilan dan boleh juga dianggap sebagai pertumbuhan "kemuncak". Bukan saja jumlah berat kering meningkat dua kali ganda ke 232 g/pasu berbanding dengan peringkat yang lepas tetapi potensi kapsul juga bertambah banyak kali. Pembungaan adalah giat. Dalam keadaan terbuka, potensi kapsul berada dalam lingkungan 325 ke 1078 kapsul/pasu, manakala dalam keadaan gelap, potensinya hanya setakat 285 ke 820 kapsul/pasu. Biji-biji yang tersebar kemudian akan berada dalam tanah dan sedia untuk bercambah bila peluang tiba dan menjadi generasi Asystasia yang akan datang. Nisbah bahan kering daun:batang:akar menjadi 22:36:42 akibat pengeluaran kapsul. Indeks daun bertambah ke 19.8.

Peringkat akhir ialah peringkat layu. Kebanyakan kapsul telah menyebarkan biji-biji mereka dan kebanyakan pokok adalah "chlorotic" dan mengalami kematian pucuk yang agak hebat.

Kebolehan penyerapan kandungan nutrien tanah yang tinggi merupakan salah satu kerosakan utama rumpai ini terhadap tanaman-tanaman. Pada pertumbuhan "kemuncak" di hari ke 135, biomas Asystasia sebanyak 232 g/pasu tersebut mengandungi 5.4 g Nitrogen, 0.4 g phosphorus, 4.1 g potassium dan 0.6 g magnesium tidak termasuk biomas kapsul. Oleh itu, mawasan-kawasan tanaman yang mempunyai populasi

Asystasia yang tinggi akan mengalami pertandingan yang hebat untuk nutrien-nutrien tanah.

CHAPTER I

INTRODUCTION

Asystasia gangetica subsp. *micrantha* (incorrectly known as *Asystasia intrusa*) was categorised as a serious noxious weed in oil palm plantations in Malaysia (Rajaratnam *et al.*, 1977). Although there are three taxa of Asystasia in Peninsular Malaysia, only subsp. *micrantha* is a problematic weed.

The weed was at first found in central and south Johore (Teoh *et al.* 1982; Chan, 1984) but has now spread to all states of Peninsular Malaysia (Anon, 1984; Saberi and Musa, 1992). At present, in Peninsular Malaysia, Asystasia is seen almost everywhere, from home gardens, along roadsides to the edge of forest. Since 1992, it has also been observed in oil palm plantations in the Tawau-Lahad Datu region.

Although the weed is easily killed by a wide range of herbicides (Rajaratnam *et al.*, 1977; Teoh *et al.*, 1982), its fast growth, early flowering and ability to spread and invade new sites throughout the country has made it one of the most successful weeds in Malaysia.

In order to control the weed, a better understanding of its biology is essential. There are many aspects of Asystasia biology that need to be elucidated of which the most important and interesting are those relating to its ability to compete, survive and spread. These primarily related to growth, dry matter production and reproduction under various environmental conditions. In order to control these environmental parameters, a pot trial study is most suitable for this purpose.

Quantitative studies of *Asystasia gangetica* subsp. *micrantha* focussed on the effect of shade, planting density and fertiliser application on :

(1) Plant growth (dry weight) of roots, stems and leaves;

(2) Individual leaf size and total leaf area per pot;

(3) Partitioning of dry matter into leaves, stems and roots;

(4) Nutrient uptake (nitrogen, phosphorous, potassium, magnesium and calcium); and

(5) Flowering and fruiting.

CHAPTER II

LITERATURE REVIEW

Botanical name

Asystasia gangetica subsp. *micrantha* belongs to the Acanthaceae that worldwide is made up of 357 genera and 4350 species (Mabberley, 1993). About 35 genera comprising 160 species are found in Peninsular Malaysia (Henderson, 1959). In the genus Asystasia, 70 species are recorded in the tropics (Mabberley, 1993).

Three taxa grow locally:

1. *Asystasia gangetica (L).T. Anders* subsp. *micrantha(Nees) Kalbessa.*

   This plant (formerly and incorrectly known as *A. intrusa)*, is native to Africa (Kiew and Vollesen, in press).

   This taxon is characterised by a corolla that is "... pure white with a large violet spot on the lower lip, 1.4 - 1.8 cm long, expanded about one third from the base, apical and lateral lobes reflexed, lower lobes strongly pleated" (Kiew and Vollesen, in press). Figure 1 shows a typical shoot of

subsp. *micrantha* that has just begun to produce flowers.

