# RESPONSE OF ROTTBOELLIA EXALTATA (LOUR) TO SHADING

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# Response of *Rottboellia exaltata* (Lour) to shading.

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## ABSTRACT

The effect of shade on the growth, biomass partitioning and photosynthesis rate of *R. exaltata* were determined under greenhouse condition. The plants were grown in polybegs for a period 10 weeks at 0%, 50% and 75% shading level. Results shown that shading significantly reduced leaf numbers, plant dry weight, photosynthesis rate and biomass partitioning. Shading also delayed tillering and flowering of *Rottboellia exaltata*. Plants at 0% shading level produced tillers and spikelets after 28 days and 14 days after transplanting respectively. Plant at 50% shading level produced flower and tiller after 28 days after transplanting. Plants at 75% shading level produced the highest value of specific leaf area (SLA) and leaf area ratio (LAR). In field survey, 5 quadrates of 1m x 1m were randomly selected from open field, 2 years old, 5 years old, and 7 years old oil palm at oil palm plantation at Bekenu, Miri, Sarawak. The result illustrated that shading from oil palm significantly reduced plant dry weight, stem weight ratio , total leaf area and leaf area index *Rottboellia exaltata* grown under 2 years old and 5 years old oil palm shading had the taller plant and highest root weight ratio. Plants under 7 years old oil palm shading recorded the highest value for leaf weight ratio and leaf area ratio.

Key word: Shading, growth analysis, biomass partitioning, photosynthesis rate.

## *ABSTRAK*

*Kesan lindungan terhadap, lindungan, taburan biojism dan kadar fotosintesis ditentukan di rumah hijau. Tumbuhan ditanam didalam polibeg selama 10 minggu dan diletakkan pada tahap lindungan 0%, 50% dan 75%. Keputusan menunjukkan lindungan menyebabkan pengurangan yang bermakna bagi jumlah daun, berat kering tumbuhan, kadar fotosintesis dan taburan biojisim. Lindungan juga menyebabkan kelewatan pengeluaran anak pokok dan bunga Rottboelia exaltata. Tumbuhan pada 0% tahap lindungan mengeluarkan anak pokok setelah 14 hari selepas pemindahan dan bunga pula dikeluarkan setelah 28 hari selepas pemindahan. Tumbuhan pada tahap lindungan 50% tahap lindungan mengeluarkan anak pokok dan bunga setelah 28 hari selepas pemindahan. Tumbuhan pada 75% tahap lindungan menghasilkan luas daun spesifik dan nisbah luas daun yang tertinggi. Pada kajian lapangan yang dijalankan, 5 kuadrat bersaiz 1m x 1m telah dipilih secara rawak di kawasan terbuka, dibawah pokok kelapa sawit berumur 2 tahun, 5 tahun dan 7 tahun di ladang kelapa sawit Bekenu, Miri, Sarawak. Hasil kajian menunjukkan lindungan pokok kelapa sawit menyebabkan pengurangan berat kering tumbuhan, nisbah berat stem, luas daun total and indeks luas daun. Rottboellia exaltata yang tumbuh dibawah lindungan pokok kelapa sawit bermumur 2 tahun dan 5 tahun mempunyai pokok dan nisbah berat akar tertinggi. Tumbuhan di bawah pokok kelapa sawit berumur 7 tahun merekodkan kadar berat daun dan kadar luas daun paling tinggi.*

*Kata kunci; lindungan, analisis pertumbuhan, taburan biojisim, kadar fotosintesis.*

Introduction.

*Rottboellia exaltata* L.f. (synonym *Rottboellia cochinchinensis* (Lour), C4 grass of tropic native from India, is an erect, strongly tufted and annual grass. It is able to attain a four meters height, which produce rhizomes and stilt roots. It can be found in opened, well-drained places and is one of the important species in old-field successions. It also occurs in pasture, cultivated field, lightly shaded plantations, border of tobacco plantations and occasionally along dikes in lowland rice field (Pancho, 1991). However, this weed can also be found at wet areas and shallow water in North Africa and in Madras.

Generally, *R. exaltata* can be found in highland crops such as sugarcane, soybean and maize. In Malaysia, it has first reported in earlier 1980's at Perlis and Kedah where in 1985 only 80 ha sugarcane plantation was infected but in 1990 the infected areas more than 900 ha (Chan *et al*, 1990). According to the Chan also, the weeds were introduced to Malaysia from Thailand through livestock and land preparation equipment.

