

Morphology and Growth of Tawa-tawa (*Euphorbia hirta* L.) Under Varying Levels of Shade and Nitrogen Source

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ABSTRACT:

A pot experiment was conducted to determine the effects of different levels of shade (open condition, 30% and 60%) and N fertilizer application (no N, 0.65 g urea [equivalent to 0.30 g of N per plant] and 1.30 g urea, 62.5g poultry litter compost, 32.08 g green manure compost and 47.24 g vermicompost [all equivalent to 0.60 g of nitrogen per plant] on morphological parameters and growth of tawa-tawa (*Euphorbia hirta* L.) *Euphorbia hirta* plants applied with vermicompost and poultry litter compost under the open condition exhibited the highest number of leaves and lateral branches. The earliest number of days to flowering was from vermicompost-applied plants under open condition and 30% shade. The most number of flowers was also observed under the same treatments. High vegetative and reproductive growth from plants applied with vermicompost under open condition correspondingly increased the resulting fresh and dry weight of the different plant parts.

Keywords: *Euphorbia hirta* L., morphology, nitrogen, poultry litter, tawa-tawa, vermicompost

INTRODUCTION

Medicinal plants play an integral role in the protection of human health and of biodiversity. They have curative properties due to the presence of various complex chemical substance of different composition (Patil *et al.*, 2009). According to the World Health Organization (WHO, 2008), 80% of the population in developing countries rely on traditional medicine, mostly in the form of plant drugs for their health care needs. In the Philippines, one of the traditionally used medicinal plant species is *Euphorbia hirta* L., locally called as tawa-tawa or gatas-gatas.

Euphorbia hirta L. belongs to the family Euphorbiaceae. It is a very common herb in the pantropic and partly subtropic areas worldwide, including China, India, Philippines, Australia, Africa, and Malaysia (Huang *et al.*, 2012). The herb is known to contain phytochemicals like terpenes, flavonoids, phenols, alkaloids, sterols, fatty acids, essential oil, and other compounds (Khare, 2007). It is a very popular herb

amongst practitioners of traditional medicine, widely used as a decoction or infusion to treat various ailments like gastrointestinal disorders, afflictions of the skin and mucous membranes and respiratory system disorders. The plant has a reputation as an analgesic to treat severe headache, toothache, rheumatism, colic and pains during pregnancy. It is used as an antidote and pain relief of scorpion stings and snakebites and the latex is also being used to facilitate removal of thorns from the skin (Basma *et al.*, 2011).

The Department of Science and Technology (DOST) and Philippine Council for Health Research and Development (PCHRD) in 2012 have embarked on a study to determine if there is science in the claims that *E. hirta* has therapeutic properties. The use of *E. hirta* for the treatment of dengue has not yet been established at present; however, the Philippine Department of Health is not against its use with emphasis that it should be accompanied by proper medical consultation (Alvero, 2014).

With its growing popularity and importance, optimum growing conditions for the production of *E. hirta* with maximum yield and good quality must be established. Hence, it is essential to understand the factors that will contribute to its proper growth and development. Among the factors that contribute to the growth, yield, and quality of medicinal plants are light intensity and the quality and quantity of fertilizer applied (Mozumber *et al.*, 2008).

As in any other crop, it is important to understand the dynamic nature of the environment that will affect the growth and development of medicinal plants. Environmental factors such as shade and nitrogen were found to be affecting growth and development of many plants. In many instances, the nature and extent of a plant response to shade is dependent on the N status of the plant and vice versa (Casey *et al.*, 2004), so an understanding of these interactions is fundamental. For *E. hirta*, shade and N requirement had not yet been studied and due to economic and environmental concerns regarding N in agriculture, it was important to elucidate this requirement. There has been no agronomic and ecological research conducted on this plant. Thus, this research was conducted with the purpose of understanding the interaction between different shade levels and N source and application in *E. hirta*. It also aimed to establish an optimal growing condition for *E. hirta* for maximized yield and secondary metabolite production without the need for excessive N fertilization.

MATERIALS AND METHODS

This study was conducted at the Experimental Area of the Institute of Crop Science, College of Agriculture and Food Science, University of the Philippines Los Baños (UPLB), College, Laguna, Philippines from January to

March 2016.

Experimental Design, Treatment and Layout

The pot experiment was laid out in a randomized complete block design across shade with four replicates. The main plot was the levels of shade: open condition, 30% and 60% shade. Subplots were organic N sources (poultry litter compost, green manure compost and vermicompost) and inorganic N in the form of urea at the rate of 50 kg ha⁻¹ N and 100 kg ha⁻¹ N. To make N rates comparable between the use of inorganic N (urea) and organic N sources, compost fertilizer rates followed the 100 kg ha⁻¹ N (equivalent to 0.60 g of N/plant) recommended level. There were a total of 18 treatment combinations (three shade levels and six N source and rate treatments). Each treatment consisted of five pots per replicate, with one plant per pot. A total of 360 test plants were used.

Fertilizer Treatments and Application

The following organic fertilizer treatments were used in the study: poultry litter compost, green manure compost and vermicompost. Prior to transplanting, the organic amendments were incorporated into the potted garden soil (approximately containing 5 kg of soil per pot) following the amount of nitrogen indicated in the treatments. Fertilizer rates selected were based on a rate-finding study of other herbaceous crops with relatively the same morphological characteristics as *E. hirta* using low, average, and high levels of N (Alsafar and Al-Hassan, 2009). N rate following the recommended 100 kg ha⁻¹ (equivalent to 0.60 g nitrogen) was satisfied by adding 62.5 g/plant of poultry litter compost, 32.08 g/plant for green manure compost and 47.24 g/plant for vermicompost (Table 1). The amount of fertilizer applied

Table 1. The amount of organic and inorganic fertilizers used in the study and the corresponding amount of N content per fertilizer.

NITROGEN TREATMENTS	RECOMMENDED N/ha (kg)	% NITROGEN	AMOUNT OF NITROGEN (g/plant)	AMOUNT OF FERTILIZER (g/plant)
No nitrogen (N0)	-	-	-	-
Urea (N1)	50	46.0	0.30	0.65
Urea (N2)	100	46.0	0.60	1.30
Poultry litter compost (N3)		0.96	0.60	62.5
Green manure compost (N4)		1.87	0.60	32.08
Vermicompost (N5)		1.27	0.60	47.24

per plant was determined based on % organic matter (N content of organic matter is approximately 5%).

Inorganic N in the form of urea (46-0-0) was applied at 50 kg ha⁻¹ N and 100 kg ha⁻¹. Urea in the form of an aqueous solution was applied through split application one week and two weeks after transplanting. The application rate was satisfied by adding 0.65 g/plant, equivalent to 0.30 g of nitrogen per plant and 1.30 g/plant, equivalent to 0.60 g of nitrogen per plant, respectively.

Seedling production

Seeds of *E. hirta* L. were obtained from the collection of the National Plant Genetic Resources Laboratory (NPGRL), Institute of Plant Breeding, UP Los Baños, Laguna. The said accession was collected from Brgy. Matin-ao, Polomolok, South Cotabato.

The seeds were sown and germinated in a rectangular pan inside the greenhouse. After three weeks, uniform seedlings with approximately 5cm height were transferred in the individually prepared 18 cm x 18 cm x 28 cm black polybags inside the shade house. The seedlings were exposed to different light attenuation following transplanting (Fig.1).



Figure1. Transplanting of *E. hirta* seedlings three weeks after sowing.

Shade Construction and Shade Levels

Shade houses were constructed using bamboo poles as posts. Black fish nets provided the desired shade levels for the two shade houses (Fig. 2). A single layer of black fish net provided for the 30% shading treatment and a double black fish net for 60% shading treatment. Open condition served as the control.

