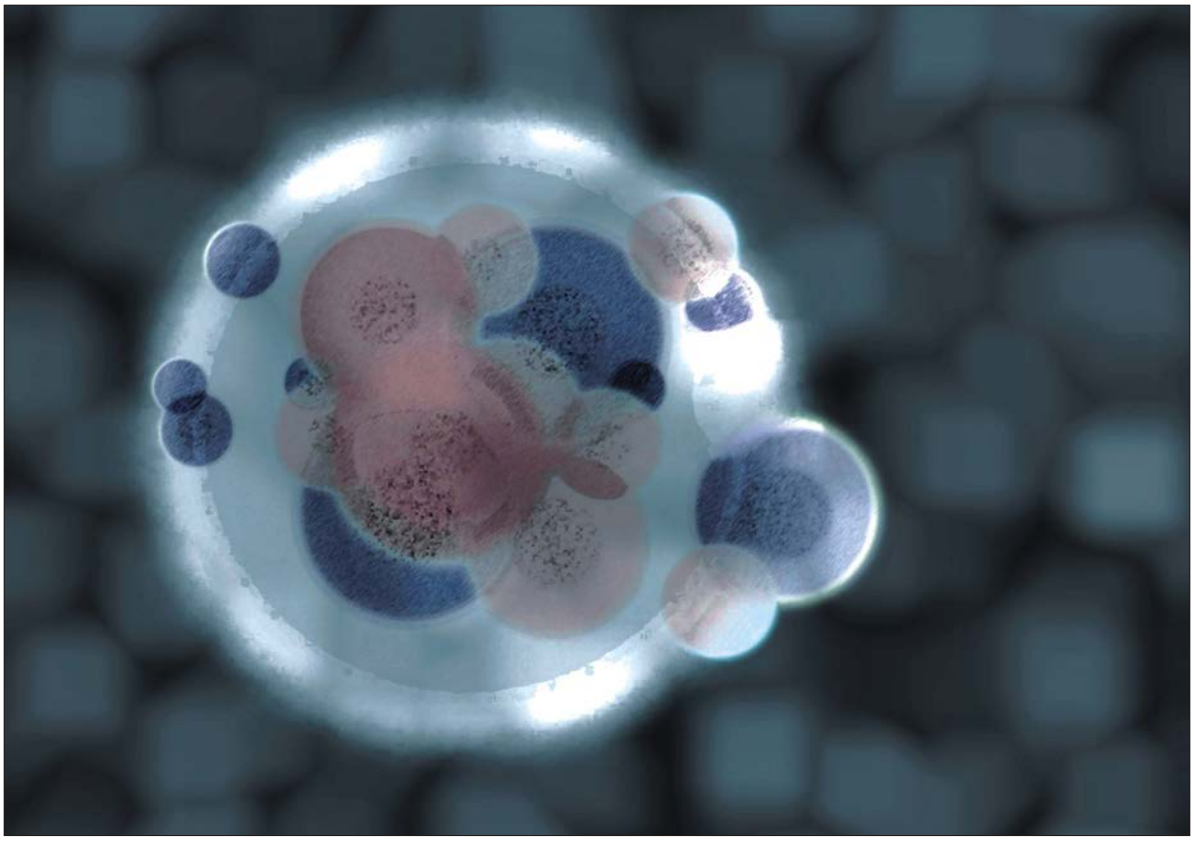

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Eco-Physiological Responses of *Tithonia diversifolia* (Hemsl) A. Gray in Nursery and Field Conditions

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Abstract: The effects of water, light and chemical fertilizer (NPK) on the growth and development of *Tithonia diversifolia* (Hemsl) A. Gray were investigated under nursery and field conditions. The number of leaves produced and biomass accumulation by *T. diversifolia* increased with the age of the plant from 55.0±6.4 at 6 weeks after planting (WAP) to 1352.0±39.8 leaves (14 WAP) and 4.5±0.2 g/plants (6 WAP) to 1259.4±19.1 g/plants (14 WAP), respectively. This trend was maintained under both optimum and stressed conditions of water, light and chemical fertilizer. Light was the next most important factor after water with respect to biomass accumulation of *T. diversifolia*. With minimum light intensity (500 lux), the biomass accumulation was 85.8±3.7 g/plants whereas without fertilizer application the biomass accumulation was 301.4±4.4 g/plant.

