Shade Effects with Potential NPK Responses on Coconut Seedlings in Tropical Agroforestry Practices

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***Abstract*—** The experiment was carried out in an experimental plot of 32 years old coconut palm of the local Malayan Tall cultivar which later on represents the different rate of light intensities canopy at MARDI Bagan Datuk, Perak. Therefore, the main objective of this study was to evaluate the responses of new coconut seedlings planted under different shade intensities and different rates of NPK application. 9 months old Malayan Brown Dwarf (MBD) seedlings were selected and planted in between the old palms (which act as a shade canopy) in the same row by using the north-south direction of planting rows. The treatments were including 4 levels of shade which represented by different old palm canopy of light intensities at 100, 75, 50, and 25 percent (%) and with 4 different rates of NPK at 1.5, 3.0, and 4.5 kg/palm including control at 0 kg/palm. Data collection parameters were collected including light intensity, chlorophyll content, plants height, and stem girth, number of fronds, and width of leaves. All data were subjected to variance analysis (ANOVA) and means values were compared with Duncan Multiple Range Test using SAS statistical analysis. The results obtained from all the parameters indicated that a significant relation between NPK rates and shade intensities levels. It found that 25% of old palm shading canopies showed significantly the highest light intensity at 458 μmol $m^{-2}s^{-1}$ compared to others while 100% of shade level gave the best chlorophyll reading. The integrated nutrient management of supplying 4.5 kg/palm (F4) recommended along with the C4 shade level showing the significant difference at ($p<0.05$) of plant height and the number of fronds. The growth parameters of the stem girth and width of leaves show significantly highest in number at F2 of NPK supplying with C4 of shade level compared to other treatments. The growth performance of coconuts seedlings at different NPK rates and different shade levels also showed significantly different from each other which it can be concluded that the increase of shade level needs for the higher amount of NPK for best growth performance of seedlings.

***Keywords*—** Coconut seedlings, NPK responses, Shade palm canopy, Plant growth.

I. INTRODUCTION

In Malaysia, the population of coconut palms is senile and urgently needs for replanting program. However, not many of us know how to replanting while maintaining the production from the old palm tree. The palm shows an indeterminate growth pattern, producing one compound leaf and an inflorescence at each leaf axils at intervals varying from 25 to 30 days over six to seven decades, depending on the environmental conditions and age of the palm (Liyanage, 1950). Quantification of the canopy photosynthetic rate of coconut palms was an important indicator to estimating the carbon balance of coconut ecosystems, yield fluctuations models, and understanding the impact of climate on performance (Pathemeswaran et al. 2018). Radiation distribution within the coconut canopy plays a significant role in determining the whole plant photosynthesis because much of the photosynthesis in a coconut canopy takes place under reduced irradiance conditions due to mutual shading (Herrick and Thomas, 1999). Three major acclimation responses to shade have been observed: a) a reduction in the respiration rate, b) an increase in the shoot to root partitioning, and c) an increase in the specific width of the leaf with a relatively low leaf mass ratio (Humphreys 1994; Lambers *et al.* 1998). At the ecosystem level, reduced of irradiance has a considerable impact on plant productivity. In the coconut canopy, estimated about 60% of the intercepted radiation is absorbed by the upper leaf stratum and the rest is distributed in the middle and lower leaf strata (Ranasinghe et al. 2018) (Liyanage et al., 1988). However, information on the variation of the irradiance response in the different canopy of strata and among different varieties of coconuts is not available.

The basis for fertilizing a crop is by understanding the amount of material that would be required to make up the difference between the nutrients needed by the crop and those supplied by the soil (Kaiser et al. 2011). This can be implied that crop performance will be improved, if we are in a position to estimate *firstly* the amount of a particular nutrient required by the plant for unrestricted growth, and *secondly* the amount that is actually supplied by the soil medium. In spite of the apparent simplicity of the basic principles of fertilization, the real problem faced by the crop nutritionist is the actual exact quantities of the nutrients that have to be added in order to ensure optimum growth of the crop. This problem however is complicated, owing to the fact that the grower is dealing with a dynamic system, the outcome of which, in terms of crop production, is dependent upon a constellation of factors associated with the soil, the plant, and the climatic environment, which would require manipulation in such a manner as not to restrict plant growth. The main objective of this study was to evaluate the responses of coconut seedlings to NPK rates under different light intensities.

