

**STRUCTURAL DEMOGRAPHY AND GROWTH  
PATTERNS OF *SCIRPUS GROSSUS* L.**

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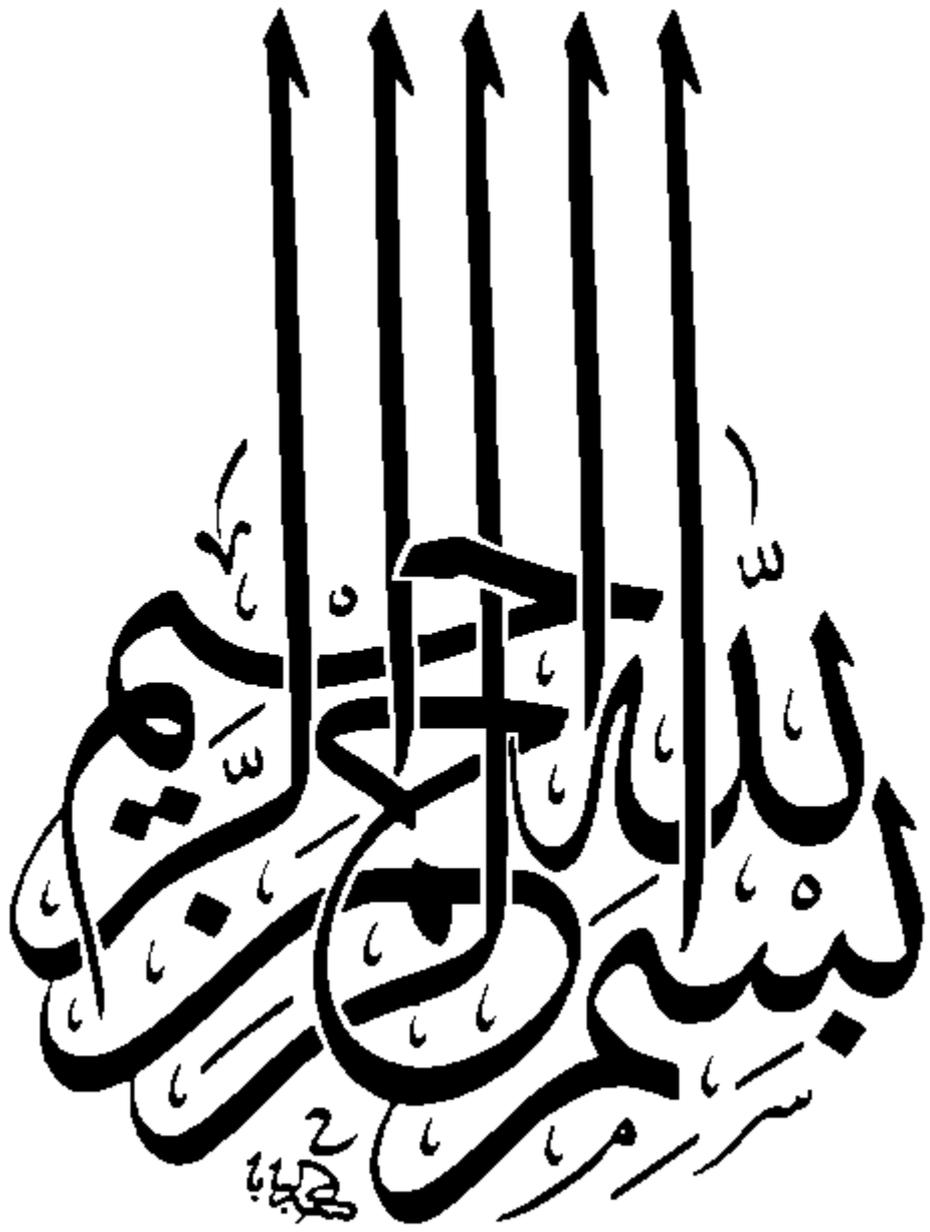
**STRUCTURAL DEMOGRAPHY AND GROWTH  
PATTERNS OF *SCIRPUS GROSSUS* L.**

**ALI ABDULLAH MAJRASHI**

**Thesis submitted in Fulfillment of the Requirements for the  
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OF *SCIRPUS GROSSUS L.***

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## **DEDICATION**

This dissertation is dedicated to my family: father, Abdullah Majrashi (May Allah bless his soul ) and mother, Fatimah, brothers Kalid ,Hani, Mhamed, Juman, Majed, Sister's Fuziah, Jamilah, Nufe, wife, Salehah and childrens Shahad, Ahmed, Dana and Lana. Their love, support, and encouragement throughout this academic research journey meant everything to me.

