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11. INITIAL GAS EXCHANGE RESULTS FROM FIELD TRIALS

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Gas exchange measurements were undertaken at field trials to investigate the impact of thinning of 12 year old gmelina plantations located at Bato. A_{max} for leaves at the thinned site were significantly higher ($p<0.05$) than for leaves at the unthinned site. In addition, trees at the thinned site had an average dbh increment over the past 15 months of 5.6 cm compared with an average 3.5 cm dbh increment for trees at the unthinned site. It appears that the photosynthetic capacity of leaves of the trees at the thinned site has increased in response to an increase in resources made available to individual trees by the removal (thinning) of competing trees. Measurement of A_{max} at for four species in a mixed species trial revealed the following pattern: falcata>narra>mahogany>mayapis. This pattern is also reflected in the average height of each species but not in the pattern for average biomass (number of leaves) and dbh which followed the pattern of falcata>mahogany>narra>mayapis. The reversal of mahogany and narra suggests a different pattern of resource allocation. Narra has high rates of A_{max} with a smaller number of leaves compared with mahogany which has a lower rate of Amax but a much greater number of leaves and total leaf biomass. There was a substantial difference between the light curves for 11 month old gmelina trees in the three experiment plots with a 3 m x 3 m spacing compared with gmelina trees in the one experimental plot with a 4 m x 4 m spacing (Figure 6). The preliminary interpretation of these results is that at even a very early age, resources are becoming limiting for photosynthesis at a 3 m x 3 m spacing. This unexpected finding will be investigated further with a variable spacing trial.

INTRODUCTION

Field trials are long term experiments, which typically take many years to produce publishable scientific results. In the case of the trials established under ASEM/2003/052, publishable results have already been achieved for the variable spacing trial in Leyte Leyte, the gmelina trial at Mahaplag and the thinning experiments at Bato and Maasin. These early results are largely due to the well thought out experimental designs which were designed to produce results from an early age, and further enhanced by the high growth rates of the species planted. The field trials will be maintained as part of ACIAR project ASEM/2006/092 and regular data collection undertaken and further results will be presented as part of the end of project report of that project.

Photosynthesis is a physiological process involving the fixation of CO2 from the atmosphere and its conversion into organic matter and at the same time capturing energy from the sun. It is the key process that drives plant growth. Photosynthesis can be measured in a number of ways, one of the most common is to use a portable infrared gas analyser (IRGA) to measure changes in CO2 concentration as leaves photosynthesize. This paper briefly presents some of the early results from photosynthesis measurements made at the various field trials sites established as part of ASEM/2003/052.

METHODS

Study Sites and Experimental Design

Gas exchange measurements were undertaken at each of field trials established as part of ACIAR project ASEM/2003/052. These field trials comprise of thinning trials for gmelina and mahogany located at Bato and Maasin; mixed species, variable spacing and shade/fertiliser trials in Leyte Leyte; and a gmelina germplasm and early age silviculture trial at Mahaplag.

Trees in the Leyte Leyte and Mahaplag sites were generally between 0.3 m and 3 m and as such there was easy access to leaves. At the Bato and Maasin sites, the trees were mature and ranged in height from 20 m to 31 m. In order to gain access to canopy leaves at these sites, four bamboo towers (Figure 1) were constructed (see Herbohn *et al.* in preparation for further details).

Figure 1. Canopy tower in thinned gmelina plot at Bato (top left), Canopy tower in unthinned gmelina plot at Bato (top right) and team members undertaking gas exchange measurements (bottom) on platform at unthinned site at Bato

