Pak. J. Weed Sci. Res., 18: 397-408, Special Issue, October, 2012

ALLOMETRY AND GROWTH PATTERNS OF *Scirpus grossus* L. ON PEAT

Ali Majrashi[1], Amru Nasrulhaq Boyce[2], Abdul Munir Jaafar[2] and Baki Bin Bakar[2]

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 soils. The NPK fertilizer application at 100:30:30 ha^{-1} resulted in more robust aerial plant growth of S. grossus with 126.75 ramets m^{-2} (mean dry aerial bioamass of 2.32 g plant^{-1}) compared with 117.83 ramets m^{-2} (1.63 g plant^{-1}) in unfertilized plots 24 weeks after planting of the mother plant. Mean ramets mortality was significantly higher in unfertilized plots at 30.3 ramets m^{-2}, while in the fertilized plots this was only 8.7 ramets m^{-2}, resulting respective net populations of 116.08 ramets m $^{-2}$ and 87.5 ramets m $^{-2}$ in fertilized and unfertilized plots. Flowering set in earlier among ramets in fertilized plots with 51.58 ramets m^{-2} vis-a-vis 38.75 ramets m^{-2}, 24 weeks after transplanting of the mother plant in unfertilized plots. Fertilizer applications did not register any significant difference in mean plant height, chlorophyll contents, and chlorophyll fluorescence measurements vis-a-vis those without fertilizer application. 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 regimes, but rather displaying opportunistic resource capture by aerial and sub-terranean modules.

Keywords: Fertilizer application, modular growth, modules, *Scipus grossus* L., subterranean rhizomes.

INTRODUCTION

Rhizomatous plants grow and reproduce vegetatively by rhizomes. Vegetative branches are formed from the reiteration of the basic units, while flowers and inflorescences come from the reiteration of units bearing modified leaves. The population dynamics of many rhizomatous plants is dominated more by the flux of clonal modules. The ability of a single genotype to form fragmented phenotypes is just one of the variants in the life patterns of modular organism (Harper

---

[1]Biological Science, Taif University, Taif, Saudi Arabia
[2]Institute of Biological Sciences, University of Malaya, Kuala Lumpur, Malaysia
Corresponding author's email: majrashiaah@gmail.com

and Bell, 1979). The process of new growth is often subjected to different pressures, including the change in soil nutrients, and resource capture ability among individual plants and their modules.

It has been well documented in the literature that nitrogen, potassium, and phosphorous are important macro-elements for healthy plant growth, in addition to other macro- and microelements (Baki, 1988; Huang *et al.,* 2004). Nitrogen is present in all the macromolecules in the cell, such as amino acids, proteins, lipids and carbohydrates. Probably more importantly, nitrogen concentration in green vegetation is often related to chlorophyll content, and therefore indirectly to one of the basic plant physiological processes, namely photosynthesis (Daughtry *et al.,* 2000). Recently, Huang *et al.* (2004) has shown in a study on rice seedlings that nitrogen deficiency brought about adverse effects on the chlorophyll content of the leaves and chlorophyll fluorescence, both of which are good indicators of photosynthetic capacity. Thus, nitrogen deficiency in soils will result in plants exhibiting limited growth and deficiency symptoms such as chlorosis. Many studies have shown that a significant increase in growth rate of plants will occur with the application of nitrogen (Ozer, 2003). Baki (1988) reported that additions of phosphate appeared to enhance the rate of flowering in *S. grossus.*

Scirpus grossus is a pan-tropical weed in the rice fields, drainage and irrigation canals, river banks, abandoned rice fields and wastelands in Malaysia and elsewhere. There is a paucity of information on the population biology of this scourge in the literature. This study reports on the allometry, modular dynamics, and spatio-temporal growth patterns of aerial plant modules and sub-terranean rhizome populations of this weed on fertilized and unfertilized peat soils.

MATERIALS AND METHODS

Plant Establishment and Care

Synthetic populations of *S. grossus* were established on peat soils in the Malaysian Agriculture Research Development Institute (MARDI) Research Station, Jalan Kebun, Klang (3.00° N /101.30° E), Malaysia for 24 weeks commencing on 24 February 2010. Cohorts of young ramets at 2-3-leaf of *S. grossus* were obtained from rice fields of Tanjung Karang, Selangor. Each ramet was planted in the centre of a plot measuring 2m x 2m, previously demarcated and lined with 5cm x 5cm grids and sub-plots (Fig. 1). Fertilizer applications with Nitrophoska Blue Special NPK fertilizer at the rate of 100:30:30 were made one week prior to planting. A set of 3 replicated plots with fertilizer application was allocated with while, another 3 sets served as a control. Watering of the plots was made twice daily, one in the morning and the other in the late afternoon using a fine rose fitted to a water hose. No weeds were allowed to grow in the plots during experimentation.