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# STRUCTURAL DEMOGRAPHY AND GROWTH PATTERNS OF *SCIRPUS GROSSUS* L.

## ABSTRACT

*Scirpus grossus* L. is a principal rhizomatous weed in the rice fields, drainage and irrigation canals, river banks, abandoned rice fields and wasteland in Malaysia. This study describes the modular dynamics, spatio-temporal growth patterns of aerial plant and sub-terranean rhizome populations of this scourge on fertilized and unfertilized peat and paddy soils. The NPK fertilizer application at 100:30:30 ha<sup>-1</sup> resulted in more robust aerial plant growth with *ca.* 253.5 ramets m<sup>-2</sup> (mean dry aerial biomass of 23.2 g plant<sup>-1</sup>) compared with 235.6 ramets m<sup>-2</sup> (16.3 g plant<sup>-1</sup>) in unfertilized peat soils 24 weeks after planting of the mother plant. The parallel figures for plants growing on paddy soils of the Jawa series were *ca.* 97.08 ramets m<sup>-1</sup> (12.19 g plant<sup>-1</sup>) (fertilized paddy soils) and 83.67 ramets m<sup>-1</sup> (10.89 g plant<sup>-1</sup>) (unfertilized paddy soils) 24 weeks after planting of the mother plant. Mean ramets mortality was significantly higher in unfertilized paddy soils at 121.3 ramets m<sup>-2</sup>, while in the fertilized paddy soils this was only 34.7 ramets m<sup>-2</sup>, resulting respective net populations of *ca.* 218.8 ramets m<sup>-2</sup> and 114.3 ramets m<sup>-2</sup> in fertilized and unfertilized plots. In paddy soils mean ramets mortality in unfertilized paddy soils was *ca.* 8.58 ramets m<sup>-2</sup>, while this was only *ca.* 5.67 ramets m<sup>-2</sup>, leading to the respective resultant net populations of 91.41m<sup>-2</sup> and 75.09 ramets m<sup>-2</sup>. Flowering set in earlier among ramets in fertilized peat soils with 103.2 ramets m<sup>-2</sup> *vis-a-vis* 77.5 ramets m<sup>-2</sup>, 24 weeks after transplanting of the mother plant in unfertilized soil. Flowering set in earlier among ramets in fertilized paddy soils with 49.56 ramets m<sup>-2</sup> *vis-a-vis* the unfertilized soil registering *ca.* 47.79 ramets m<sup>-2</sup>, 24 weeks after transplanting of the mother plant. Fertilizer applications to either peat or paddy soils did not register any significant difference in mean plant height, chlorophyll contents, and chlorophyll fluorescence measurements *vis-a-vis* those plants devoid of

fertilizer application. No measurable differences were registered in rhizome lengths over time of *S. grossus* plants devoid of fertilizer application compared with those growing in fertilized peat soils. Similarly patterns were observed among *S. grossus* populations in both fertilized and unfertilized paddy soils. The time- and space-mediated clonal growth of *S. grossus* did not register any significant preferential directionality and dispersion of aerial plants and their sub-terranean rhizomes irrespective of fertilizer application or soil types, but rather displaying opportunistic resource capture by aerial and sub-terranean modules.

ANOVA and Tukey's HSD tests, response surface, fractal dimension and fractal topography analysis under fertilizer application factor and differences soils (peat soils - paddy soils) were used in the study from the first week to the 24<sup>th</sup> week. Dispersion analyses of rhizomes was also employed.

In circular statistics  $r$  (concentration),  $s$  (angular deviation), Rayleigh's  $R$  and Rayleigh's  $z$  were computed on the emerged ramets of *S. grossus*. Results of Rayleigh's  $z$  test showed significant mean direction of ramets emergence for all replicates in the fertilized plots ( $p > 0.01$ ). Significant mean direction was obtained only for replicate R1 for the unfertilized plots. No significant mean direction for replicates R2 and R3 of the unfertilized plots means that ramets emergence is distributed uniformly around the circle, that is originating from the mother plant. They occur when  $s$ , the dispersion given by the angular deviation is near the maximum (where  $0 < s < 83.01$ ). Dispersion analysis of ramets by circular statistics on *S. grossus* generated no special preferences in the direction of modules or emerged ramets as explained by the Rayleigh's  $r$ , Rayleigh's  $z$ , and mean angle of dispersion in peat and paddy soils. However, there were heavier concentrations of ramets in the eastern sector of the plot, presumably due to phototropic effect of sunlight.