The black fish nets were positioned at a height of 2 meters from the ground surface. The four sides including the roof of each shade house were

enclosed with fish nets. Such design excluded any direct illumination and obviated any microclimate alterations. Each shade house had a dimension of 2 m x 6 m. For each shade house, all four plant replicates with varying N sources and N rates were placed.

Light meter readings using Licor Li-250A were taken regularly for 2 weeks before the actual set-up to verify the light reduction levels in each shade house. In the middle of the experiment, readings were again done to check on the light levels received by the plants.

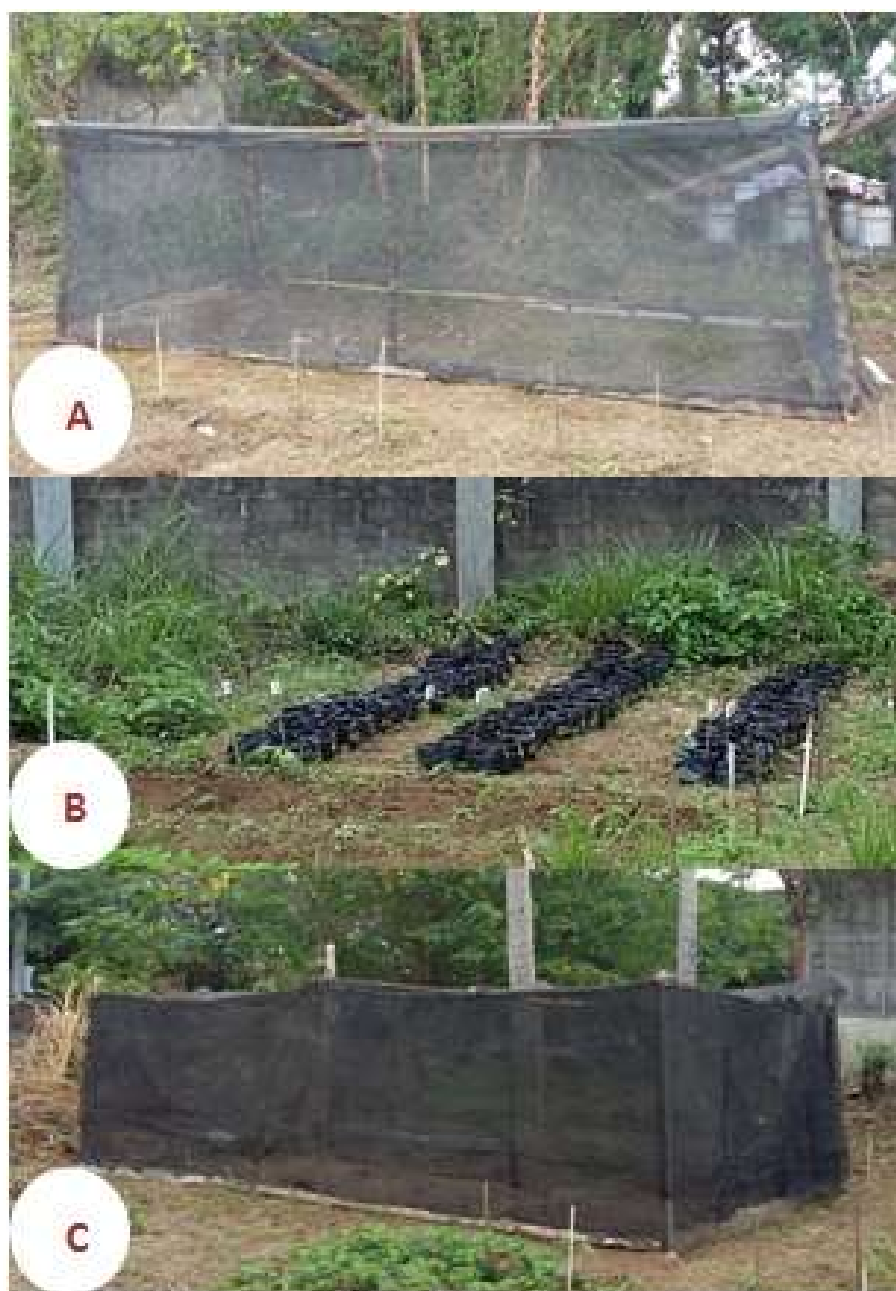


Figure2. A) Single net shade house; B) Open condition; C) Double net shade house

Statistical Analysis

The data gathered were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) Software. If treatments and their interactions were found significant, the means were then subjected to Tukey's Studentized Range (HSD) Test using the GLM procedure to determine the significant differences at 5% level.

RESULTS AND DISCUSSION

Chemical Analysis of Soil and Composts

Nutrient analysis for poultry litter compost showed a neutral pH, with moderate amount of organic matter and N content. Green manure compost was slightly acidic, with the highest amount of organic matter and N content. The vermicompost has a neutral pH, with high organic matter and N content while the garden soil was moderately acidic with a very low, almost negligible amount of organic matter and N content (Table 2).

Vegetative Growth of *E. hirta*

Plant height. The weekly plant height of *E. hirta* was significantly influenced by the interaction of different levels of shade and fertilizer treatments. A week after transplanting, plants treated with vermicompost and poultry litter compost were the tallest plants under all shade levels. In the second week, the tallest plants of 14.4 and 13.5 cm were recorded from vermicompost-treated plants under open condition and 30% shade, respectively. These values were comparable to that of poultry litter compost-treated plants under the two shade levels. In the third week, plants under the open condition, vermicompost and poultry litter compost-treated was significantly taller than the rest of the treatments. Plants not applied with

fertilizer were observed to have a comparable height with the other treatments. A week before termination, plants exhibited a plant growth comparable to each other within each shade level. At termination, the tallest plant was observed from poultry litter compost-treated plants under 30% shade with a final plant height of 43.4 cm. This value did not differ from the rest of the treatments under the same shade level and in open condition, except for the plants without fertilizer. Plants under 60% shade had values that were similar to each other. Plants without fertilizer exhibited no significant differences from that of the plants applied with fertilizer (Fig. 3).

Number of leaves. Interaction between different levels of shade and fertilizer treatments was significant for the number of leaves of *E. hirta*. Higher number of leaves were from the plants grown under open condition. Poultry litter compost and vermicompost treatments had a significantly higher total leaf number of 130 and 139, respectively. However, plants with no fertilizer under open condition had number of leaves that did not vary from the remaining treatments within the same shade level and were also comparable to the plants under 30% shade treated with poultry litter compost and vermicompost. The remaining treatments in 30% shade, on the other hand had values that were similar to that of the plants under 60% shade in all fertilizer treatments (Fig. 4).

Number of laterals. The number of laterals of *E. hirta* plants was significantly influenced by the interaction of different levels of shade and fertilizer treatments. Comparison of treatment means showed highly significant value of 31 lateral growths from plants applied with poultry litter compost followed by vermicompost at 26, both grown at the open condition (Fig. 5). The remaining treatments gave no significant

Table 2. Characteristics of the soil and composts used in the study.