Data Acquisition and Management

The clonal growth of *S. grossus* based on the number of emerged plants in each plot, its location, and heights was recorded on a weekly basis for 24 weeks. Likewise for the number of dead plants and their positions in each plot were also recorded. The phenology of *S. grossus* was also recorded, taking into account the time of flowering after planting, and the number flowers were recorded on a weekly basis. The chlorophyll content in the leaves was determined at the end of planting using a Minolta SPAD meter. From each plot 15 leaves were randomly selected for measurement. In the case of the chlorophyll fluorescence which has been well documented to be closely related to photosynthetic capacity and quantum yield was recorded using a Hansatech (UK) Photosynthetic Efficiency Analyzer. Variable (Fv) and maximum fluorescence (Fm) readings were taken and the Fv/Fm values, which correspond to quantum efficiency, were calculated. A minimum of five readings per plot for each treatment were taken and the average determined.

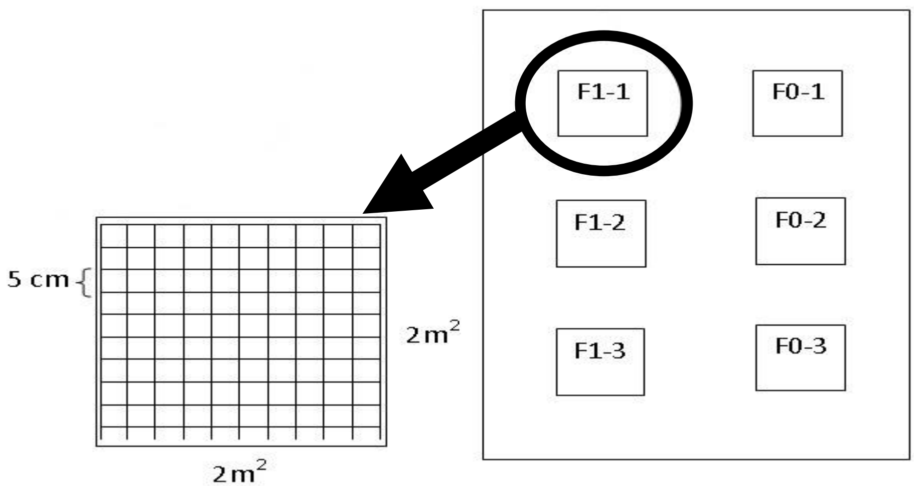

Figure 1. Experimental design and quadrats arrangement of *Scirpus grossus* in MARDI Research Station, Jalan Kebun, Selangor, Malaysia. F_0 – No fertilizer application; F_1, NPK applied.

After 24 weeks of experimentation, the plants were harvested by dismembering them into leaf, stem, and inflorescence components, and their dry weights were determined. Ten flowering plants taken at random were harvested from each plot. These components were subjected to chemical analysis. The sub-terranean rhizomes remained intact by ensuring that no rhizome damage was inflicted during harvest of the aerial plant parts.

As far the spatio-temporal growth pattern, ramification and mapping of the architecture of sub-terranean rhizomes, a water hose with strong pressure was used to wash way the peat soils to expose the rhizomes. Extra care was instituted so as not to damage the exposed rhizomes during this operation. The exposed rhizomes were mapped by measuring inter-nodal lengths of each rhizome, and noting the precise positions of the harvest plants. These data were transferred into the data logger, and together with the weekly data on the precise spatio-temporal positions of emerged plants of *S. grossus*, computer generated subterranean rhizome architectures were produced. The computer program used was AutoCAD 10. These were generated based on time- and space-mediated architecture of the weed at 1, 2, 3, 4, 5 and 6-months old.