Gas Exchange Measurements

Light response curves were determined for trees occurring at each site. In the case of 12 year old gmelina at Bato, response curves were determined on consecutive days for 5 trees at the unthinned and thinned sites. Environmental conditions were similar on both days. Leaf gas exchange was measured using a LI-6400XT (LI-COR, Lincoln, Nebraska) portable gas exchange system with a 6400-02B LED leaf chamber. Light response curves were constructed using the automatic light curve function available with the LI-6400XT version 6 software. Photosynthetic Photon Flux Density was initially set at 2000 µmol m^{-2} s^{-1} and then stepped down in nine increments to 0 µmol m^{-2} s^{-1}. A flow rate of 500 µmol and the reference CO_2 concentration was set at 400 µmol CO_2 mol-1 air. Leaf chamber humidity was maintained at 60 to 80 % and leaf temperature at 29–31 ^{o}C. All measurements were made between 9 am and 3 pm and were suspended if leaves exhibited signs of wilting or if conditions became excessively hot (i.e. above 33 ^{o}C) or wet. Light saturated photosynthesis (A_{max}) was measured at 2000 µmol m^{-2} s^{-1} for additional individual trees at each site. Unless otherwise stated, measurements were made on fully expanded sun leaves.

For the gmelina trial at Mahaplag, average light response curves for each of the experimental plots were obtained by measuring three leaves on each of five randomly selected trees. One leaf measurement was discarded from two sites due to apparent inconsistencies in the data once plotted. For 5 randomly selected trees in each plot, the tree was divided into vertical quadrants (Figure 2) and Amax was measured for three leaves in each quadrant. The first leaf was at random in the quadrant, the next two leaves sampled in the quadrant were then selected by moving 120^{o} in both a clockwise and anti-clockwise direction.

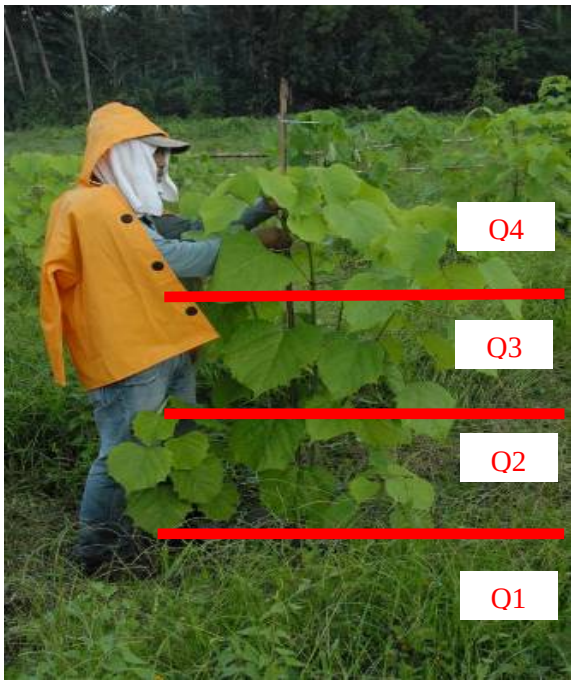


Figure 2. Identifying and measuring quadrants on 8 month old gmelina trees at Mahaplag

RESULTS AND DISCUSSION

Light response curves for 12 year old gmelina at the thinned and unthinned sites at Bato are presented in Figure 3. The light response curves at the thinned site are generally higher than those for trees at the unthinned site, with only a slight overlap. T-tests revealed that A_{max} for leaves at the thinned site were significantly higher ($p<0.05$) than for leaves at the unthinned

site. In addition, trees at the thinned site had an average DBH increment over the past 15 months of 5.6 cm compared with an average 3.5 cm DBH increment for trees at the unthinned site. It appears that the photosynthetic capacity of leaves of the trees at the thinned site has increased in response to an increase in resources made available to individual trees by the removal (thinning) of competing trees. This response is probably due to the increased availability of a limiting resource such as light, water, a macronutrient such as N or P or a combination of these. It is also interesting to note that this impact starts to become statistically significant at quite low levels of PPFD.