SAMPLE	OM (%)	N (%)	MOISTURE (%)	pH
Garden Soil	0.5	0.02	-	6.6
Poultry Litter Compost	19.3	0.96	31.3	7.0
Green Manure Compost	37.5	1.87	23.5	6.7
Vermicompost	25.5	1.27	57.5	7.0

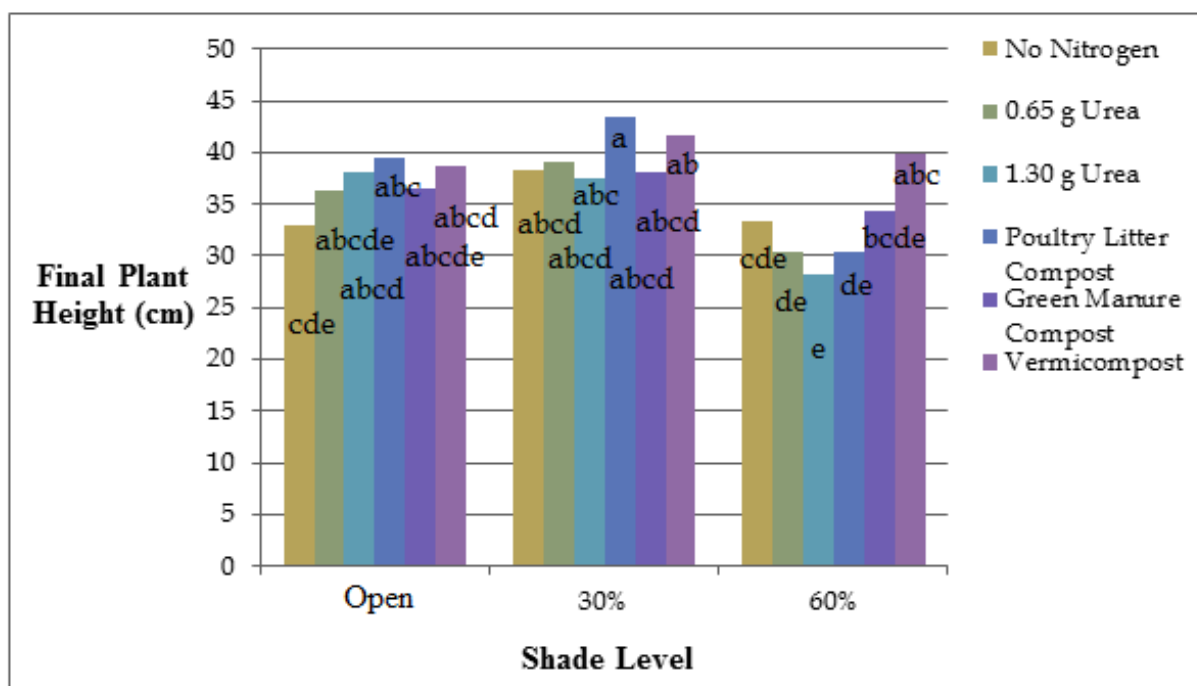


Figure 3. Final plant height (Week 5) of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

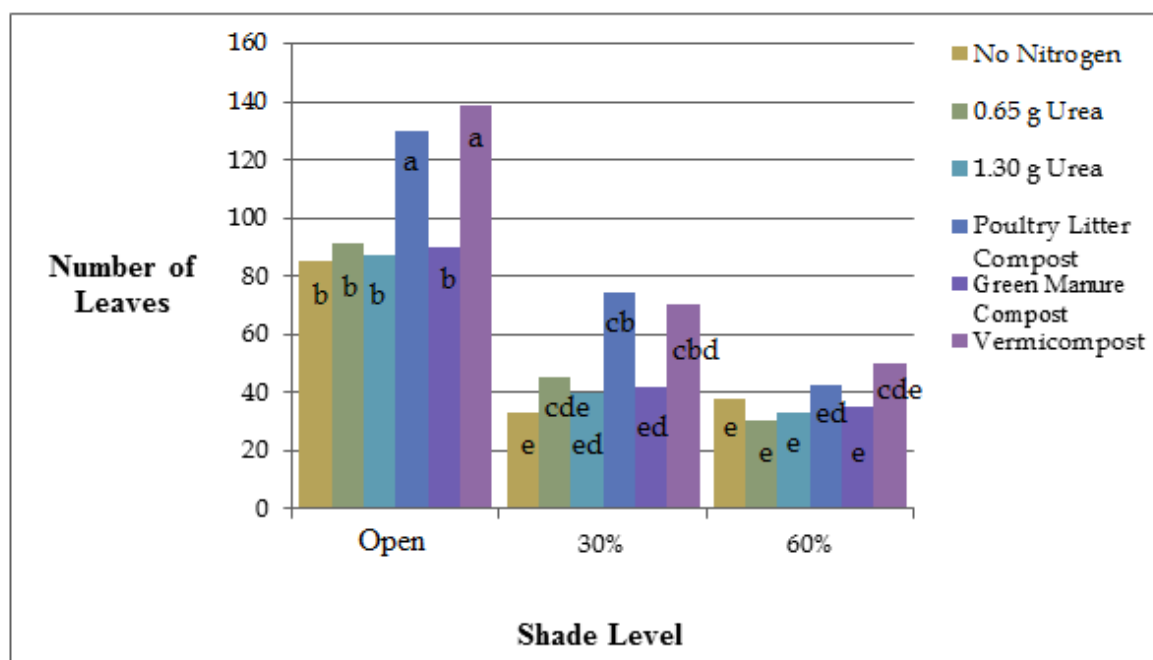


Figure 4. Number of leaves of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

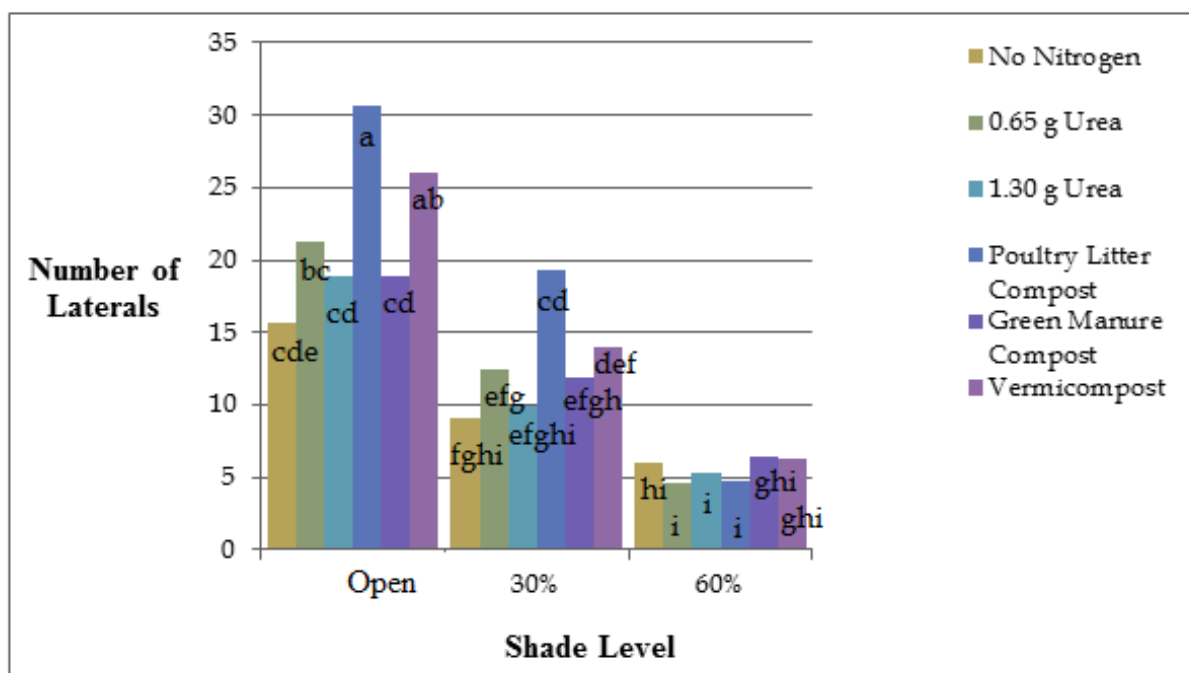


Figure 5. Number of laterals of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

differences when compared with the plants not applied with fertilizer within all shade levels, except for poultry litter compost treatment from plants under 30% shade which was at par with those plants under the open condition. The lowest number of laterals was recorded to be about 5 when applied with 0.65 g urea and grown under 60% shade level. This value, however, was not different from the other treatments under 60% shade.

Root length. The length of the longest root of *E. hirta* plants was found to be significantly influenced by the interaction of different levels of shade and the fertilizer treatments. The root length of plants without fertilizer did not vary among different fertilizer treatments under all shade levels except with the poultry litter compost treatment at 30% shade level (Fig. 6). Plants under open condition were, however, found to be longer than plants under 60% shade, with the exception for 1.30 g urea treatment, which was similar to green manure compost.