The directionality and dispersion patterns of sub-terranean modules of the weed with time and space were also analyzed using Circular Statistics (Zar, 2006). For this purpose, the computer-generated maps of emerged plants and rhizomes in the fertilized and unfertilized plots for 1, 2, 3...6 months old *S. grossus* were each arbitrarily divided into 8 sub-sectors with respect to the geographical north. The number of emerged individuals and the length of each rhizome in each sub-sector were recorded. The analysis were based on Rayleigh's *r* and Rayleigh's *z* values, and mean angle of dispersion (Zar, 2006) in the assessment whether there is a particular preferential direction of growth of the emerged plants and the subterranean rhizomes, or otherwise with respect to the geographical north.

The rates of spread (based on the number of emerged plants or ramets, and length of rhizomes away from the mother plants) were also calculated. This was done based on the computer-generated maps described earlier. The plants were grouped according to their concentrations in six concentric circles; each circle representing the mean monthly individuals established from the single mother plants. This analysis is to assess whether the rates of emergence of individual ramets and their associated rhizomes were different or otherwise as they move away from the mother plant as a strategy to avoid self-crowding and minimize mean density of emerged individuals from each other with time.

The appropriate data were subjected to ANOVA and their treatment means were tested for significant difference, if any, using HSD and *t*-tests (Zar, 2006).

RESULTS

General Clonal Growth Patterns

Scirpus grossus plant reiterates by rhizomatous growth and branches from a single mother plant. As shown in Figure 2, the best period of clonal growth in general is between 10-18 weeks. The best period of clonal growth in fertilized soils was at week 12^{th} while in unfertilized soils it was at week 13. At the end of the 24 weeks of study period, the total average gross number of emerged ramets in fertilized soils were 126.75 ramets/m^{-2} and 117.83 ramets/m^{-2} in unfertilized soils.

The mortality rate recorded was 30.33 ramets in unfertilized soils and 8.67 ramets in fertilized soils (Figure 3),while the real rate showed 87.5 ramets/m^{-2} in unfertilized soils and 116.08 ramets/m^{-2} in fertilized soils (Figure 4a & 4b).

The results for subsequent recruitment of shoot modules appeared convergent (Table-1) where the highest average plant height in unfertilized soils was 161.67 cm while in fertilized soils it was 160.67 cm.

Plants growing in unfertilized soils started to flower 16 weeks after transplanting, while in fertilized soils, *S. grossus* started to flower at week 13. At the end of the 24 weeks period study, the average number of flowering ramets in unfertilized soils stood at 38.75 ramets/m^{-2} *vis-a-vis* 51.58 ramets/m^{-2} for those devoid of fertilizer application (data not shown).

Table-1 shows the dry biomass of selected plant parts of *S. grossus* taken after harvest at 24 weeks after transplanting displaying measurable differences according to fertilizer regimes. In unfertilized soils: the leaves were 6.90 g, and the stems 7.99 g whilst the flowers were 1.92 g in weight. In fertilized soils these were 9.73 g (leaves), 10.51 g (stems) and 2.77 g for flowers.

Chlorophyll content in leaves has always been regarded as a measure of the health status of a plant. For example plants deficient in nitrogen will exhibit chlorosis and the leaves will be less green than a healthy plant. (Table-1) shows that the chlorophyll content in leaves of plant growing in fertilized soil was slightly higher (46.51) than that recorded in leaves of the control plant (49.48). However this difference was not significant. Similarly, in the case of chlorophyll fluorescence, to determine to photosynthetic capacity of the leaves, there was very little difference between the two sets of plants.

Population Spread and Sub-Terranean Rhizome Architecture

Figure 3a shows the time-mediated growth of subterranean rhizomes of *S. grossus.* in unfertilized soils, showing the best period 3 month after sowing of the mother plant. The parallel figure for fertilized soils was 4 months after sowing of mother plant (Figure 3b).

The time-mediated emergence of ramets in both fertilized and unfertilized peat soils are shown in Figs. 4a and 4b. Invariably, more ramets were recorded in fertilized soils than those in the unfertilized counterparts, indicating the stimulatory effects of fertilizer application of the growth and proliferation of *S. grossus*.

Table-1. General growth patterns of *Scirpus grossus* in unfertilized and fertilizer soils.