In response surface analyses in peat soils results showed the stationary points obtained for the unfertilized plots is at x-distance = 0.03 m, y-distance = - 0.06 m and time (t) = 9.8 months. This function predicted a maximum density of 178 plants m<sup>-2</sup> to occur at the location and time. For the fertilized plot, the stationary point is at x-distance = 0.20 m, y-distance = -0.82 m and t = 11.31 months. The predicted density obtained was 291.02 plants m<sup>-2</sup>. While in paddy soils the best location and time in unfertilized soil was between x- distance 0.00 m and y- distance -0.14 m at t = 8.16 month, while in fertilized soil the location was between x- distance -0.13 m and y- distance 0.20 m and the best time at t = 8.48 month.

In fractal topography analysis results showed value fractal dimension from  $gl=0$  –  $gl=100$  between area-covering and ranched network ( $1 < D > 2$ ). The area-covering concentrated at  $gl=0$  and  $gl=40$  in both peat and paddy soils (fertilized and unfertilized). While after  $gl=100$  –  $gl=255$  sporadic distribution ( $D= 0$ ) in peat (fertilizer and unfertilized) and unfertilized paddy soils. While for fertilized paddy soil,  $gl=100$  –  $gl=255$ .

The fractal dimension analysis method allows the structural complexity of such associations to be compared between plant communities, with regard to their potential for soil resource acquisition and utilization. In peat soil, distinct and partly not significant differences are found (fractal dimension between  $1.52 \pm 0.53$  and  $1.50 \pm 0.59$ ) in unfertilized and fertilized plots. In paddy soil, fractal dimension between  $1.53 \pm 0.55$  and  $1.52 \pm 0.49$ ) in unfertilized and fertilized plots. We found distinct and partly not significant differences between plant in peat and paddy soils, when analysing many small units of a complex root system association. In larger plant communities, a broad variety of below-ground structures are recorded in its entirety, integrating the specific features of single sub-structures. In that way, extreme fractal dimensions are lost and the

diversity decreases. Therefore, the analysis of larger units of root system associations provides a general knowledge of the complexity of root system structures for heterogeneous plant communities.

Under the prevailing experimental conditions in the studies, the following conclusions can be drawn, *viz.*: (i) The optimal period of clonal growth for *Scirpus grossus*, in general was between 10-18 weeks after planting; (ii) Augmentation with different NPK fertilizer concentrations and at different water depths had the following effects on *S. grossus* growth in both fertilized and unfertilized peat and paddy soils, (a) Increased rate of natality and the population number of ramets, fortified by enhanced proliferation of subterranean rhizomes; (b) Decreased rates of ramets mortality; (c) Increased rate and production of inflorescence of the weed; and (d) Enhanced production of biomass *vis-a-vis* the control of various plant components. However, the NPK fertilizer treatment did not have a significant impact on the plant height; chlorophyll content; and chlorophyll fluorescence, registering non-significant difference in both fertilizer and control plants; (iii) Fertilizer concentration with water depth did have a significant impact on the following parameters; namely (a) plant height; and (b) inflorescence number; (iv) Aerial modular growth, dispersion, response surface, plant topography-fractal analyses on emerged ramets, and fractal dimension boxing analyses of subterranean rhizome modules confirmed that the fertilizer treatment (at NPK 100:30:30) did not have a significant and prevalent impact on the growth patterns of *S. grossus*.