Figure 1 : Vegetative shoots and terminally borne inflorescence of *Asystasia gangetica* subsp. *micrantha* (Adapted from Rajaratnam *et al.*, 1977)

2. *Asystasia gangetica* subsp. *gangetica*

A native to India it is now a pan-tropical weed (Kiew and Vollesen, in press). The flower of this species has many shades from pale yellow to mauve and is much less aggressive in its growth and spread than subsp. *micrantha.*

Unlike subsp. *micrantha,* this taxon has a large flower and corolla colour that ranges from "... pale cream or yellow, rosy cream, pale or dark purple, sometimes with yellow nectar guides in the base of the throat, 2.5 - 3.5 cm long, expanded from the base, lobes spreading, lower lobes not pleated" (Kiew and Vollesen, in press).

3. *Asystasia chelonoides*

This species is cultivated as a pot plant, its flowers being a showy dark purple velvet colour. It is occasionally seen in home gardens (Henderson, 1959).

For the ease of discussion, subsequent reference to *A. gangetica* subsp. *micrantha* is referred to as Asystasia.

Competition to economic crops

Asystasia is a noxious weed because it can absorb large amounts of soil nutrients to the detriment of cultivated crops. Its rapid spread and seed bank make eradication difficult. Almost all agricultural and horticultural sectors in this country are affected by this weed. Frequent weeding is necessary otherwise the cultivated sites can easily be covered with this prolific weed.

Oil palm plantation

Asystasia is capable of immobilising large amounts of soil nutrients especially potassium. Rajaratnam *et al.* (1977) reported from observations over a 25-month period that oil palm fruit yield was depressed by 3.9 ton/ha.

More recently, Nazeeb and Loong (1992) found that over a five-year period there was no significant difference in yield in a field trial of oil palm infested with Asystasia. They concluded that Asystasia was more vigorous in the open than under the shaded conditions of mature oil palm where the weed need not be eradicated but could be kept as "natural" under-storey vegetation. However, they gave no quantification of the amount of Asystasia present nor the fertilisers applied in the trial, which makes it difficult to assess the severity of competition for nutrients by the weed.

Cocoa plantation

Chung and Lam (1991) reported that Asystasia suppressed the growth and yield of young cocoa plantings.

Pineapple cultivation

Asystasia was reported in the pineapple growing region in south Johore in 1975 and became so troublesome that in 1984 a seminar specifically on the weed was held (Anon, 1984). The weed can cause a 19.2% reduction in yield in pineapple cv. `Masmerah' (Lee, 1986).

Another problem with this weed is that it can reach up to 1.5 metres (Saberi, 1989) and may eventually cover the crop if left unchecked.

Asystasia is considered to be similar, if not more serious than other major competitive weeds in the plantations due to its fast growth and spread, and its abilility in absorbing large amounts of soil nutrients.

Examples of other competitive weeds that can suppress crop yields especially for plantation crops include:

Ischaemum muticum - Teo *et al.* (1989) reported a yield increment of 32% when this weed was eradicated from oil palm field;

Chromolaena odoratum - Aya and Fayemi (1982) reported significant increase of oil palm fruit yield when the weed was eradicated;

Mikania micrantha - Teoh and Chew (1980) reported that yield of oil palm could decline by 10% when Mikania became predominant; and

Mikania micrantha and *Imperata cyclindrica* - Gray and Hardon (1967) reported a 20% reduction of oil palm yields when these weeds were dominant.

Chemical control of Asystasia

Asystasia is easily killed by a wide range of systemic herbicides (Rajaratnam *et al.*, 1977; Teoh *et al.*, 1982; Chung *et al.*, 1984; Lee, 1984a; Chong and Moshin, 1986; and Teng and Teh, 1990).

However, regeneration from seed is rapid following chemical spraying of infested areas (Rajaratnam *et al.*, 1977; Teoh *et al.*, 1982). Attempts to control Asystasia using pre-emergence herbicides were unsuccessful (Teoh *et al.*, 1982).

Most research on chemical control shows that Asystasia is easily killed but long term chemical control of the weed has not been successful. Teoh *et*

al. (1982) and Rajaratnam *et al.* (1977) attributed this to the rapid regeneration from seeds.

Animal grazing to control Asystasia

In 1960, sheep grazing for weed control in rubber plantation was introduced, followed by pilot studies in 1968 (Velayuthan and Lim, 1986).

Arope *et al.* (1985) rekindled interest in sheep grazing to control weeds in plantation crops when they reported a cost saving of 15-25% on overall weeding costs for rubber cultivation with a 15% return on investment. Although Asystasia is one of species that sheep graze on, it was Rosley (1985) who specifically advocated sheep as a biological control agent when he noticed that sheep preferred Asystasia while grazing in mixed vegetation cover in the interrows of rubber trees.

Asystasia as a fodder crop was found to contain 7-20% crude protein dry matter content and 0.07% digestible crude protein which is sufficient to meet the daily dietary protein requirement for most phases of sheep production (Suparjo and Wong, 1988).

However, Wong *et al.* (1988) warned against the possibility of copper toxicity for sheep fed on Asystasia alone, although no clinical symptoms were observed in sheep that had high levels of copper