	Unfertilized peat	Fertilized peat
Gross plant number	117.83 ± 60 /m^{-2}	126.75 ± 48/m^{-2}
Mortality number	30.33 ± 22.25 /m^{-2}	8.67 ± 11.75/m^{-2}
Net plant number	87.5 ± 37.75 /m^{-2}	118.08 ± 36.25 /m^{-2}
Flowers number	38.75 ± 67.75 /m^{-2}	51.58 ± 66.75/m^{-2}
Plant height	161.67 ± 51 cm	160.67 ± 44 cm
Chlorophyll content	46.51 ± 3.16) SPAD	49.48 ± 7.1 SPAD
Chlorophyll fluorescence	0.76 ± 0.016	0.77 ± 0.038
Leaf weight (g)	6.9 ± 5.7	9.7±4.9
Stem weight (g)	7.9 ± 4.4	10.5 ±6.7
Florescence (g)	1.9 ±1.0	2.8 ±2.2
No. inflorescence*	152.4 ± 36.6	211.0 ± 28.8

* after 24 weeks

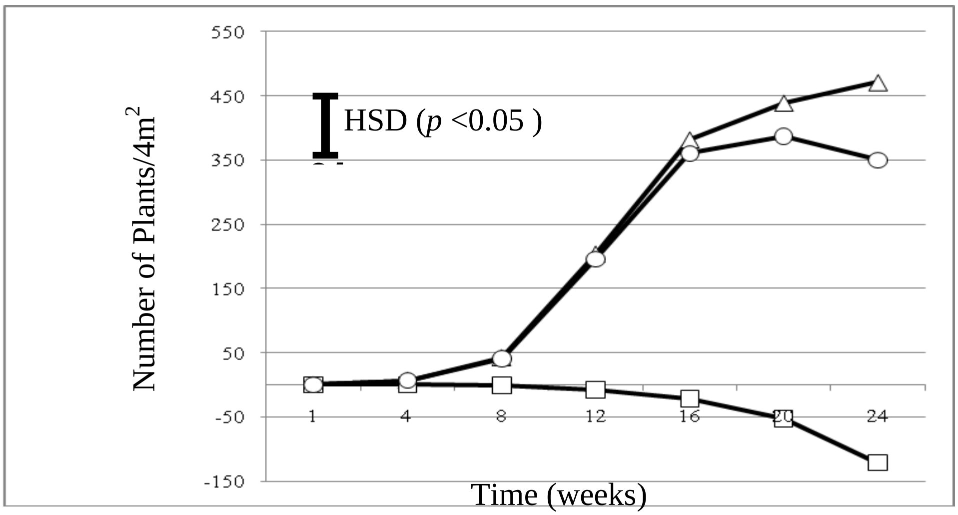

Figure 2a. Population fluxes of *Scirpus grossus* on unfertilized. peat. Natality (▲), Mortality (■), Net population (●).

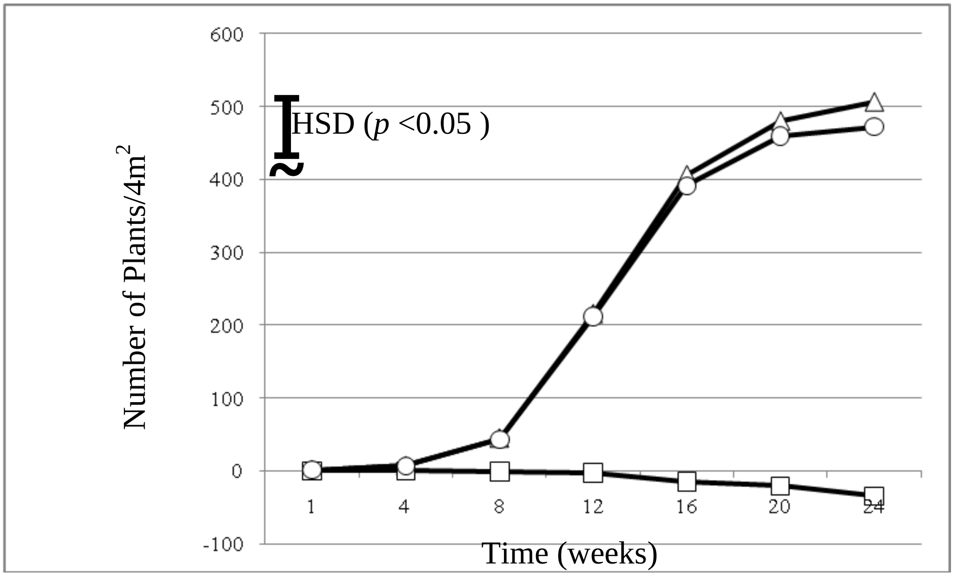

Figure 2b. Population fluxes of *Scirpus grossus* fertilized peat. Natality (▲), Mortality (■), Net population (●).