II. METHODOLOGY

A. Experiment sites

The experiment was carried out for one year in a plot of 32 years old coconut palm of the local Tall cultivar at MARDI Bagan Datuk. The site was located at 3°53'36.0" N latitude and 100°51'24.0" E longitude. The daily temperature during the experiment was in the range of 24–36°C. The research station received an annual average rainfall of 600 mm on 30 rainy days distributed from September to November. The soil was riverine alluvial with low medium pH and low availability of N, P, and K.

B. Planting materials

Planting materials of 9-month-old Malayan Brown Dwarf (MBD) were used with a minimum of 5 leaves for each plant. The seedling was planted between old palms in the same row by using the north-south direction of planting rows.

C. Treatments

The experimental design was a Complete Randomize Design with the factorial arrangement and two replications as detailed as below:

Shade level strata:

C1- 100 % of old palm standing canopy

C2- 75 % of old palm standing canopy

C3- 50 % of old palm standing canopy

C4- 25 % of old palm standing canopy

NPK Rate kg/palm:

F1- Control (No manure or fertilizer)

F2- 1.5 kg/palm/year of NPK dose application

F3- 3.0 kg/palm/year of NPK dose application

F4- 4.5 kg/palm/year of NPK dose application

Fertilizer was applied in the form of NPK Green 15:15:15 compound as per treatment. The percentages of shade level are calculated by the number of permanent old palms after the rest of the old palms have been cut.

D. Data collections

The rate of light intensity was collected monthly from averages of three different points for each plant using light intensity meter. The chlorophyll content of plant leaves was collected every three-month using a Spad meter. The readings were taken differently from the avengers of three leaves at the same.

The width of leaves was taken from averages of three different leaves at the same plant using Leaf Area Meter. Data of growth performance are depending on parameters such as plant height, stem girth (2 cm from the base), and the number of fronds is collected every three months.

E. Data analysis

Means of the measured variables were compared by using the appropriate ANOVA procedure (SAS Institute 1989) and the Duncan test ($P<0.05$). All parameters were taken during the 12 months of the initial study period. Plant variables were normalized accordingly by using the appropriate numeric transformation.

III. RESULTS AND DISCUSSIONS

A. Photosynthesis and chlorophyll measurement at different shade level

Table 1 shows the averages light density level and chlorophyll content at different old palm canopies. The nature of the root system, the shape of the canopy, and the shade from the layout of the old palm frond make the coconut suitable for underplanting with the new seedling. The results show significant differences ($p<0.05$) in light intensity levels at different old palm-standing canopies.

We found that 25% of old palm standing canopy showed significantly the highest light intensity at 458 µmol $m^{-2}s^{-1}$ compared to others on a typical day during the experiment occurred at around 12.00–14.00 noon, and decreased from 458 µmol m^{-2} s^{-1} to 426, 378 and 266 µmol m^{-2} s^{-1} for C3, C2, and C1. Until midday, the chlorophyll content was significantly different at $p<0.05$ which was slightly highest in the full canopy treatment C1.

The chlorophyll content was declined as the reduction of the canopy from old palm standing from 292.4 at C1 to 264.8 at C4.

Light intensities will assist in the process of photosynthesis for the growth of coconut planted under the canopy. The penetration of light through coconut fronds depends on the size, age, density, and layout of the tree.

Table 1: light intensity level and chlorophyll content at different shade level percentages.

Treatment	Light intensity (µmol m^{-2} s^{-1})	Chlorophyll (Spad reading)
C1	266 c	292.4 a
C2	378 b	280.2 a
C3	426 a	274.1 b
C4	458 a	264.8 c

Mean value with the same letter for each treatment are not significantly different at $P < 0.05$

B. Growth character of coconut at different NPK rates and shade level

Figure 1 shows the growth response of coconut seedlings affected by NPK rates and different shade levels on plant height (m). The integrated nutrient management of supplying 4.5 kg/palm (F4) recommended along with the C4 shade level showing the significant difference at (p<0.05) of plant height with 2.2 meters compared to other treatments.