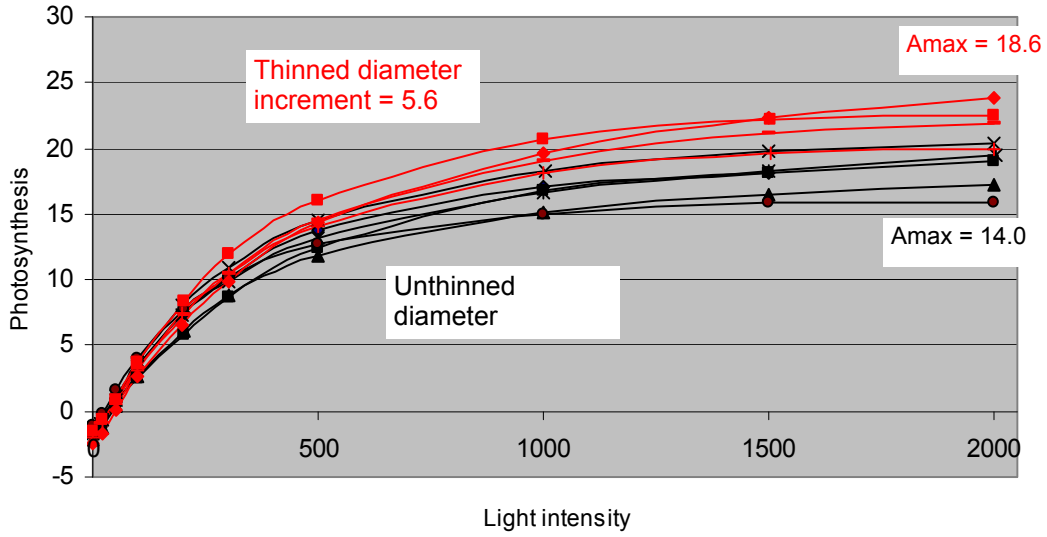


Figure 3. Light response curves for Gmelina trees at thinned and unthinned plots at Bato

The average light response curves for the four species used in the mixed species trial in Leyte Leyte are given in Figure 4. A_{max} follows the pattern of falcata>narra>mahogany>mayapis. This pattern is also reflected in the average height of each species but not in the pattern for average biomass (number of leaves) and dbh which followed the pattern of falcata>mahogany>narra>mayapis. The reversal of mahogany and narra suggests a different pattern of resource allocation. Narra has high rates of A_{max} with a smaller number of leaves compared with mahogany which has a lower rate of Amax but a much greater number of leaves and total leaf biomass. There is a far greater variability in both the shape of the individual light response curves and A_{max} for mayapis compared with the faster growing falacta, mahogany and narra (Figure 5).