Directionality and Dispersion Analyses

Dispersion analysis of subterranean rhizomes 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 (Table 2). However, there were heavier concentrations of ramets in the eastern sector of the plot, presumably due to phototropic effect of sunlight (Fig. 5)

DISCUSSION

This study was an attempt to determine the effect of NPK fertilizer on the structural life *S. grossus* L. on peat. It showed details of different growth patterns. The best period of clonal growth in general was between 10-18 weeks, an outcome similar to the results mentioned by (Baki, 1988). This phenomenon is probably due to the finite amount of resource in the soil, diminishing with time. In addition to this although there may be resources still available, the plants are ageing and the leaves start to show reduced effective photosynthesis. Furthermore the assimilatory activity of the plant may have been approaching the compensation point with the respiratory burden of accumulated support tissue.

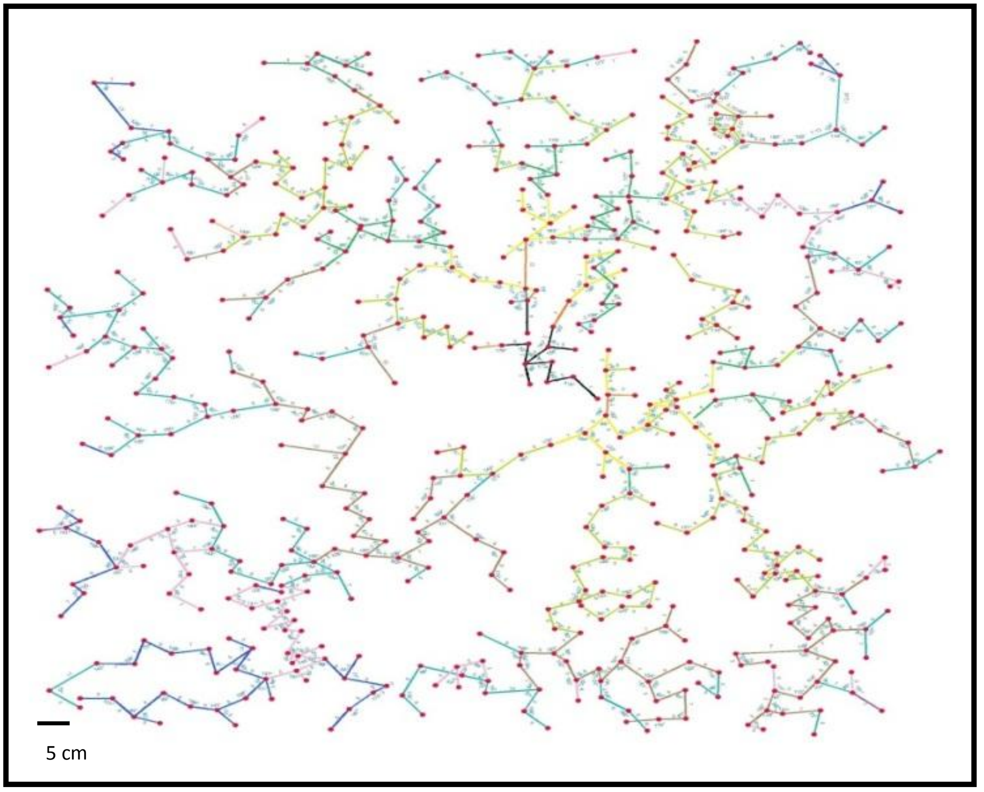

Figure 3a. Time-mediated growth of subterranean rhizomes of *Scirpus grossus* in unfertilized peat soil (F_0) 6 months after planting of mother plant. Black, 1st, 2nd week; Orange, 3rd, 4th week; Yellow, 5th and 6th week; Dark green, 7th and 8th week.; Olive green 9th, 10th week; Blue, 11th, 12th week; Brown, 13th, 14th week; Pink, 15th, 16th week; Dark blue, 17th, 18th week; Purple, 19th, 20th week; Grey, 21th, 22th week.