# DEMOGRAFI STRUKTUR DAN CORAK TUMBESARAN *SCIRPUS GROSSUS L.*

## ABSTRAK

*Scirpus grossus* L. adalah rumpai rizomatous utama di sawah padi, parit dan terusan pengairan, tebing sungai, sawah padi terbiar dan tanah terbiar di Malaysia. Kajian ini menerangkan dinamik modular, corak pertumbuhan spatio temporal tumbuhan rumpai dan sub-terranean populasi rhizome hakisan ini di tanah berbaja, tidak berbaja dan tanah disawah padi. Penggunaan baja NPK 100:30:30 ha<sup>-1</sup> telah menghasilkan tumbuhan rumpai yang lebih kuat dengan *ca.* 253.5 ramets m<sup>-2</sup> (mean udara bioamass kering sebanyak 23.2 g plant<sup>-1</sup>) berbanding dengan 235.6 ramets m<sup>-2</sup> (16.3 g plant<sup>-1</sup>) di tanah gambut tidak berbaja 24 minggu selepas penanaman ibu tumbuhan. Bacaan selari untuk tumbuhan berkembang pada tanah padi siri Jawa adalah *ca.* 97.08 ramets m<sup>-2</sup> (12.19 g plant<sup>-1</sup>)(tanah sawah padi berbaja) dan 83.67 ramets m<sup>-2</sup> (10.89 g plant<sup>-1</sup>)(tanah sawah padi tidak berbaja) 24 minggu selepas penanaman tumbuhan induk. Min ramets daya tahan adalah jauh lebih tinggi pada tanah sawah padi tidak berbaja di 121.3 ramets m<sup>-2</sup>, manakala di tanah padi berbaja hanya pada 34.7 ramets m<sup>-2</sup>, menghasilkan jumlah bersih populasi masing-masing pada *ca.* 218,8 ramets m<sup>-2</sup> dan 114.3 ramets m<sup>-2</sup> didalam plot berbaja dan tidak berbaja. Bagi tanah padi daya tahan min ramets pada tanah padi tidak berbaja adalah *ca.* 8.58 ramets m<sup>-2</sup>, manakala ini adalah hanya *ca.* 5.67 ramets m<sup>-2</sup>, menghasilkan jumlah bersih populasi berikut 91.41 m<sup>-2</sup> dan 75.09 ramets m<sup>-2</sup>. Pembungaan yang dilakukan pada peringkat awal dikalangan ramets tanah gambut berbaja dengan 103.2 ramets m<sup>-2</sup> merujuk kepada 77.5 ramets m<sup>-2</sup>, 24 minggu selepas dipindahkan dari tumbuhan induk ke tanah tidak berbaja. Pembungaan yang dilakukan pada peringkat awal dikalangan ramets pada tanah padi berbaja dengan 49.56 ramets m<sup>-2</sup> merujuk kepada tanah tidak berbaja mencatat bacaan *ca.* 47.79 ramets m<sup>-2</sup>, 24 minggu

selepas dipindahkan dari tumbuhan induk. Pengaplikasian baja kepada tanah gambut atau padi tidak mencatatkan perbezaan yang ketara pada bacaan ketinggian tumbuhan purata, kandungan klorofil, dan ukuran klorofil florensens berbanding tumbuhan tanpa pembajaan. Tiada perbezaan ukuran rizom yang diperolehi bagi sepanjang tempoh tumbuhan *S. grossus* tanpa penggunaan baja berbanding dengan tumbuhan yang ditanam di tanah gambut berbaja. Persamaan corak dapat diperhatikan di kalangan populasi tumbuhan *S. grossus* di kedua-dua tanah padi berbaja dan tidak berbaja. Masa dan ruang-pengantara pertumbuhan klon *S.grossus* tidak mendaftarkan mana-mana arah keutamaan yang signifikan dan penyebaran '*aerial plant*' dan rizom sub-terranean mereka tanpa mengira pembajaan atau jenis tanah, tetapi memaparkan penangkap sumber oportunistik secara udara dan sub-modul terranean.

Didalam tesis ini, kami menggunakan ujian ANOVA sehalu dan Tukey HSD, respon permukaan, dimensi fraktal dan analisis topografi fraktal di bawah faktor penaplikasian pembajaan dan perbezaan tanah (tanah gambut – padi tanah). Kemudian faktor waktu yang digunakan adalah dari tempoh minggu pertama sehingga minggu ke 24. Kami juga menggunakan analisis penyebaran rizom.

Dalam *circular statistic*  $r$  (penumpuan),  $s$  (sisihan sudut), Rayleigh  $R$  dan Rayleigh  $z$  dikira pada kemunculan ramets *S. grossus*. Keputusan ujian Rayleigh  $z$  menunjukkan arah min yang signifikan kepada kemunculan ramets untuk semua replikasi dalam plot yang disenyawakan ( $p > 0.01$ ). Arah min yang signifikan diperolehi hanya untuk R1 tiruan untuk plot tidak berbaja. Tiada arah min yang signifikan untuk replikasi R2 dan R3 plot tidak berbaja bermakna bahawa kemunculan ramets diagihkan secara seragam di sekitar bulatan, yang berasal dari tumbuhan induk. Ini berlaku apabila  $s$ , penyebaran dengan sisihan sudut berhampiran maksimum (di mana  $0 < s < 83.01$ ). Analisis sebaran ramets oleh *circular statistic* mengenai *S. grossus* tidak menghasil

sebarang keistimewaan pada arah modul atau kemunculan ramets seperti yang dijelaskan oleh Rayleigh r, z Rayleigh, dan min sudut sebaran dalam perosak dan tanah padi. Walau bagaimanapun, terdapat kepekatan tinggi ramets di sector timur plot, ini mungkin disebabkan kesan phototropic cahaya matahari.