Area per leaf. Area per leaf (cm^2) of *E. hirta* showed no significant interaction between different levels of shade and fertilizer treatments. This parameter, however, was independently affected by the two

main factors. From the main effect of the varying shade levels, comparable results for area per leaf were noted for plants under open condition and 30% shade. Both were significantly different from those under 60% shade (Fig. 7). The greatest area per leaf of 2.7 cm^2 from plants grown under 60% shade was found to be 75% and 63% larger than in the open condition and 30% shade levels, respectively.

Regardless of shade levels, plants with no fertilizer had an area per leaf that did not vary from all the fertilizer treatments (Fig. 8). Vermicompost treatment showed the largest area per leaf at 2.0 cm^2 , and the value did not significantly differ from those given organic or inorganic sources except for the application of 0.65 g urea.

Total Leaf Area. The trend for the total leaf area (cm^2) of *E. hirta* plants was similar to that of the area per leaf (cm^2) data. From the main effect of varying fertilizer treatments, the largest total leaf area was observed in the vermicompost treatment which was not significantly different from the plants treated with poultry litter compost. The remaining treatments did not differ significantly from one another.

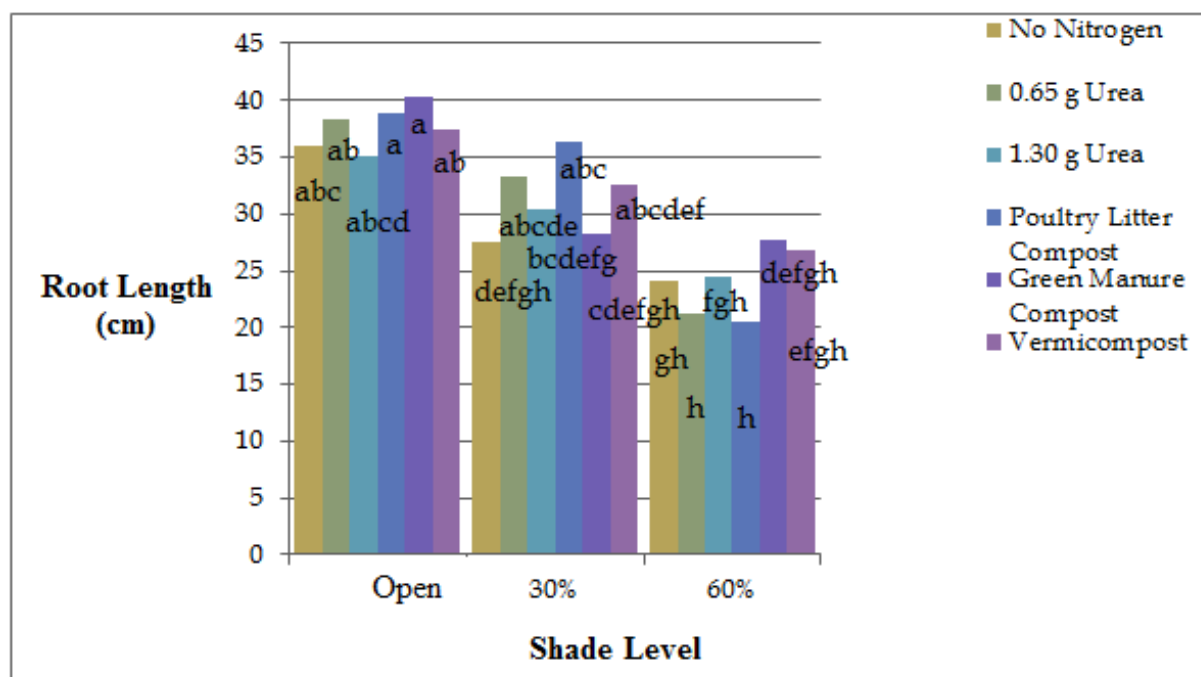


Figure 6. Root length of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

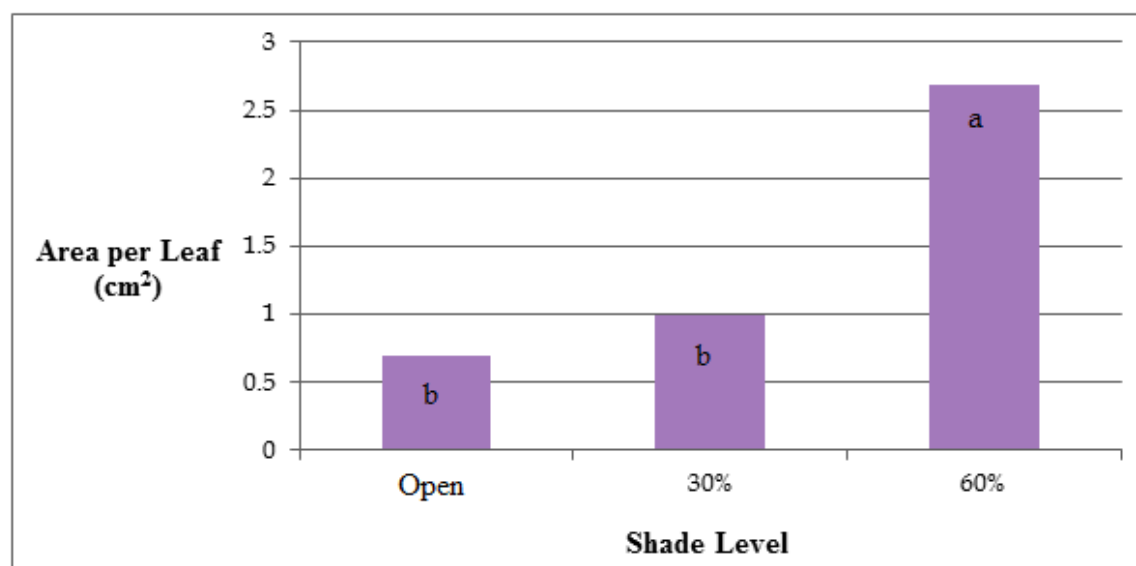


Figure 7. Area per leaf of *E. hirta* plants as affected by different shade treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

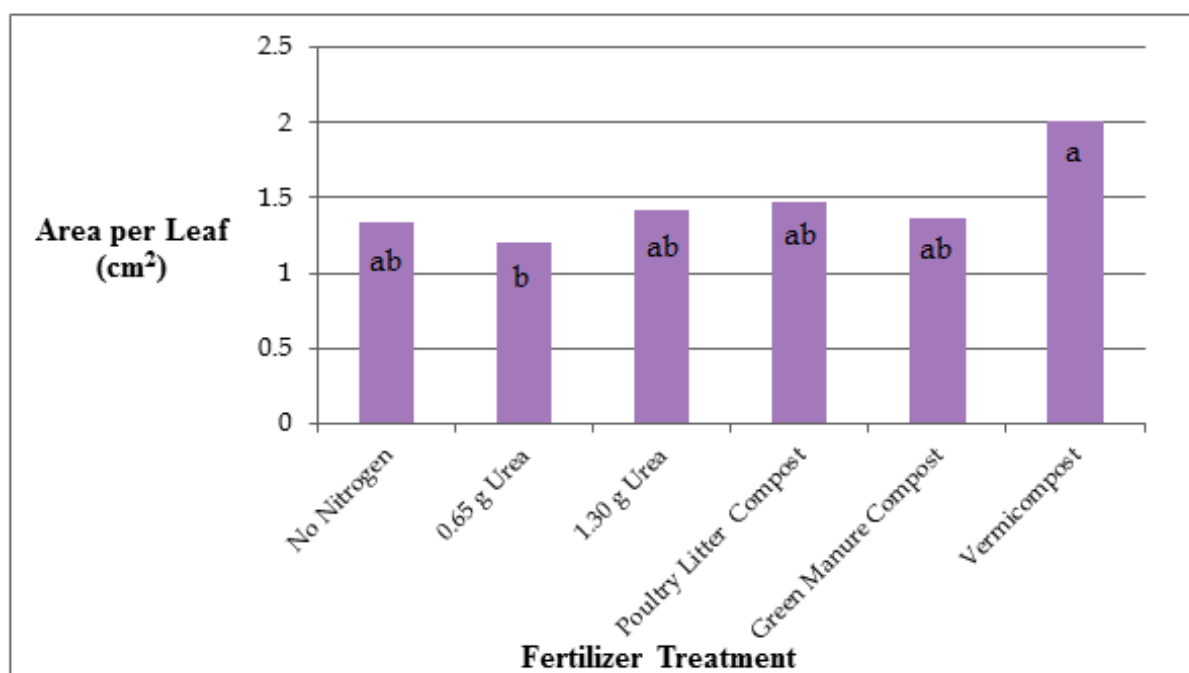


Figure 8. Area per leaf of *E. hirta* plants as affected by different fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