The results showed that the use of fertilizers had a significant impact on content in growth parameter but others did not show a significant impact. The addition of NPK fertilizer had a significant effect on clonal growth where it dramatically increased the population flux of the weed. Similarly, the NPK fertilizer caused a decrease in the number of deaths, and this was similar to the findings of Baki (1988) who studied the structural demography and growth patterns of *S. grossus.*

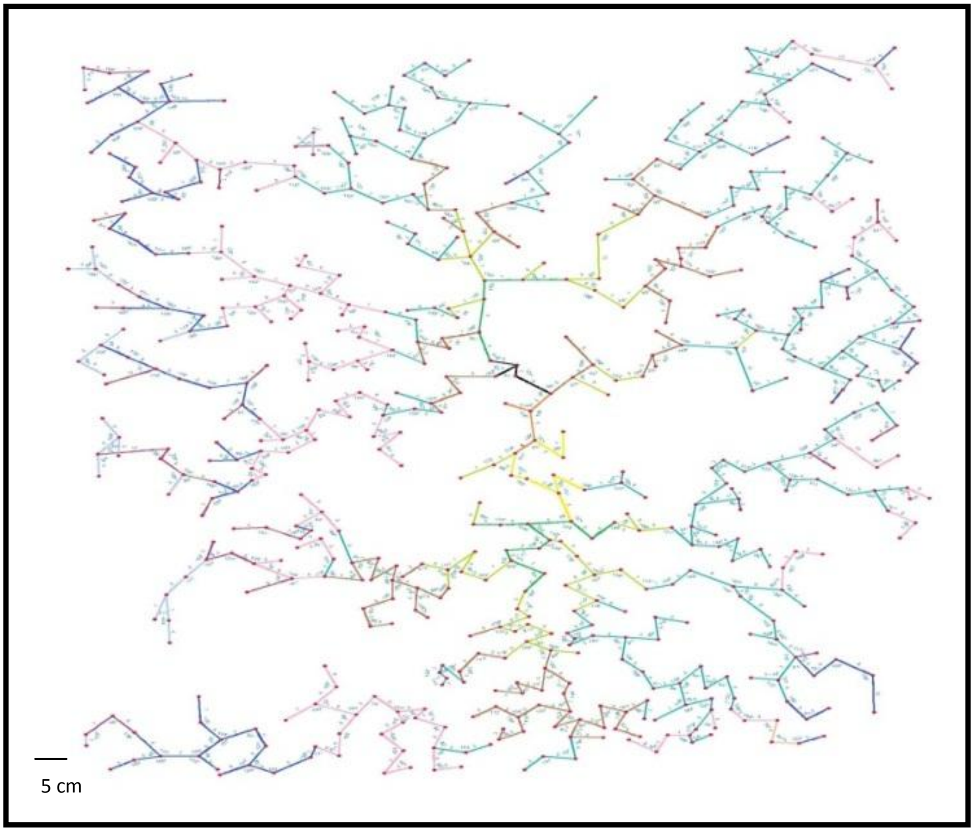

Figure 3b. Time-mediated growth of subterranean rhizomes of *Scirpus grossus* in fertilizer peat soil (F_1) 6 months after planting of mother plant. Black, 1st, 2nd week; Orange, 3rd, 4th week; Yellow, 5th and 6th week; Dark green, 7th and 8th week.; Olive green 9th, 10th week; Blue, 11th, 12th week; Brown, 13th, 14th week; Pink, 15th, 16th week; Dark blue, 17th, 18th week; Purple, 19th, 20th week; Grey, 21st, 22th week.

The NPK fertilizer, which contains 30% of phosphate, also increased the flowering rate of the weed. A similar observation was reported by Baki (1988). In addition, the NPK fertilizer helped to strengthen the plant and this was observed in the significant increase in the weights of the various plant parts in fertilized soils.

However with regard to other measurements made, the fertilizer treatment did not have a significant impact and this included plant height. Baki (1988) explained the height of *S. grossus* was affected by the depths of inundation.

In addition to this NPK fertilizer treatment had minimal effect on the leaf chlorophyll content and chlorophyll fluorescence. This probably indicates that the soil on which the rice plants were grown had sufficient macro and micro nutrients to support healthy growth.