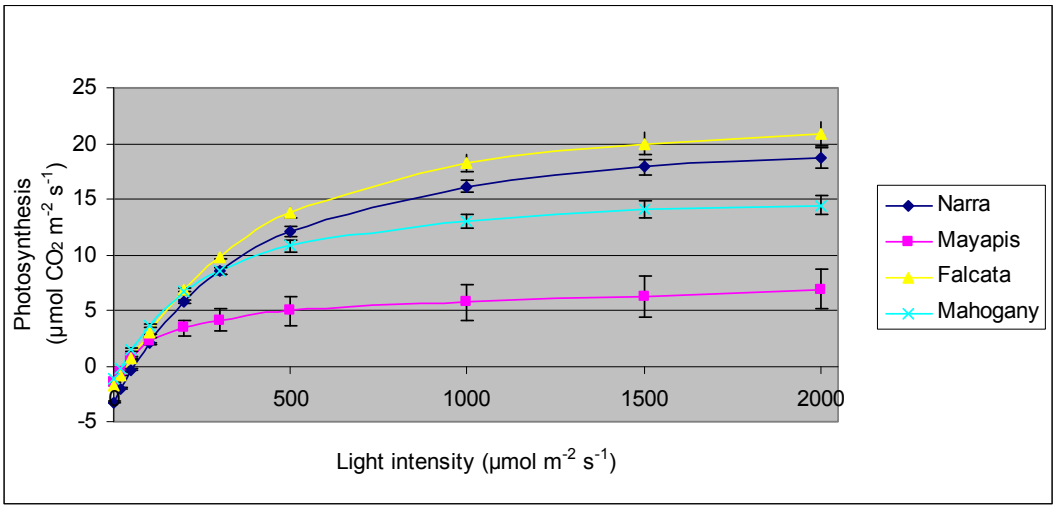


Figure 4. Average light curves for species used in mixed species trial

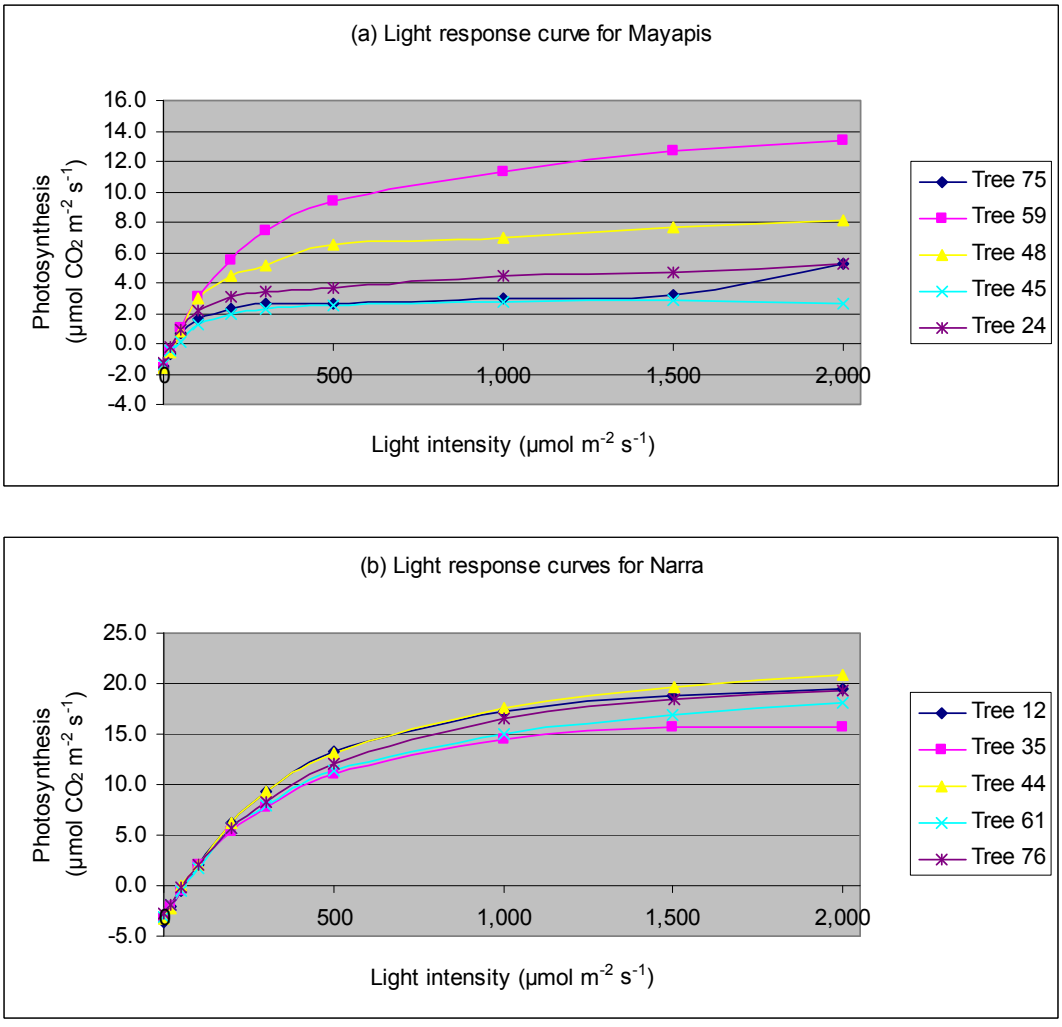
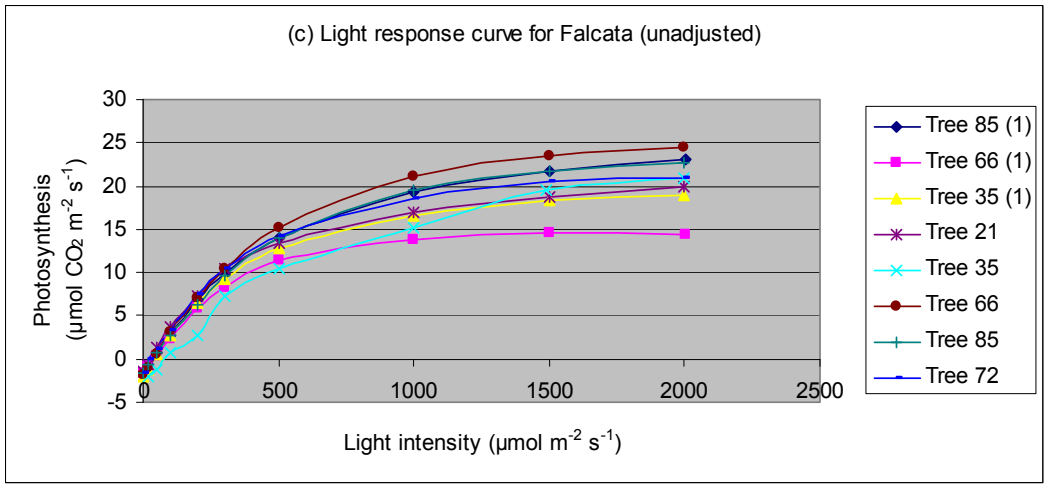