Reproductive Growth of *E. hirta*

Days to Flowering. The number of days from transplanting to first flower bud appearance in *E. hirta* plants was significantly affected by the interaction of different levels of shade and fertilizer treatments. The earliest number of days to flowering was first monitored from vermicompost treatment both under open condition and 30% shade levels at an average of 16 days from transplanting (Fig. 9). On the other hand, at 22 days after transplanting, the latest number of days to flowering was recorded and observed from all treatments under 60% shade. Regardless of the kind of N sources and N rates, number of days to flowering for all treatments within each shade levels were similar to one another, except for the vermicompost treatment in 30% shade.

Number of Flowers. The number of flowers of *E. hirta* plants was significantly influenced by the interaction of different levels of shade and fertilizer treatments. Among all treatments means, poultry litter compost and vermicompost under open condition shade exhibited the most number of flowers at 86 and 85 per plant, respectively (Fig. 10). These values were statistically different from the rest of the treatments for all shade levels and fertilizer treatments. The plants not applied with fertilizer under open condition

were of the same level as that of the plants treated with 1.30 g urea and green manure compost. At 30% shade, the number of flowers in plants without fertilizer was also comparable to both urea treatments and green manure compost. The lowest number of flowers at 12 was recorded from plants under 60% shade, which did not significantly vary with fertilizer treatments.

Percent Flowering. At termination, all *E. hirta* plants flowered. Being often regarded as a weed growing in either cultivated areas in lowland, paddy fields, gardens, roadsides and even waste places, tawa-tawa is adapted to reproduce at any given circumstances, regardless of any level of shade or fertilizer treatment provided (Huang *et al.*, 2012).

Biomass Production

Total plant weight. The various treatments and their interaction effect significantly influenced the total plant weight of *E. hirta* plants. The heaviest total plant fresh weight of 34.7 g from vermicompost treatment under the open condition was significantly heavier than those of the rest of the treatments under all shade levels (Fig. 11). Weight of *E. hirta* plants applied with poultry litter compost and subjected to open condition was similar to those plants applied with poultry litter

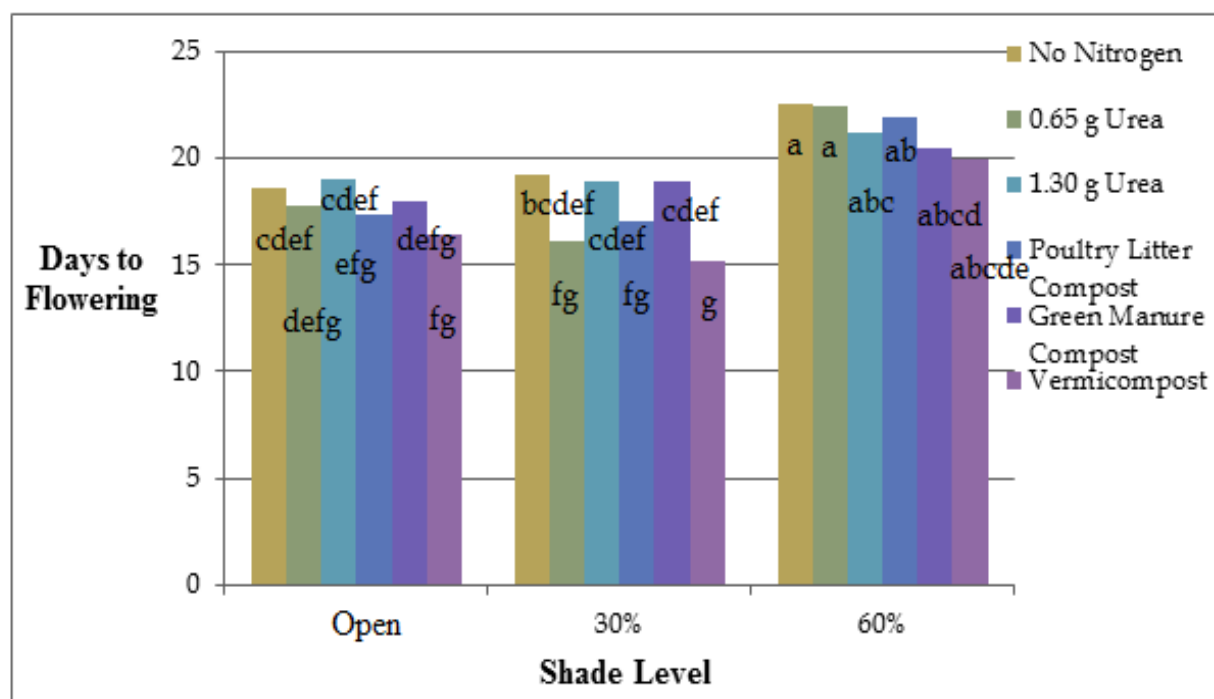


Figure 9. Days to flowering of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

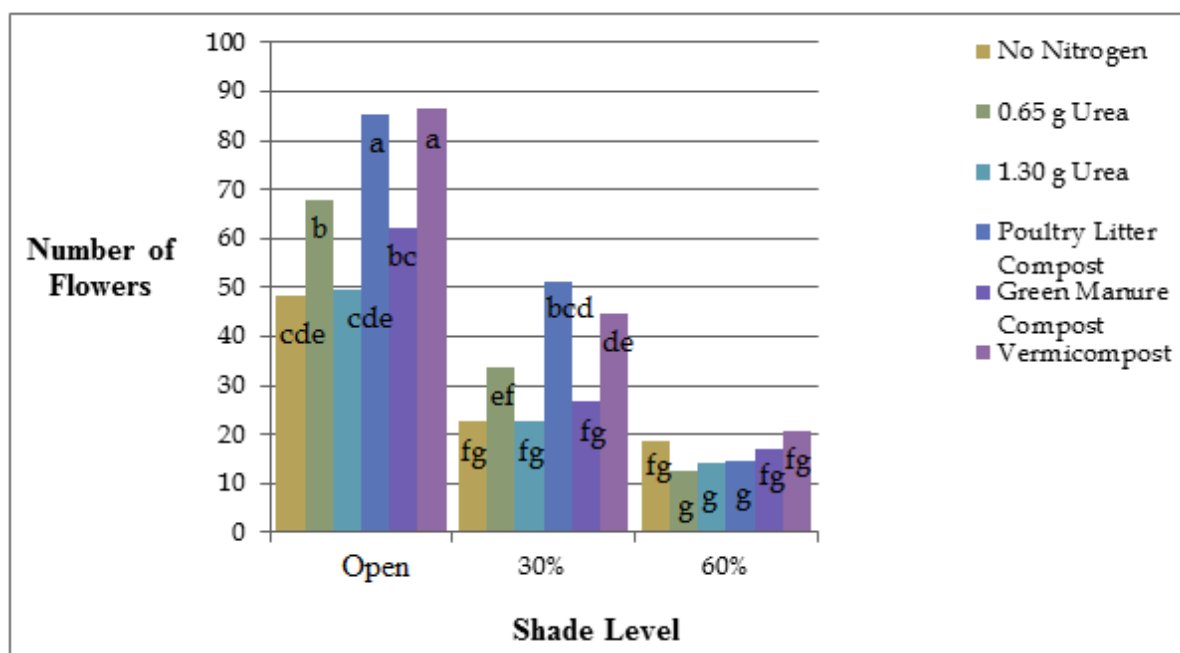


Figure 10. Number of flowers of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

compost and green manure compost under 30% shade. Fresh weight of the plants with no fertilizer under the open condition was the same with those applied with urea and green manure compost. On the other hand, plants without fertilizer under 30% shade

were also similar to those with N applied. Total plant fresh weight under 60% shade did not differ from one another. A more or less similar trend for total plant dry weight was observed (Fig. 12).