The importance of this weed to the commercial agricultural due to its very wide spread characteristic. According to Holm *et. al* (1977), *R. exaltata* is ranked for 18$^{th}$ worst weed in the world. The spread is via seeds that may cause serious losing through competition to the crops. Every seed can produce between 600- 5000 seeds per life cycle (Holm *et.al*, 1977). Seeds are spread by water, in poorly cleaned crop seeds and by harvesting machines. Due to the value of this weed to commercial crop, study and understanding of physiology *R. exaltata* is important for control and management in crop product. Thus, this study is to determine the effects of different shading level growth, biomass allocation, and photosynthesis rate of *R. exaltata*

Materials and Methods.

Seedlings at third leaf stage were transplanted in polybeg 10cm x 12cm. After 3 days, the seedlings were then placed in 3 different shading levels that is 0% (open shade), 50% shade, and 75% shade. The different shade regimes were obtained by using different intensity of lathe netting. The light intensity of the shading regimes were checked with Skye light meter (Skye Instrument Limited, UK). An example of the light intensity measurements recorded in the greenhouse was shown in Figure 1.

For each shading, 100 seedlings of *R. exaltata* were sited. The media for grown these plant are soil mixture in rate 3:1:1: (Soil: sand: organic material). Watering carried at every morning and evening.

Five seedlings were selected randomly for vegetative growth measurement such as plant height, leaf numbers, tiller numbers and spikelet numbers. The vegetative measurement commenced on first day of seedling placed in different shading conditions and then followed every two weeks until 10 weeks.

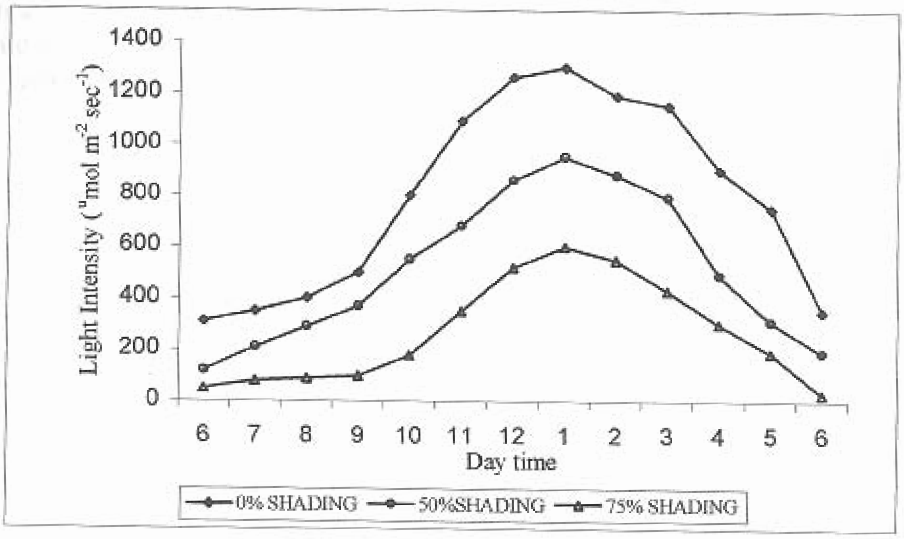


Figure 1: Light intensity measurements under three shade levels in greenhouse.

In another assessment, 5 plants were harvested after 30 day of transplanting harvested from each shading to determine biomass allocation. Leaves, stems, roots, stilt roots and spikelets are separated from each other's. Leaf area was measured by leaf area method (Area Measurement System). The separate vegetative parts were oven dried at $60^0$C for 72 hours to determine their dry weight. Similar harvest and assessment was carried out after 30 days of first harvest. The growth analysis and biomass allocation pattern were assessed by using method described by Patterson (1982). Abbreviations and formulas for the calculations are summarized in Table 1.

Five plants from each shading were randomly selected photosynthesis rate measurement using "LI-6200 Portable Photosynthesis System". Photosynthesis was carried after two until four hours sun rises (Walters. Al, 1992) or from 8.00 am until 11.30 am using. For each plant, threes leaves were chosen randomly for the measurement.

Field survey was carried out at various stage of oil palm plantation such as open field (no oil palm plantation), 2 years old, 5 years old oil palm and 7years old palm oil at Bekenu, Miri, Sarawak at. For each shade level, five quadrates (1m x 1m) were selected randomly. In each quadrate, all plant rooted for biomass allocation. Leaf, stem, root, were separated to determined dry weight (dried at $60^0$C for at least 72 hours). Total leaf area was measured by "Area Measurement System".

Table 1: Mathematical growth analysis formulas.