Key words: Water, light, chemical fertilizer, *Tithonia diversifolia*, growth

INTRODUCTION

Tithonia diversfolia (Hemsl) A. Gray, the Mexican sunflower as it commonly called, belongs to family Asteraceae (Agnew, 1974; Akobundu and Agyakwa, 1987; Chukwuka, 2003). The plant was probably introduced into West Africa as ornamental plant (Akobundu and Agyakwa, 1987). It came into Nigeria recently through Ogbomoso with the seeds of *Zea mays* imported from Isreal (Chukwuka, 2003; Lordbanjou, 1991) by the then Oyo State Phased Agricultural Development Project (OSPADP). The plant has since become a weed of field crops and roadsides especially in the Southern States of Nigeria (Chukwuka, 2003).

Weeds are major problems in almost every agronomic activities involving cultivation of crops in both subsistence and mechanized farms. The effects of weeds in the sustainability of soil nutrient resources and yield of agricultural products are known (Oyetunji *et al*., 2003). In all agroecosystems, weeds constitute a great threat to agricultural food security and consequently affect net domestic product (NDP) of many developing nations since the scarce financial resources will be directed towards improving the cost of living of the citizenries.

The significant effects of water, light and chemical fertilizer application to the growth and development of plants have been reported by several scholars (Fagbola *et al*., 2001; Oyetunji *et al*., 2003; Santos *et al*., 1997) while Chukwuka (2003) reported that *T. diversifolia* colonizes every available sunny or open space with high water table. It was therefore the specific aim of this study to investigate the effects of different water, light and nutrient regimes on the growth and biomass production of *T. diversifolia*.

MATERIALS AND METHODS

Screen house and field experiments were conducted in the nursery and research farm respectively of the Department of Botany and Microbiology, University of Ibadan, Ibadan-Nigeria between May 7 and August 12, 2001.

Responses of *Tithonia diversifolia* to water stress: Screen house studies were carried out to test the effects of water stress on the growth and biomass accumulation of *T. diversifolia* for 14 weeks. Seeds of *T. diversifolia* were broadcast on four 10 L plastic buckets labeled A, B, C and D containing equal weights (9.5 kg) of sterilized soil samples and watered daily until after germination. Two Weeks After Germination (WAG), the seedlings were thinned to one seedling per bucket and the plants subjected to different water stress conditions (regimes).

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The volume of water supplied to the plants (treatments) were varied and doubled in each case progressively from bucket B, C to D. The watering of the plants was done at alternate days. The treatments were:

Bucket A (T_0) = No water
Bucket B (T_1) = 250 mL of water
Bucket C (T_2) = 500 mL of water
Bucket D (T_3) = 1000 mL of water

All the buckets were perforated at their bases in order to allow excess water to drain out. The experimental design was completely randomized design with three replicates. At the end of the 14th week after planting (WAP), all the plants were harvested. Each replicate (based on the treatment) was harvested and plants roots washed clean in a running tap water. These were dried for 48 h in an oven at a temperature of 70°C and weighed. The results obtained were subjected to analysis of variance.

Responses of *Tithonia diversifolia* to light stress: Field experiments on light intensity stress were conducted to determine the effects of different shading levels on the growth and biomass accumulation of *T. diversifolia* grown for 12 weeks. Three different artificial shading levels (green nylon mesh) were provided in addition to full sunlight as a control (zero shading) using a modification of Santos *et al.* (1997) method where the plants were grown in cage frames of $1\times1\times1$ m^3 and covered with green nylon mesh using variable thickness that allow light intensities of 500, 1000 and 1500 lux to enter the respective different cages. The treatments were:

Cage A (T_1) = 500 lux of light
Cage B (T_2) = 1000 lux of light
Cage C (T_3) = 1500 lux of light
Cage D (T_4) = Full sunlight.