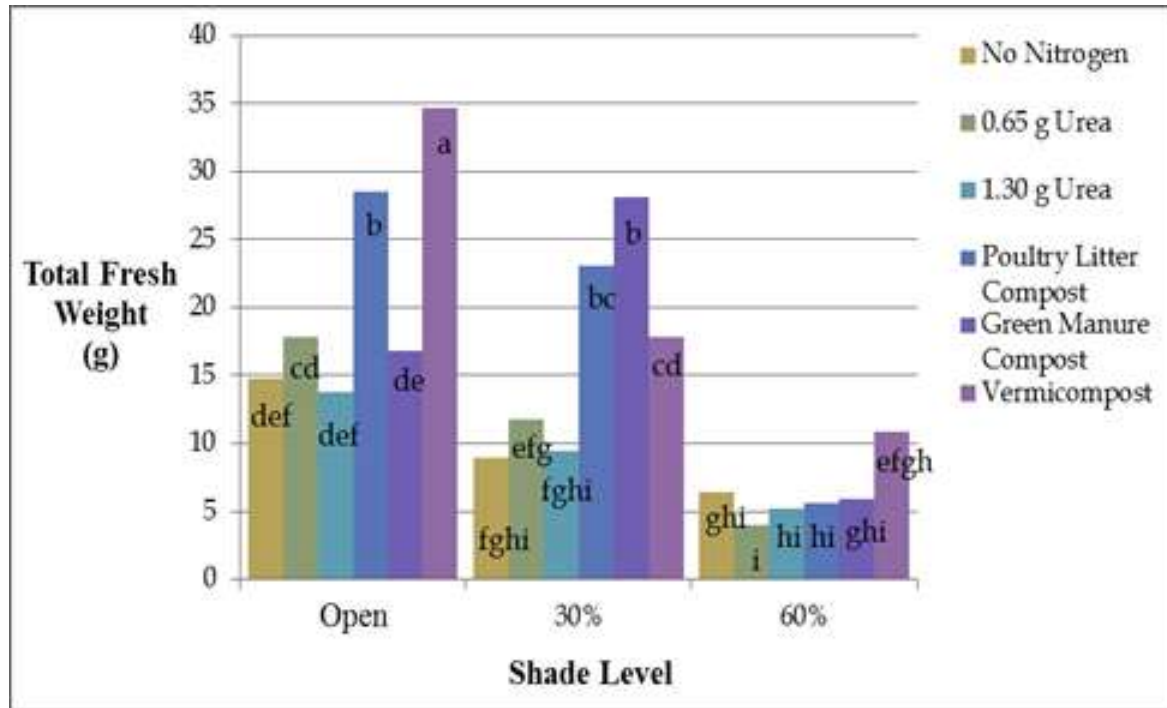


Figure 11. Total fresh weight of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

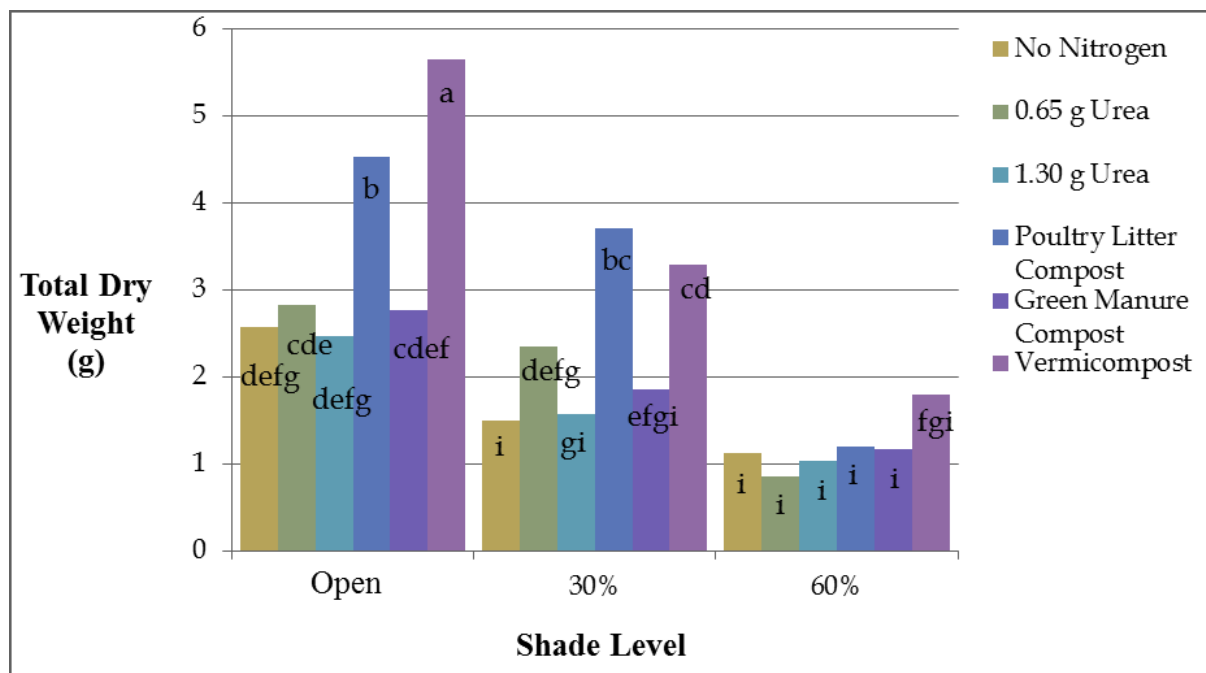


Figure 12. Total dry weight of *E. hirta* plants as affected by different levels of shade and fertilizer treatments. Bars with a common letter are not significantly different using Tukey's Studentized Range (HSD) Test at 5% level.

The promotive effects of various organic amendments on the vegetative and reproductive growth of *E. hirta* plants were clearly demonstrated in this study (Fig.13A-F). *E. hirta* plants treated with organic fertilizers, specifically for poultry litter compost and vermicompost and allowed to grow under full sunlight, generally had better growth performance compared with the plants without fertilizer and urea-treated plants. In terms of vegetative growth, plants under open condition treated with poultry litter compost and vermicompost showed enhanced growth on the first week after being transplanted. There was a noticeably faster growth at the initial stage that continued until the last phase. A high number of leaf, lateral and flower production were also exhibited by the plants applied with these composts. Normal plant growth needs optimal light irradiance because excessively high and low irradiances would result in photoinhibition and light deficiency respectively resulting in severely restricted growth of the plant. Under low irradiance conditions, insufficient ATP is produced to allow for carbon fixation and carbohydrate biosynthesis, thereby, reducing and delaying plant growth (Shao *et al.*, 2014).