Calculation requiring data from single harvest:
Given that W, L, R, and S = dry weight of total plant, leaves, roots, and stems and A = Leaf area, then:
Leaf weight ratio (LWR) = L/W, g/g
Stem weight ratio (SWR) = S/W, g/g
Root weight ratio (RWR) = R/W, g/g
Specific leaf area (SLA) = A/L $dm^2/g$
Leaf area ratio (LAR) = A/W , $dm^2/g$

Calculation requiring data from two harvests over a time interval, $\Delta T$;
Given that $\Delta T$: length of harvest interval (days) $W_1$ and $W_2$ = total plant dry weight (g) at the beginning and end of the interval, then:
Dry matter production (DMP) = $\Delta W = W_2 - W_1$, g
$\Delta A = A_2 - A_1$, dm2
Net assimilation rate (NAR) or rate of dry matter production per unit leaf area = $(W_2/A_2 - W_1/A_1) \times (\alpha / (\alpha - 1) / \Delta t$, where $\alpha = \ln W_2 - \ln W_1) / (\ln A_2 - \ln A_1)$, g $dm^{-2}$, $day^{-1}$.
Leaf area duration (LAD) or total amount of leaf area present during harvest interval = $\Delta A / (\ln A_2 - \ln A_1) \times \Delta T$, $dm^2$ days.

Results and Discussion.

Plants at 0% shading level were initially higher than those from 50% and 75% shade level, 14 days after transplanting (Figure 2A) after 56 days of transplanting, plants at 50% were higher than those from 0% shade level. Shortest plants were recorded at 75% shade level. Ishimine *et. al* (1985) noted that reduced light at certain degree would reduced tallness of vaseygrass (*Paspalum urvillei* Steud). In addition, further reduction will suppressed the plant growth. Increasing plant height in the shade condition also the one of strategies *R. exaltata* to escape shading by the crop (Patterson, 1979)

The numbers of *R. exaltata* leaves was significantly influenced by shading (Table 2B). Plants grown at 0% percentage shade level had significantly more leaves than those at 50% and 75% shade. Plants grown at 50% shade had slow increase in leafs number from 0 day to 28 days and eventually with great increase of leaves production after 42 days to 70 days after transplanting.

Table 2A, 2B, 2C nd 2D show effect of shading on height, leaf numbers, tiller numbers and spikelet numbers of *R. exaltata*

Table 2A

| | Days of transplanting | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 14 | 28 | 42 | 56 | 70 |
| Shade level | Height (cm) | | | | | |
| 0% | 3.46a | 15.78a | 38.60a | 104.68a | 132.46a | 156.52a |
| 50% | 3.54a | 13.14b | 22.60b | 59.02b | 157.74a | 171.08a |
| 75% | 3.58a | 10.88b | 15.44b | 20.52c | 22.84b | 32.4b |

Table 2B

| | Days of transplanting | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 14 | 28 | 42 | 56 | 70 |
| Shade level | Numbers of leaf | | | | | |
| 0% | 3.00a | 26.00 a | 60.00a | 103.00a | 124.00a | 160.00a |
| 50% | 3.00a | 6.00b | 13.00b | 26.00b | 59.00b | 88.00b |
| 75% | 3.00a | 5.00b | 6.00c | 7.00c | 9.00c | 10.00c |

Table 2C

| | Days of transplanting | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 14 | 28 | 42 | 56 | 70 |
| Shade level | Numbers of tiller | | | | | |
| 0% | 0.00a | 6.00a | 19.00a | 19.00a | 21.00a | 38.00a |
| 50% | 0.00a | 0.00b | 0.00b | 4.00b | 10.00b | 10.00b |
| 75% | 0.00a | 0.00b | 0.00b | 0.00c | 0.00c | 0.00c |

Table 2D

| | Days of transplanting | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 14 | 28 | 42 | 56 | 70 |
| Shade level | Numbers of spikelet | | | | | |
| 0% | 0.00a | 0.00a | 0.00a | 7.00a | 28.00a | 56.00a |
| 50% | 0.00a | 0.00a | 0.00a | 0.00b | 5.00b | 23.00b |
| 75% | 0.00a | 0.00a | 0.00a | 0.00b | 0.00c | 0.00c |

Within each column, values sharing the same letter are not significantly different at 5% level, according to Fisher Least Significant Different test.

Increasing shade level to 75% had significantly effect the tillering of *R. exaltata* (Table 2C). At 75% shade, there was no tiller produced. Plants at 0% shade level started produce tillers 14 days after transplanting while 42 days after transplanting for 50% shade level.