The first cage (T_1) was covered with nine layers of the green nylon mesh to allow only 500 lux of light to it, the second cage (T_2) was covered with six layers of the green nylon mesh which allowed only 1000 lux of light to enter it. The third cage (T_3) was covered with three layers of the green nylon mesh, which allowed only 1500 lux of light to enter it while the control (T_4) was exposed to full sunlight.

The experimental design was completely randomized design with three replicates. The light intensities were determined using a light meter equipped with a standard quantum sensor. The experimental set-up together with their plants was watered twice per week (Mondays and Thursdays) using a watering can in order to avoid water stress.

At the end of the 12th week, the plants were harvested. Plants with the same treatment were harvested together and their roots washed in a running tap water to ensure that they were free from soil particles. Subsequently, they were oven dried for 48 h to a constant weight at a temperature of 70°C and their weights noted. The data obtained were subjected to 2-way analysis of variance and Duncan's multiple range test were used to separate their means.

Response of *Tithonia diversifolia* to nutrient stress: Screen house studies were also conducted to determine the effects of nutrient stress on the growth and biomass accumulation of *Tithonia diversifolia* for 12 weeks. To determine this, week old seedlings of *T. diversifolia* raised in the screen house (nursery) were transplanted into four 10 L buckets labeled A, B, C and D containing equal weights (9.5 kg) of sterilized washed sand and watered at alternate days with 2 L of water to avoid water stress. Light stress was also prevented by keeping the plants where they were exposed to full sunlight. Each bucket used in the experiment was perforated at the base to allow excess water to drain out. Immediately after transplanting, each bucket was subjected to different levels of nutrient stress (treatment) to determine their effects on the growth and biomass accumulation of the plant. The treatments were:

Bucket A (T_0) = Without nutrient (to serve as control)
Bucket B (T_T) = 5 g of NPK fertilizer
Bucket C (T_2) = 10 g of NPK fertilizer
Bucket D (T_3) = 15 g of NPK fertilizer

These different weights of fertilizer were applied round each seedling in their respective buckets a day before the commencement of wetting.

The experimental design was also completely randomized design with three replicates. At the end of the 12th week, the plants were harvested based on the type of treatment they had and their roots washed in a clean running tap water to ensure that there was no soil particle on their roots. Subsequently they were oven- dried for 48 h to a constant weight at 70°C and the mean dry weights of the shoots and roots taken. The treatment effects were tested using analysis of variance and treatments means separated using Duncan (1995).

RESULTS

Growth responses of *Tithonia diversifolia* to stress:

Responses of *Tithonia diversifolia* to water stress: The highest mean dry matter (above and below ground biomass) was produced in *T. diversifolia* supplied with 1000 mL of water at alternate days while the lowest mean dry matter was produced by *T. diversifolia* with zero (0) water supply. The figure also shows that as the water supply to the plants at alternate days increased, the mean dry weight matter produced by the plants increased (Fig. 1). However, treatment effects (water supply to the plants) on the growth and mean dry matter production of *T. diversifolia* has no significant effect on the plants ($p>0.05$).

Responses of *Tithonia diversifolia* to light stress: The effects of light stress on growth and dry matter production of *Tithonia diversifolia* are shown in Fig. 2 and Table 1.