The promotion of *E. hirta* growth brought about by the application of compost can be attributed to their relatively high organic content. Vermicompost and poultry litter compost contained about 57x and 43x higher organic matter content, respectively, than the soil. Green manure compost contained about 83x more organic matter than the soil and the highest among the organic composts used in the study. The growth of *E. hirta*, however, was not affected by green manure compost as much as other composts. Vermicompost has nutrients such as P, K, Ca and Mg in a form that is readily available for plant uptake (Atiyeh, 2002). It contains biologically active substances that also act as growth regulators. Some study showed that vermicompost increases the water-holding capacity, nutrient supply and production of plant hormones that have beneficial effects on seed germination, plant growth, and development, especially in ornamental and medicinal plants (Sartip *et al.*, 2015). According to Atiyeh *et al.* (2000), earthworms play a major role in nitrogen transformations in manure, by enhancing nitrogen mineralization. Generally, earthworms are voracious feeders and they excrete a large part of these consumed materials in a semi-digested form. Earthworms ingest organic waste then excrete casts (excreta). As organic matter passes through the earthworm gut, it is mineralized into ammonium (later nitrified) and other plant nutrients. The grinding effect of its gizzard and the effect of its gut muscle

movement result in the formation of casts. Vermicast undergo 2 weeks of nitrification, where ammonium transforms to nitrate, a form that plants can uptake. Some findings of Arancon *et al.*, (2004) on *Fragaria ananasa* were in accordance with the results of the experiments and observations of this study. Similar results were also obtained for several other plants such as *Artemisia pallens* and *Foeniculum vulgare* (Pandey 2005; Roy and Singh, 2006; Darzi *et al.*, 2007). Many investigators obtained best results by using animal manure for several medical and aromatic plants. In *Ocimum sanctum* and *Mentha arvensis*, two of the most common medicinal plant in Bangladesh, the use of cow dung and poultry litter gave the best results in terms of growth, yield and soil quality (Rahman *et al.*, 2014). The suitability and usefulness of organic manure have been attributed to high availability of NPK content. Increasing the rates of decomposed organic material readily enhances the release of nutrient for plant uptake, while improving the physical properties of the soil as well (Detpiratmongkol *et al.*, 2014). In anise (*Illicium verum*) and coriander (*Coriandrum sativum*), the most effective organic fertilizers were vermicompost and poultry litter (Acimovic, 2013).

E. hirta plants grown in 60% shade had larger and thinner leaves as compared to the smaller and thicker ones from the sun-exposed leaves. Leaf area is an important part of the plant responsible for interception and conversion of solar energy (Mathivanan *et al.*, 2013). Total leaf area is the index of rate of photosynthesis which reflects crop production. The larger leaves produced under shade provide a larger area for trapping light energy needed for photosynthesis in a place where light levels were low. It could also be observed that plants subjected to low light intensity had long internodes to better reach light needed for their growth (Kumar *et al.* 2012). Studies involving the use of vermicompost had demonstrated the positive effects of this organic amendment on leaf area increase in some plants. Ahloowalia *et al.* (2004) reported that application of vermicompost improves leaf expansion. A high total leaf area was recorded in groundnut (*Arachis hypogaea*) crop in the application of 200 g of vermicompost (Mathivanan *et al.*, 2013). Zucco *et al.* (2015) reported greater total leaf area in tomato plants treated with vermicompost. In ngo gai (*Eryngium foetidum*), leaf area was also influenced by N (Casey *et al.*, 2004). Nitrogen plays an important role in leaf area expansion (Radin, 1983). According to Yoshida *et al.* (1969), an increased leaf area in rice resulted from the increase in N fertilization rates.

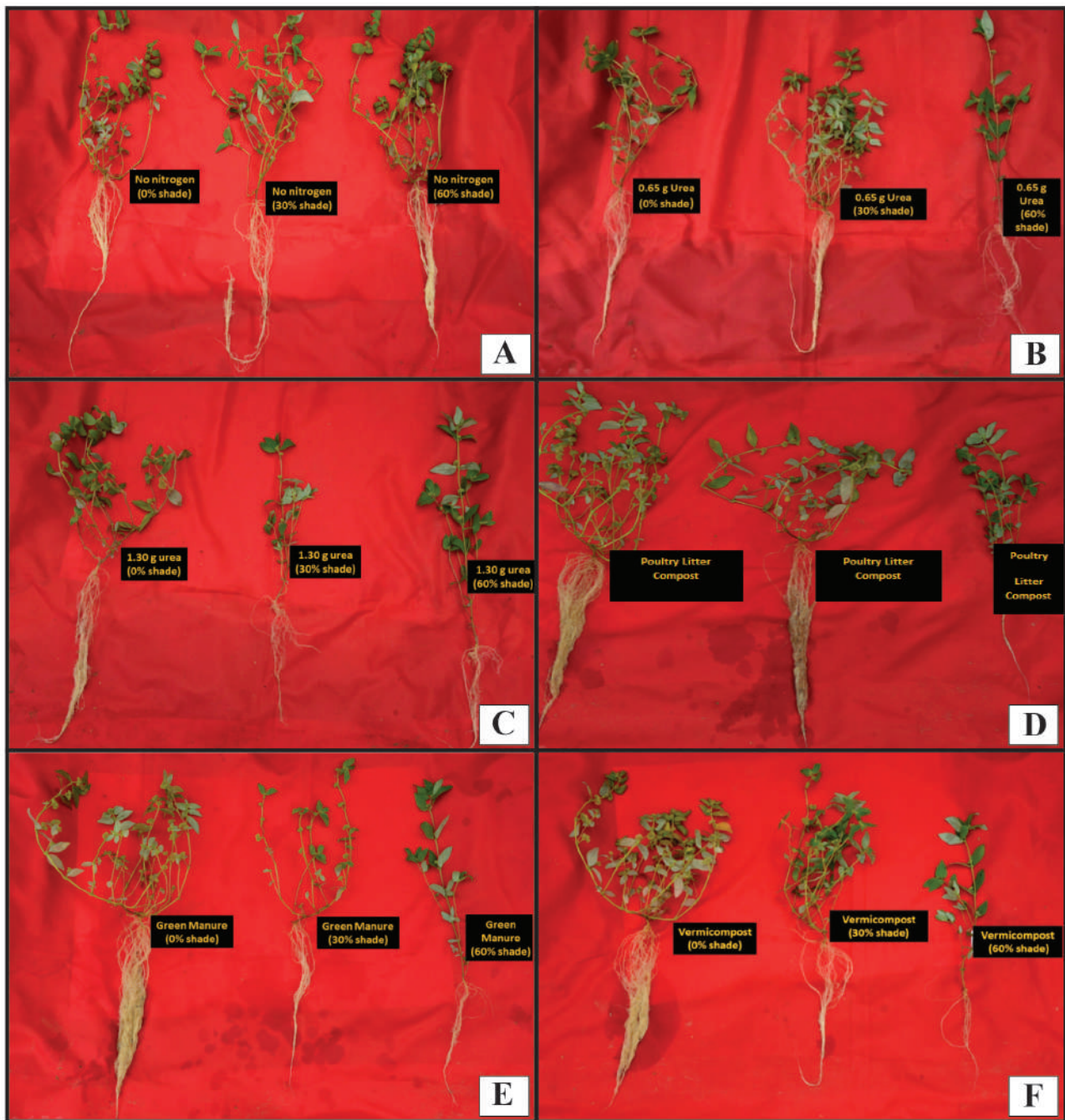


Figure 13. A-F. *Euphorbia hirta* L. plants as affected by different levels of shade and fertilizer treatments (A - No Nitrogen; B - 0.65 Urea; C - 1.30 g Urea; D - Poultry Litter Compost; E - Green Manure Compost; F - Vermicompost).