On the other hand, integrated NPK in F1 and shade level of C1 in figure 1 shows the lowest parameter performance of plant height with 1.33 meters respectively.

Light availability is a major ecological factor influencing plant growth and survival. Plants can respond with genetic adaptation and phenotypic acclimation to low levels of irradiance (Lambers *et al*. 1998). Shade tolerance of species adapted to open habitats will depend on the capacity of the plants to adjust morphologically and physiologically to a given level of irradiance

Table 2 shows the effect of NPK rates on variables parameter response of stem girth (cm) at different shade levels. It shows that the growth parameters of the stem girth show significantly highest in number at F2 of NPK supplying with C4 of shade level compared to other treatments with 14.50 cm2. Otherwise, the growth parameters of the stem girth show significantly lowest in number at F1 of NPK supplying compared at C1 of shade level with 7.00 cm2. The result also shows that the increasing shade level needs a higher amount of NPK to increase the growth performance of seedlings. It was happened due to the light and nutrient uptake competition between old palm and new seedlings planted.

Table 2: Effect of NPK rates on stem girth (cm) at different shade level.

Treatment/NPK rates	C1	C2	C3	C4
F1	7.00 c	7.15 c	8.00 c	9.50 b
F2	9.00 b	11.00 a	9.50 b	14.50 a
F3	10.70 b	6.55 c	10.65 b	10.90 b
F4	12.25 a	6.50 c	12.65 a	12.80 a

Mean value with the same letter for each treatment are not significantly different at $P < 0.05$

There was an appreciable variation in the total shade level and the different rates of NPK (Figure 2) for the parameter of number of fronds.

The supplying of the nutrient balance of NPK in F4 and shade level of C4 showing the significantly difference (p<0.05) with the biggest number rather than other treatment with 12 fronds.

On contrastive, the nutrient supply of NPK in F1 incorporated with shade level of C1 showing the significantly difference (p<0.05) with the smallest number with 6 fronds.

A critical factor for better performance is the increased soil nutrient availability beneath the tree canopy (Wilson *et al*. 1990; Belsky 1992; Wilson1996; Scholes and Archer 1997). The canopy of a healthy coconut palm consists of about 30–35 green leaves of different maturity stages and averages with 12–14 fruit bunches with varying numbers of fruits at different developing stages.

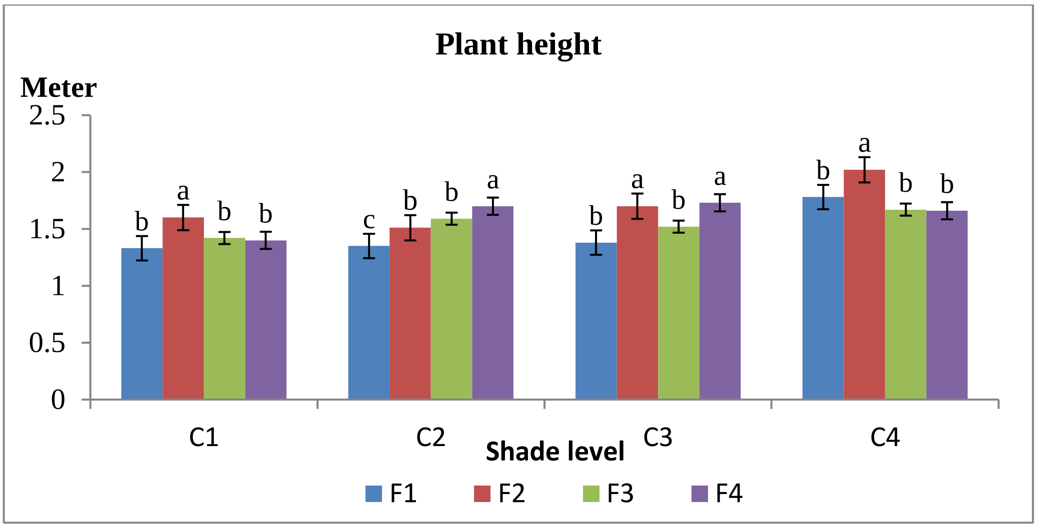

Figure 1: Effect of NPK rates and different shade level on plant height (m). Bars with the same letter for each treatment are not significantly different at P < 0.05.