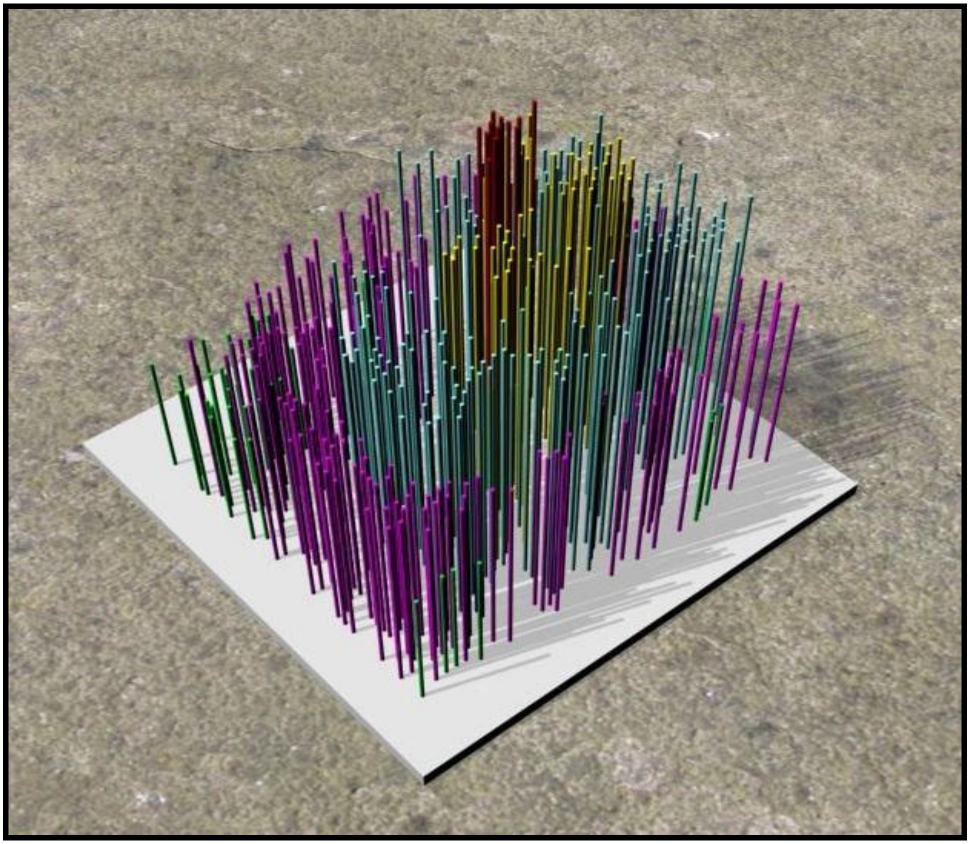

Figure 4a. The time-mediated growth of ramets in *Scirpus grossus* in unfertilized peat soil (F_0) 6 months after planting of the mother plant. Red, emerged ramets in the 1st month; Yellow, emerged ramets in the 2nd month; Blue, emerged ramets in the 3rd month; Purple, emerged ramets in the 4th month; Green, emerged ramets in the 5th month and Black, emerged ramets in the 6th month.