Daripada analisis respond permukaan untuk tanah gambut kami menunjukkan titik pegun yang diperolehi bagi plot tidak berbaja adalah jarak  $x = 0.03$  m, y jarak =  $-0.06$  m dan masa = 9.8 bulan. Fungsi ini meramalkan densiti maksimum  $178 \text{ plant m}^{-2}$  berlaku pada lokasi dan masa tersebut. Untuk plot berbaja, titik pegun adalah pada jarak  $x = 0.20$  m, y jarak =  $8.16$  m dan masa = 11.31 bulan. Densiti yang diramalkan diperolehi adalah  $291.02 \text{ plant m}^{-2}$ . Bagi tanah padi lokasi dan masa terbaik bagi tanah tidak berbaja adalah diantara jarak  $x = -0.00$  m, y jarak =  $0.14$  m dan masa terbaik pada = 8.16 bulan, sementara tanah berbaja, kedudukannya berada diantara jarak  $x = -0.13$  m, y jarak =  $0.20$  m dan waktu terbaik adalah pada = 8.48 bulan.

Didalam analisis topografi fraktal kami menunjukkan dimensi nilai fraktal dari  $gl = 0 - gl = 100$  diantara kawasan liputan dan rangkaian *ranches* ( $1 < D < 2$ ). Kawasan liputan bertumpu di  $gl = 0$  dan  $gl = 40$  di kedua-dua tanah gambut dan tanah padi (berbaja dan tidak berbaja). Sementara  $gl = 100$   $gl = 255$  penyebaran spora (D-0) pada 'beat soil' (berbaja dan tidak berbaja) dan tanah padi tidak berbaja. Sementara tanah padi berbaja  $gl = 100 - gl = 255$ .

Kaedah analisis dimensi fractal membolehkan kerjasama struktur yang rumit ini boleh dibandingkan antara komuniti tumbuhan, dengan mengambil kira potensi mereka untuk pemerolehan sumber dan penggunaan tanah. Di kawasan tanah gambut, perbezaan yang ketara dan sebahagiannya tidak penting telah ditemui (dimensi fraktal antara  $1.52 \pm 0.53$  dan  $1.50 \pm 0.59$ ) pada plot tidak berbaja dan berbaja. Dan dalam tanah padi, (dimensi fraktal antara  $1.53 \pm 0.55$  dan  $1.52 \pm 0.49$ ) pada plot tidak berbaja

dan berbaja. Kami menjumpai perbezaan ketara dan sebahagiannya tidak penting berbanding antara tumbuhan di tanah gambut dan padi. Ketika menganalisa jumlah unit-unit kecil dengan banyak kerjasama system akar yang kompleks. Didalam komuniti tumbuhan yang lebih besar, pelbagai hasil struktur bawah tanah direkodkan secara keseluruhannya, pengabungan ciri-ciri khusus sub-struktur tunggal. Melalui cara ini, dimensi fraktal melampau hilang dan kepelbagaian berkurangan. Oleh itu, analisis unit yang lebih besar kerjasama system akar menyediakan pengetahuan am tentang kerumitan struktur system akar bagi komuniti tumbuhan heterogen.

Di bawah keadaan percubaan yang sediada, beberapa kesimpulan boleh diperkatakan, iaitu: (i) Jangkamasa optimal bagi tumbesaran klonal bagi *S. grossus* pada amnya adalah di antara 10- 18 minggu selepas penanaman; (ii) tambahan baja NPK pada kepekatan berbeza serta kedalaman air juga berbeza menunjukkan kesan-kesan berikut terhadap tumbesaran *S. grossus* di dalam tanah sawah dan tanah gambut (a) penambahan kadar kelahiran dan populasi ramet, di tambah pula dengan penyebaran rizom bawah tanah; (b) pengurangan kadar kematian ramet; (c) peningkatan kadar dan pengeluaran bunga; (d) peningkatan pengeluaran biojizim berbanding dengan tanpa rawatan bagi semua komponen tumbuhan. Walaubagaimanapun, rawatan dengan baja NPK tidak mempunyai impak ke atas ketinggian pokok, kandungan klorofil and fluresen klorofil, dengan daftaran tidak signifikan terhadap pokok yang dibaja dan tidak dibaja. Rawatan baja NPK dan kedalaman air memberi impak yang signifikan ke atas beberapa parameter berikut (a) ketinggian pokok, dan (b) bilangan bunga. Pertumbuhan aerial, penyerebakan, tindakan permukaan, analisis fraktal-tofografi tumbuhan bagi ramet yang menjelma dan analisis dimensi fractal kotak bagi modul rizom bawah tanah memastikan bahawa rawatan baja NPK pada kadar 100:30:30 tidak mempunyai impak yang signifikan ke atas corak tumbesaran *S. grossus*.