Plants under 0% shade produce significantly more spikelet than the other two-shade level 42 days after transplanting (Table 2D). Reduction in sunlight suppressed the production of the spikelet. At 0% shade spikelet for 0% shading level emerged after 28 days after transplanting while 42 days for 50% shade level. No spikelet was produced at 75% shade level. Kobayashi *et.al* (2001) in their sudy in *Plantago asiatica* L. reported the repoductive plants parts were reduced compare to the population plants in exposed site. According to Patterson (1982), shading would delay the reproductive development of plant. Delayed flowering also suggested that plant in limited resource (i.e. light) favored vegetative growth and biomass accumulation rather than flowering (Hori and Oshima, 1996; Hori *et. al*, 1987; Miao and Bazzaz, 1990; Bierre, 1995; Elle 1996). Kobayashi *et. al* (2001) further noted that at lower light environment, constrained reproduction is a vital strategy for support plant growth.

Table 3: Effect of shading on vegetative growth, leaf area production and biomass allocation in *R. exaltata* (30$^{th}$ day harvest).

| Shade level | Plant Dry Weight | Total leaf area | LWR | SWR | RWR | SPWR | SLA | LAR |
|---|---|---|---|---|---|---|---|---|
| | (g/g) | (cm$^2$) | ---------------(g/g)--------------- | | | | (cm$^{2/}$g) | |
| 0% | 30.58a | 3948.19a | 0.33b | 0.49a | 0.20a | 0.45a | 308.71b | 107.32b |
| 50% | 3.01b | 943.38b | 0.57a | 0.29a | 0.05b | 0.09b | 563.56b | 319.52a |
| 75% | 0.18c | 60.2c | 0.50a | 0.30a | 0.07b | 0.0b | 771.34a | 380.22a |

Within each column, values sharing the same letter are not significantly different at 5% level, according to Fisher Least Significant Different test.

Plant grown in 0% shade produced the highest total dry weight, followed by 50% and 75% shade level (Table 3). This pattern grows also reported by Ipor and Price (1993) on their study of *P. conjugatum*. *Cynodon dactylon*, another C4 species weed also was reported reduced biomass production when shaded (Burton *et. al*, 1959 & 1988; Chen *et. al*, 1969: Santos *et. al* 1997). The leaf area decreased correspondingly with increase shade level (Table 3). The highest leaf area was 3948.19 $cm^2$ from 0% shade followed by 943.38 $cm^2$ from 50% shade and 60.2 $cm^2$ from 75% shade.the reduction of total leaf area at 75% possibly because of reduction in total leaf number at the shade level as assumed by Ipor and Price (1993) in their study of *Paspalum conjugatum*.

The highest LWR (leaves weight ratio) was recorded at 50% shade level followed by 75% shade level (Table 3). Stem Weight ratio (SWR) not significantly different among shade levels. This indicated that partitioning biomass into stem not significantly influenced by shade level. Partitioning of plant biomass into root differed significantly by among shade level (Table 3). The highest root weight ratio was recorded at 0% shade level followed by 75% shade level. Plants at 75% shade have the greatest specific leaf area (SLA) among shade levels. This probably due to plants under a light –limited regime invested more to the production of light- harvesting apparatus rather than other components of plants biomass (Patterson, 1979). Highest leaf area ratio (LAR) at 75%. Shade level indicated that the leaves expanded (380.22$cm^2$/g) significantly thinner than those plant at two other shades level. Dale and Couston (1992) also found the specific leaf area (SLA) and leaf area ratio (LAR) of *Veronica chamaedrys*, *V. Montana* and *V. officinalis* were increased at low radiance. Patterson (1970 & 1982) further suggested that the characteristic of itchgras (*Rotboellia exaltata*) to maintain the potential for high photosynthesis activity even in light limited conditions. This explained that the ability of this species ability to compete effectively with tall and dense crop, such as corn or sugarcane.

Dry matter production (DMP) and leaf area duration (LAD) of *R. exaltata* were highest at 0% shade and 50% shade for net assimilation ratio (NAR) (Table 4). DMP and LAD significantly differed among the three shade level.

Table 4: Effect of shading on dry matter production, net assimilation rates, leaf area duration o *R. exaltata* during 30th to 60th day interval.

| Shade | DMP (g) | NAR ($mg/dm^2$/day) | LAD ($dm^2$/day) |
|---|---|---|---|
| 0% | 45.97a | 17.18a | 2922.02a |
| 50% | 26.94b | 18.43a | 1466.95b |
| 75% | 0.31c | 5.35b | 75.38c |

Within each column, values sharing the same letter are not significantly different at the 0.05 levels, according to Fisher Least Significant Different test.