Figure 5. Individual light response curves for individual trees for each species used in the mixed species trial in Leyte Leyte



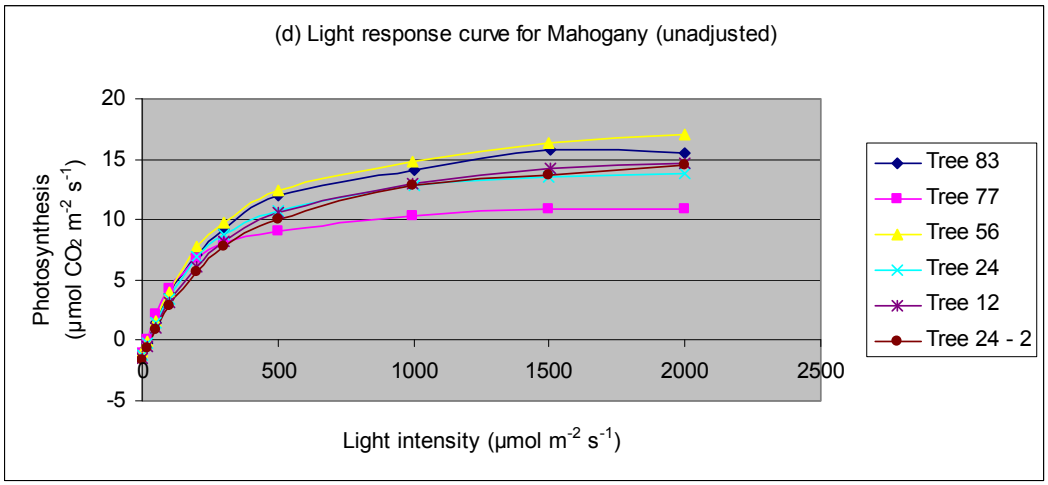


Figure 5 (Cont.). Individual light response curves for individual trees for each species used in the mixed species trial in Leyte Leyte

There was a substantial difference between the light curves for 11 month old gmelina trees in the three experiment plots with a 3 m x 3 m spacing compared with gmelina trees in the one experimental plot with a 4 m x 4 m spacing (Figure 6). The differences were statistically significant, as evidenced by the non-overlap of standard error bars. The preliminary interpretation of these results is that at even a very early age, resources are becoming limiting for photosynthesis at a 3 m x 3 m spacing. This unexpected finding will be investigated further with a variable spacing trial.