The highest dry matter was produced when *T. diversifolia* was exposed to full sunlight while the least dry matter was produced when only 500 lux of light was allowed to reach the plants (Fig. 2). The above-ground and below-ground dry matter produced were more in *Tithonia diversifolia* exposed to full sunlight, followed by that which was exposed to 1500 lux of light and that exposed to 1000 and 500 lux of light, respectively. Table 1 also shows that treatment effect (light supply to the plants) on the dry matter production (total dry matter production that is, above-ground and below-ground biomass put together) was highly significant ($p<0.001$). Light intensity significantly ($p<0.001$) reduced biomass production on *T. diversifolia*. Duncan (1955) multiple range test however showed that the effects of light on *T. diversifolia* exposed to 1000 and 500 lux of light was not significantly different ($p>0.05$) implying that there is no significant difference on the effects of these light intensities on dry matter production of *T. diversifolia*. Full light intensity and 1500 lux were responsible for the significant effect.

Responses of *Tithonia diversifolia* to nutrient stress: The effects of nutrient stress on the growth and biomass production of *Tithonia diversifolia* are presented in Fig. 3 and Table 2.

The highest total dry matter production of *Tithonia diversifolia* was produced when the plant was treated with 15 g of NPK fertilizer, followed by 10g NPK in that order and finally the zero (0) NPK fertilizer treatment. The trend is the same for the mean above-ground biomass production. However, the highest below-ground biomass

Table 1: Effects of light intensity stress on total dry matter production of *Tithonia diversifolia*

Treatments	Mean dry weight (g)
Tithonia diversifolia + 500 lux of light	85.75c
Tithonia diversifolia + 1000 lux of light	141.52c
Tithonia diversifolia + 1500 lux of light	377.57b
Tithonia diversifolia + full sunlight	496.02a

Means with the same letter are not significantly different according to Duncan's Multiple Range Test ($p<0.05$)

Table 2: Total dry matter production of *Tithonia diversifolia* as affected by fertilizer application under screen house condition

Treatments	Mean dry weight (g)
Tithonia diversifolia + 0 NPK fertilizer	301.37d
Tithonia diversifolia + 5 g NPK fertilizer	400.15c
Tithonia diversifolia + 10 g NPK fertilizer	601.95b
Tithonia diversifolia + 15 g NPK fertilizer	904.80a

Means with the same letter are not significantly different according to Duncan's Multiple Range Test ($p<0.05$)

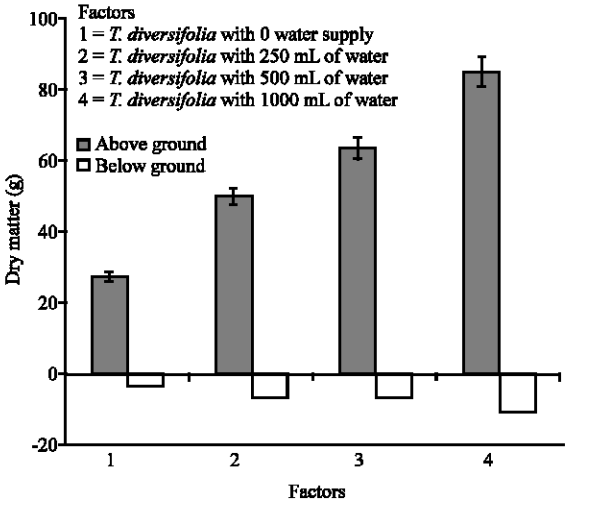

Fig. 1: Dry matter production of *Tithonia diversifolia* as affected by water regime under screen house conditions | = Standard error

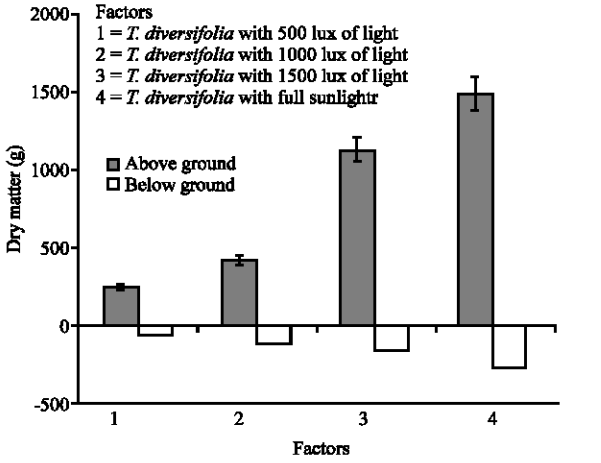

Fig. 2: Dry matter production of *Tithonia diversifolia* as affected by light stress under field conditions | = Standard error