Increased shade level will resulted insignificant decreasing the photosynthesis rate. The highest photosynthesis rate at 0% shade level could explain the highest rate of total dry weight of plant at 0% shade level (Table 5). Kobayashi *et. al*. (2001) noted net photosynthesis rate of the leaves in the exposed site were higher than those at the shaded site.

Table 5: Effect of shading on dry matter production, net assimilation rates, leaf area duration o *R. exaltata* during 30th to 60th day interval.

| Shade level | 0% | 50% | 75% |
|---|---|---|---|
| Photosynthesis rate ($\mu$ mol $m^{-2}$ $s^{-1}$) | 19.17a | 8.49a | 2.56a |

Within row, values sharing the same letter are significantly different at the 0.05 level, according to Fisher Least Significant Different test.

Table 6: Effect of shading on vegetative growth, leaf area production and biomass allocation in *R. exaltata* under different ages of oil palm.

| | Open field | 2 years oil palm | 5 years oil palm | 7 years oil palm |
|---|---|---|---|---|
| Plant Height (cm) | 195.56b | 226.52a | 210.56ab | 139.08c |
| Numbers of culms per $m^2$ | 190a | 207a | 136b | 21c |
| Total leaf area ($cm^2$) | 119913.40a | 81094.62b | 43882.20c | 28668.95d |
| Plant Dry Weight (g/g) | 960.68a | 672.36b | 228.04c | 67.21d |
| Leaf Dry Weight (g/g) | 218.87a | 148.02b | 80.10c | 52.33c |
| Stem Dry Weight (g/g) | 618.16a | 421.48b | 118.94c | 9.68d |
| Root Dry Weight (g/g) | 123.65a | 102.87b | 38.87c | 5.2d |
| *LWR( g/g) | 0.23b | 0.22b | 0.36c | 0.79a |
| *SWR (g/g) | 0.64a | 0.62a | 0.52a | 0.14b |
| *RWR( g/g) | 0.13a | 0.16a | 0.17a | 0.08b |
| *LAI ($m^2/m^2$) | 11.99a | 8.11b | 4.39c | 2.87c |
| *LAR ($dm^2$/g) | 1.99b | 1.75b | 1.90b | 5.67a |

Within each row, values sharing the same letter are not significantly different at the 0.05 level, according to Fisher Least Significant Different test.

*LWR = leaf weight ratio, SWR = stem weight ratio, RWR = root weight ratio, LAI = leaf area index, LAR = leaf area ratio.

Field survey demonstrated that *R. exaltata* grown under 2 years old and 5 years old oil palm were taller than those at open field and 7 years old oil palms (Table 6). There was no significant different between height of *R. exaltata* under 2 years and 5 years old palm plantation. The shortest plants were recorded under 7 years old oil palm plantation. This indicated that *R. exaltata* could compete with crops under certain degree of shading. Further shading would suppress *R. exaltata* growth. Plants under 7 years old oil palm also recorded the lowest total leaf area, total dry weight, stem dry weight and root dry weight.

Patterson (1982) assumed that shading caused significant reduction on the average of dry weight per plant that along reduction of leaf number, contributed to the substantial reductions in total leaf weight associated with increased shading. The highest number of culms per in $1m^2$ were recorded under 2 years old oil palm followed by open field, 5 years old and lastly by 7 years old oil palm plantation.

Biomass partitioning showed *R. exaltata* under 7 years old oil palm produced the highest leaf weight ratio (LWR)(Table 6). This leaves less or dense and thinner compare to those *R. exaltata* under different age of oil palm plantation. Stem weight ratio (SWR) seemed to be decrease as shade increased. The highest values for root weight ratio (RWR) were recorded from plants under 2 years old oil palm plantation. *R. exaltata* at open field is the highest leaf area index (11.99 $m^2/m^2$) among those plants grown under different age of oil palm plantation. This indicated leaf area *R. exaltata* was able to cover about 12 times the surface area of the ground. Conversely, for LAR, plant under 7 years old has the highest LAR value that are 5.6 $dm^2/g$ and the lowest from plant at open shade. According to Stoller and Myers (1989), *A. theophrasti*, *Chenopodium album* L. (common lambsquarters), *Solanum ptycanthum* Dun. (estern black nightshade) and *Amaranthus albus* L. (tumble pigweed) responded to shade with decreased leaf respiration rates and increased leaf area ratios.

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