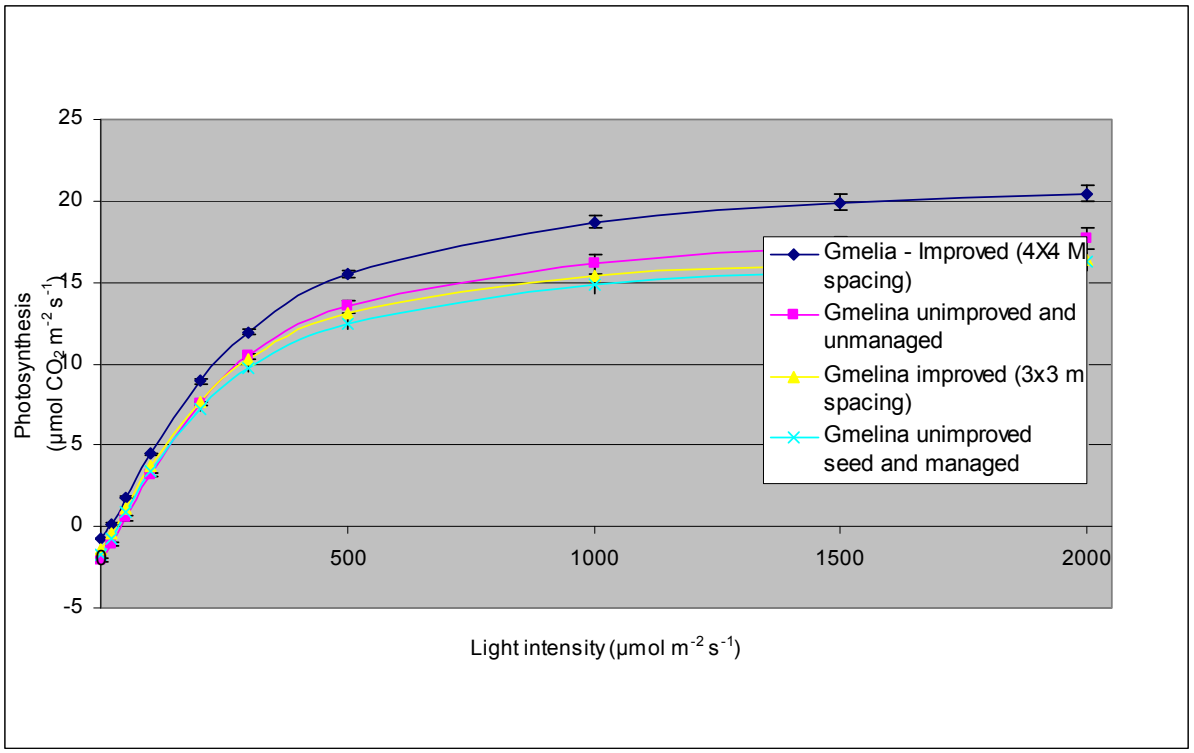


Figure 6. Light response curves for 11 month old gmelina treatments at Mahaplag

For each of the four experimental plots at Mahaplag there was a trend of increasing Amax from the lower Quadrant 1 to the upper Quadrant 4 (Figure 7). This is consistent with the greater proportion of older (and hence less photosynthetically active) leaves being located in the lower two quadrants and the upper quadrants containing a higher proportion of younger and highly photosynthetically active leaves. It is also interesting to note that there is much greater variability in Amax across the quadrants in sites from sites two and four with unselected germplasm.