The rate at which *E. hirta* plants progressed to its reproductive stage, on the other hand, was not affected by the different fertilizer treatments but instead by the levels of shade. Plants grown under the double net shade house (60% shade) flowered 7 days later than those of the plants under the unshaded and moderately shaded treatments. This could imply that though *E. hirta* can flower under shady condition, full sunlight and/or only partial shade is more favorable

for its growth. Flower production can somewhat be suppressed at lower light levels. Casey *et al.* (2004) reported some findings by other researchers that were consistent with this result. Nevertheless even at the lowest light level, some plants continued to produce flower stalks. In the case of *E. hirta*, floral development also took place even under low light, only the process was delayed by 7 days.

SUMMARY AND CONCLUSION

Euphorbia hirta L., locally called as tawa-tawa or gatas-gatas, is one of the traditionally used medicinal plant species. With its growing popularity and importance, optimum growing conditions for its production with maximum yield and good quality must be established. It is essential to understand the factors that will contribute to its proper growth and development. Hence, this study was conducted to characterize the growth and morphological responses of *E. hirta* under different light intensities, to compare the use of organic and inorganic sources of N and their rates on the vegetative and reproductive growth under these abiotic conditions.

As a general finding, *E. hirta* plants applied with vermicompost and poultry litter compost under the open condition demonstrated a more favorable vegetative response than the rest of the treatments, as reflected in the greater number of leaves and lateral branches. The earliest number of days to flowering was first monitored from vermicompost-treated plants under the open condition and 30% shade. Plants grown under the 60% shade flowered 7 days later. Flower production was suppressed at lower light levels. The most number of flowers was also observed under these treatment conditions. The promotion of *E. hirta* growth brought about by the application of organic composts can be attributed to their relatively high organic content. In terms of productivity, high vegetative and reproductive growth from plants applied with vermicompost under the open condition correspondingly increased the resulting fresh and dry weight of the different plant parts.

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REFERENCES

- Acimovic, M.G. 2013. The influence of fertilization on yield of caraway, anise and coriander in organic agriculture. *International Journal of Agricultural Sciences* 58(2): 85–94.
- Ahloowalia, B.S., M. Maluszynski and K. Nichterlin. 2004. Global impact of mutation derived varieties. *Euphytica* 135:187–204.
- Alsafar, M.S. and Y.M. Al-Hassan. 2009. Effect of nitrogen and phosphorous fertilizers on growth and oil yield of indigenous mint (*Mentha longifolia* L.). *Biotechnology* 8(3): 384–389.
- Alavero, R. 2014. *Euphorbia hirta*. In: DAYRIT FM, MACAHIG RA (Eds). *Encyclopedia of Common Medicinal Plants of the Philippines Volume I. Philippine Institute of Traditional and Alternative Health Care. Department of Health*. p. 265–273.
- Arancon, N., C.A. Edwards, P. Bierman, C. Welch and J.D. Metzger. 2004. Influences of vermicomposts on field strawberries: Effects on growth and yields. *Bioresource Technology* 93: 145–153.
- Atiyeh, R.M., N. Arancon, C.A. Edwards and J.D. Metzger. 2002. The influence of humic acids derived from earthworm processed organic wastes on plant growth. *Bioresource Technology* 84(1): 7–14.
- Basma, A.A., Z. Zakaria, L.Y. Latha and S. Sasidharan. 2011. Antioxidant activity and phytochemical screening of the methanol extracts of *Euphorbia hirta* L. *Asian Pacific Journal of Tropical Disease* 4(5): 386–390.
- Brady, N.C. 1990. *The Nature and Properties of Soils*. 10th ed. New York. MacMillan Pub. Co. 315 p.
- Casey, C.A., F.X. Mangan, S.J. Herbert, A.V. Barker and A.K. Carter. 2004. *The effect of light intensity and nitrogen fertilization on plant growth and leaf quality of NgoGai (Eryngium foetidum L.) in Massachusetts*. Proceedings XXVI IHC – Future for Medicinal and Aromatic Plants. Eds. L.E. Craker et al. Acta Hort. 629, ISHS 2004. p. 215–216.
- Darzi, M. T., A. Ghalavand and F. Rejali. 2007. Effect of mycorrhiza, vermicompost and phosphate biofertilizer application on flowering, biological yield and root colonization in fennel (*Foeniculum vulgare* Mill.). *International Journal of Agriculture and Crop Sciences* 10(1): 88–109.
- Detpiratmongkol, S., T. Ubolkerd and S. Yoosukyinhstaporn. 2014. Effects of chicken, pig and cow manures on growth and yield of kalmegh (*Andrographis paniculata* Nees). *Journal of Agricultural Science and Technology* 10(2): 475–482.
- Huang, L., S. Chen and M. Yang. 2012. *Euphorbia hirta* (Fei yangcao): A review on its ethnopharmacology, phytochemistry and pharmacology. *Journal of Medicinal Plants Research* 6(39): 5176–5185.
- Khalil, M. Y., A.A. Moustafa and N.Y. Naguib. 2007. Growth, phenolic compounds and antioxidant activity of some medicinal plants grown under organic farming condition. *World Journal of Agricultural Research* 3(4): 451–457.
- Khare, C.P. 2007. *Indian Medicinal Plants*. Euphorbia. New Delhi, India: Springer Science + Business Media, LLC. p. 251.
- Kumar, S. and D. Kumar. 2010. Evaluation of antidiabetic activity of *Euphorbia hirta* Linn. in streptozotocin induced diabetic mice. *Indian Journal of Natural*

- Products and Resources* 1(2): 200–203.
- Mathivanan, S., R. Kalaikandhan, A. Chidambaram and P. Sundramoorthy. 2013. Effect of vermicompost on the growth and nutrient status in groundnut (*Arachis hypogaea* L.). *Asian Journal of Plant Sciences* 3(2): 15–22.
- Mozumber S.N., M. Moniruzzaman and P.C. Sarker. 2008. Effect of nitrogen rate and application interval on yield and profitability of bilatidhonia. *Journal of Agriculture and Rural Development* 6(1&2): 63–68.
- Naguib, N. 2011. Organic vs chemical fertilization of medicinal plants: A concise review of researches. *Advances in Environmental Biology* 5(2): 394–400.
- Ohlund, J. and T. Nasholm. 2001. Growth of conifer seedlings on organic and inorganic nitrogen sources. *Tree Physiology* 21:1319–1326.
- Pandey, R. 2005. Management of *Meloidogyne incognita* in *Artemisia pallens* with bio-organics. *Phytoparasitica* 33(3): 304–308.
- Patil, S.B., N.S. Naikwade and C.S. Magdum. 2009. Review on phytochemistry and pharmacological aspects of *Euphorbia hirta* Linn. *Journal of Pharmaceutical Research and Health Care* 1(1): 113–115.
- Rahman, K.M., M.A., Sattar and M.M. Rahman. 2014. Effect of fertilizer and manures on growth and yield of tulsi and pudina medicinal plant. *Journal of Environmental Science and Natural Resources* 7(2): 13–16.
- Roy, D.K. and B.P. Singh. 2006. Effect of level and time of nitrogen application with and without vermicompost on yield, yield attributes and quality of malt barley (*Hordeum vulgare*). *Indian Journal of Agronomy* 51:40–42.
- Sartip, H., H. Yadegari and B. Fakheri.. Organic agriculture and production of medicinal plants. *International Journal of Farming and Allied Sciences* 4(2): 135–143.
- Shao, Q., H. Wang, H. Guo, A. Zhou, Y. Huang, Y. Sun and L. Mingyan. 2014. *Effects of shade treatments on photosynthetic characteristics, chloroplast ultrastructure, and physiology of Anoectochilus roxburghii*. Retrieved January 19, 2017 from [www. http://journals.plos.org](http://journals.plos.org).
- Zucco, M.A., S.A. Walters, S.K. Chong, B.P. Klubek and J.G. Masabni. 2015. Effect of soil type and vermicompost applications on tomato growth. *International Journal of Recycling of Organic Waste in Agriculture* 4(2): 135–141.

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