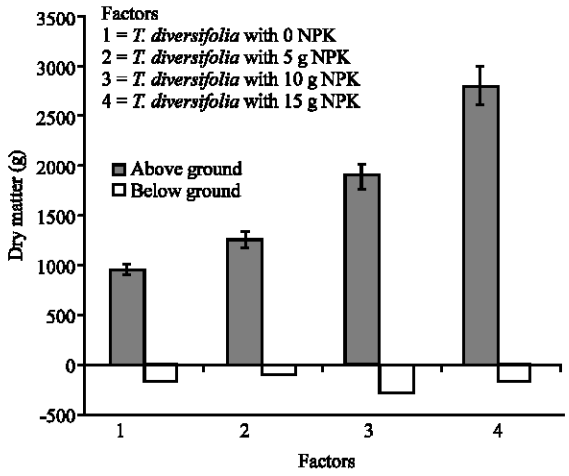

Fig. 3: Dry matter production of *Tithonia diversifolia* as affected by Nutrient stress under screen house conditions | = Standard error

was observed for *T. diversifolia* treated with 10 g of NPK fertilizer, followed by those treated with 15 g of NPK fertilizer, zero (0) NPK fertilizer and lastly 5 g of NPK fertilizer in that order.

Treatment effect of fertilizer application on the biomass production of *T. diversifolia* was highly significant ($p<0.001$).

DISCUSSION

The effects of water stress on dry matter production (above and below ground biomass accumulation) in *Tithonia diversifolia* grown under screen house conditions showed that *T. diversifolia* performed better under wet conditions than under drought conditions. The above and below-ground biomass accumulation continued to increase as the amount of water supplied to *T. diversifolia* increase. This explains why *Tithonia diversifolia* is wide spread in the forest zone where there is more water availability than any other ecological zone. However, the analysis of variance showed that the effects of water stress on dry matter production of *T. diversifolia* were not significant ($p>0.05$).

On the other hand, the effects of light stress on dry matter production (above and below-ground) in *Tithonia diversifolia* grown under field conditions showed that the (above and below-ground) biomass accumulation increases as the shading level decreases. This could be due to fact that, as more light reaches the plants, this leads to increase in the primary production of the plants. This increase leads/results to increase in the development of plant body tissues and energy storage suggesting that *T. diversifolia* is a sun loving species. This could explain the high competitive vigour of *T. diversifolia* with field crops. Previous reports (Boardman, 1997; Gachengo *et al*., 1999; Santos *et al*., 1997) on growth and the effects of light, shading on the growth and biomass partitioning on *Cyperus esculentus*, *C. rotundus*, *Amaranthus* and *Tithonia* support the findings in this study. The present observation suggests that shading off light from *Tithonia diversifolia* could serve as a good control measure for the weed.

Effect of light stress on total dry matter production by *Tithonia diversifolia* were however significant ($p<0.05$). In the present study, the reduction in plant biomass by plants stressed of light may be due to reduction in their photosynthetic activities as influenced by light supply to them.

The response of *Tithonia diversifolia* to nutrient stress revealed significant effects ($p<0.05$) of nutrient treatments on the biomass accumulation of the plants. The above-ground biomass production by the plants increased as the quantity of nutrients the growing seedlings were treated with increased. Unlike in the above-ground biomass accumulation, the below-ground biomass accumulation did not increase as the quantity of nutrients the growing seedlings were treated with increased. This was because the initial nutrient supply stimulated more root proliferation in order to obtain sufficient nutrient for growth. This might explain why 0 NPK and 10 NPK had more below-ground biomass accumulation than 5 NPK and 15 NPK treatments, respectively.

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