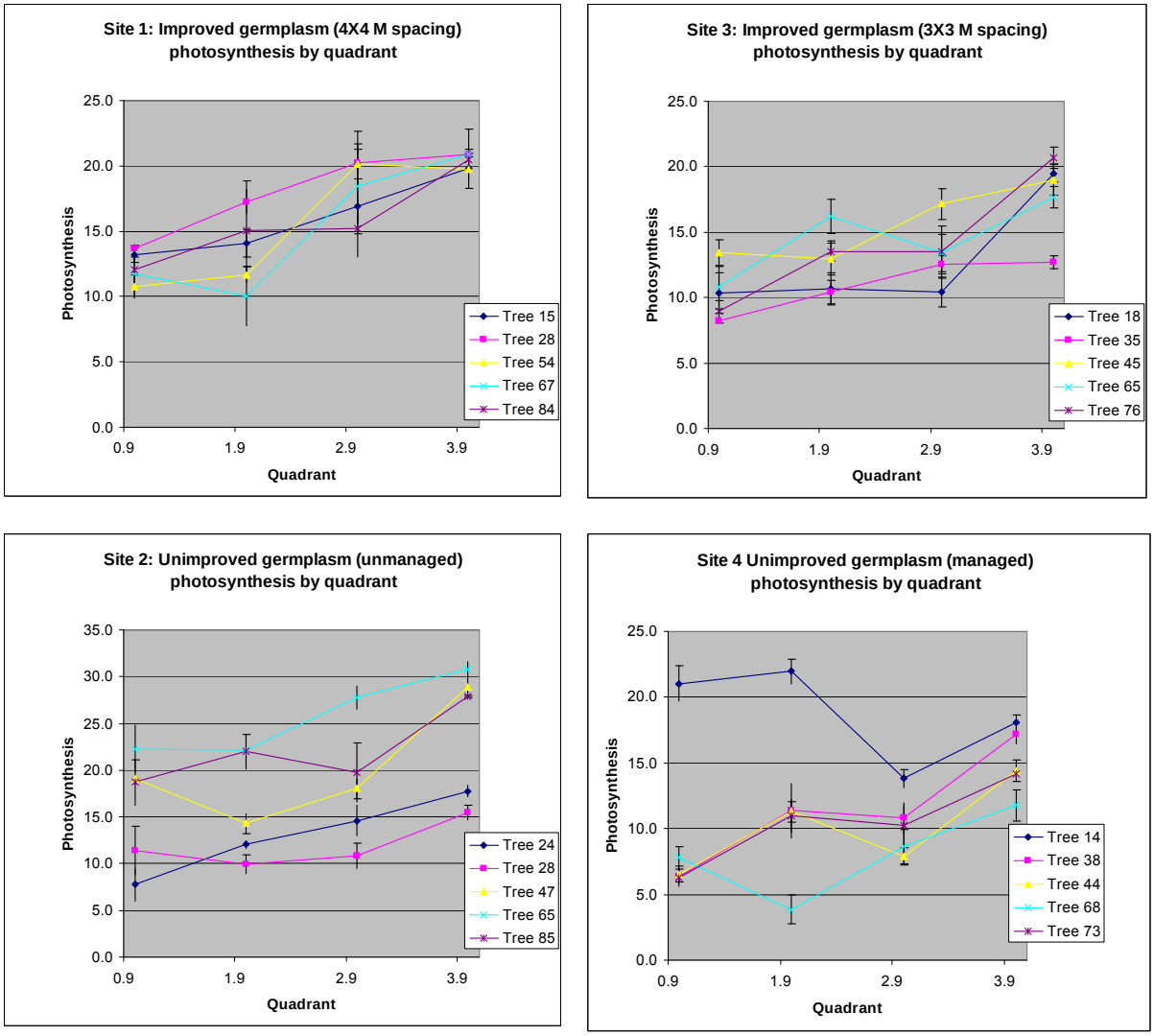


Figure 7. Amax by quadrant for 8 month old gmelina trees at Mahaplag

REFERENCE

Herbohn JL, Mangaoang E, Gregorio N and Vanclay J (in preparation). Using bamboo scaffolding to access forest canopies: some lessons from their use in the Philippines