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## **CHAPTER 2 GENERAL GROWTH PATTERNS OF *SCIRPUS GROSSUS* L.**

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## ABBREVIATIONS

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|                 |  |
|-----------------|--|
| 3D              | Three-Dimensional  |
| Amine or Ester  | 2,4-D amine/ester  |
| ANN             | Artificial Neural Network  |
| AutoCAD         | Program from Autodesk C. From USA  |
| Azimsulfuron    | 4-amino-3,5-dichloro-6-fluoro-2-pyridinyl)oxy)- aceticaci;4-amino-3,5-dichloro-6-fluoro-2-pyridyloxyaceticacid;ff404 |
| BCD             | Box-Counting Dimension   |
| Benthiocarb     | <i>S</i> -(4-Chlorobenzyl) diethylcarbamothioate   |
| CR              | Capacity to reduce   |
| Cyclosulfamuron | 1-[2-(cyclopropylcarbonyl)anilinosulfonyl]-3-(4,6-dimethoxypyrimidin-2-yl)urea                                       |
| Cyhalofop-butyl | butyl ( <i>R</i> )-2-[4-(4-cyano-2-fluorophenoxy)phenoxy]propionate  |
| D1              | Level water 0 cm (control)   |
| D2              | Level water 5 cm   |
| D3              | Level water 10 cm  |
| D4              | Level water 20 cm  |
| DLA             | Diffusion Limited Aggregation  |
| ExG –ExR        | Color index  |
| F0              | NPK concentration (control) ( without fertilizer)  |
| F1              | Soil with fertilizer   |
| F2              | NPK concentrations (50g/500 ml)  |
| F3              | NPK concentrations (75g/750 ml)  |
| F4              | NPK concentrations (100g/1000 ml)  |
| F5              | NPK concentrations (125g/1250 ml)  |
| FD              | Fractal dimension Analysis   |

## ABBREVIATIONS (*continued*)

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|                     |   |
|---------------------|---|
| Flufenacet          | 4'-fluoro- <i>N</i> -isopropyl-2-[5-(trifluoromethyl)-1,3,4-thiadiazol-2-yloxy]acetanilide      |
| FO                  | Soil without fertilizer   |
| FS                  | Functional–Structural   |
| Glufosiate ammonium | Ammonium (2-amino-4-(methylphosphinato) butanoate   |
| GR                  | Garland chrysanthemum and edible amaranth   |
| Imazapyr            | <i>RS</i> -2-(4-Methyl-5-oxo-4-propan-2-yl-1 <i>H</i> -imidazol-2-yl)pyridine-3-carboxylic acid |
| IWM                 | Integrated Weed Management  |
| KPI                 | Keratoconus Prediction Index  |
| LAD                 | Leaf Area Duration  |
| LAD                 | Liquid Anaerobic Digestate  |
| LEI                 | Low-External-Input  |
| LJ                  | Large Juveniles   |
| MARDI               | Institut Penyelidikan Dan Kemajuan Pertanian Malaysia   |
| MCPA                | 4-chloro, 2-methoxyphenylacetic acid  |
| Molinate            | <i>S</i> -ethyl hexhydro-1 <i>H</i> -azepine-1-carbothiate                                      |
| MPM                 | Matrix Population Models  |
| NPK                 | Nitrogen: Potassium :Calcium (100:30:30)  |
| PDSI                | Palmer Drought Severity Index   |
| Propanil            | <i>N</i> -(3,4-Dichlorophenyl)propanamide   |
| PSII                | Purification of Two Consecutive Photosystem II  |
| RCBD                | Randomized Complete Block Design  |
| RSAM                | Response Surface Analysis   |
| RYT                 | Relative Yield Total  |

## **ABBREVIATIONS** *(continued)*

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|     |                                 |
|-----|---------------------------------|
| SAS | Statistical Analysis System     |
| SI  | Sweet corn residue incorporated |
| SR  | Sweet corn residue removed      |
| WRA | Weed Risk Assessment System     |