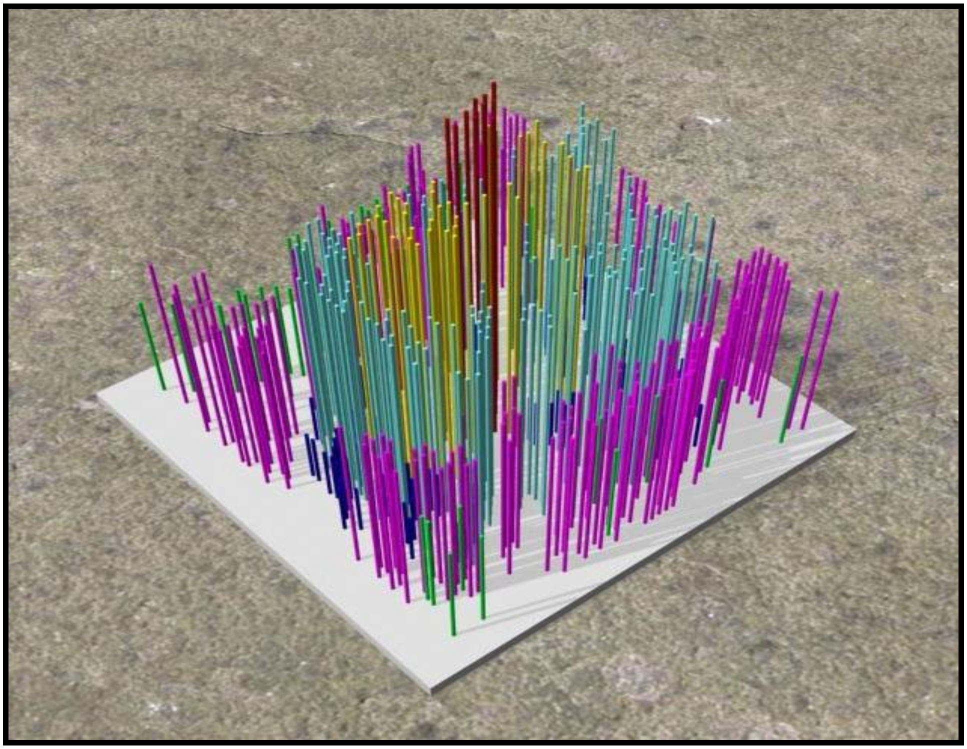

Figure 4b.The time-mediated growth of ramets in *Scirpus grossus* in fertilizer peat soil (F_1) 6 months after planting of the mother plant. Red, emerged ramets in the 1st month; Yellow, emerged ramets in the 2nd month; Blue, emerged ramets in the 3rd month; Purple, emerged ramets in the 4th month; Green, emerged ramets in the 5th month; and Black, emerged ramets in the 6th month.

Table-2. Degree of directional and dispersion in the circular distributions of emerged ramets around the mother plant of *Scirpus grossus* in fertilized (F_1) and unfertilized peat soils (F_0) as measured by selected attributes.

Parameter	Replicate	Attributes		
		R	Z	θ°
Fertilized Soils	R1	51.739	6.529	88.08
	R2	58.195	6.653	39.34
	R3	111.747	20.743	23.20
Unfertilized soils	R1	78.361	10.887	65.12
	R2	15.862	0777	82.39
	R3	21.235	0.857	75.57

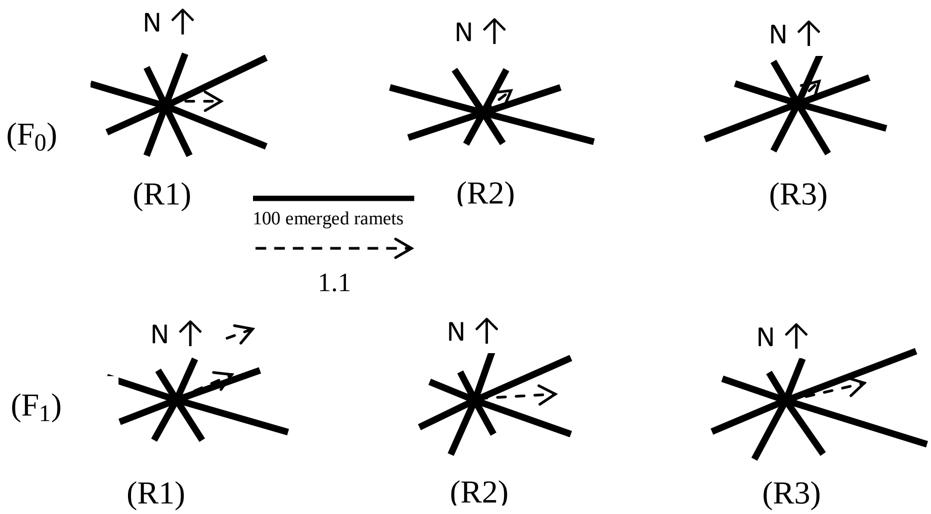

Figure 5. Dispersion analysis of emerged ramets of *Scirpus grossus* by circular statistics in unfertilized soil (F_0) and fertilizer soil (F_1). N, geographical north; mean angle of dispersion.

REFERENCES CITED

Baki, B.B. 1988. The structural Demography and Growth Patterns of Scirpus grossus L. Proc. National Seminar and Workshop on Rice Field Weed Management, Penang, pp. 299-314.

Daughtry, C.S.T., C. L. Walthall, M.S. Kim, E. Brown de Colstoun and J.E. McMurtrey. 2000. Estimating corn leaf chlorophyll concentration from leaf and canopy reflectance. Remote Sensing Environ. 74:229–239.

Harper, J.L.and Bell, A.D. 1979. The Population Dynamics Of Growth Form In Organisms With Modular Construction. Proc. Symp. British Ecol. Soc. 20:29-52.

Ozer, H. 2003. Sowing date and nitrogen rate effects on growth, yield and yield components of two summer rapeseed cultivars. Europ. J. Agron. 19: 453-463.

Zar, J.H. 2006. Biostatistical Analysis. 5th Edition, Prentice Hall Inc., Euglewood Cliffs, N.J.