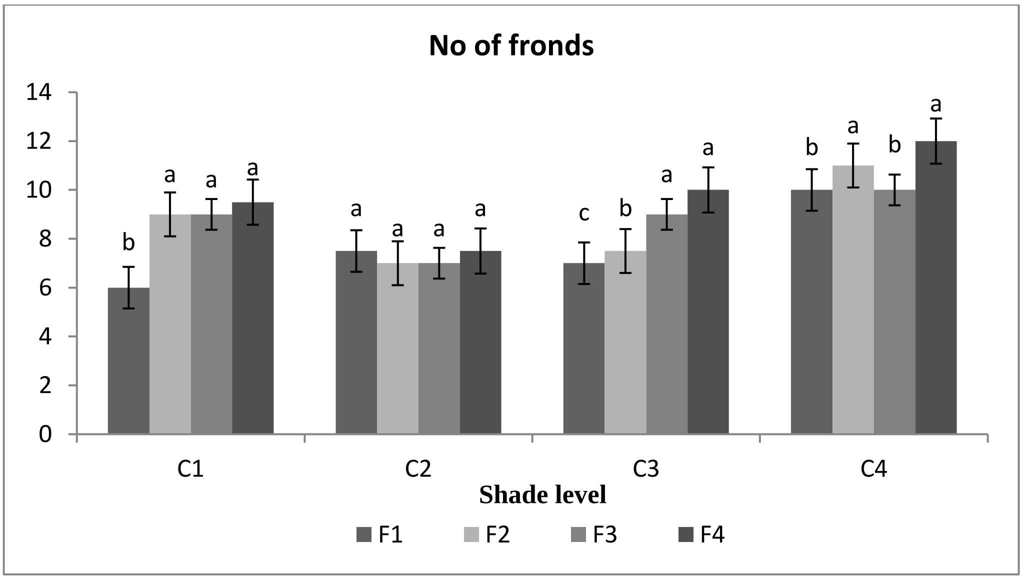

Figure 2: Effect of NPK rates and shade level on number of fronds. Mean value with the same letter for each treatment are not significantly different at P < 0.05

Table 3 shows the effect of NPK rates on the width of the leaf (cm2) at different shade levels. NPK supplying of F2 in collaboration with shade level of C4 shows the highest number for parameters of the width of leaves are 156.00 cm2 while NPK rate at F1 and shade level at C1 shows the lowest with 95.50 cm2 respectively. All the results show that the increasing NPK rate will assist in the increasing number of fronds (Khairol. *et al*, 2019). However, if the nutrient recycling rate from the soil by the extractor is known, that is, the relation between the recycled nutrient quantity by the extractor and the nutrient quantity applied to the soil, it is possible to estimate the available quantity of nutrients to be applied for plants, according to the soil volume and the roots explore.

Table 3: Effect of NPK rates on width of leaf (cm^2) at different different shade level.

Treatment/	Shade level			
NPK rates	**C1**	C2	C3	C4
F1	95.50 c	102.50 b	119.50 b	152.00 a
F2	139.00 a	114.50 b	130.00 a	156.00 a
F3	115.50 b	114.00 b	116.00 b	129.00 b
F4	155.00 a	121.50 a	126.00 a	149.00 a

Mean value with the same letter for each treatment are not significantly different at $P < 0.05$

IV. CONCLUSION

The results obtained from all the parameters indicated that a significant relation between NPK rates and shade intensities levels. It found that 25% of old palm shading canopies showed significantly the highest light intensity at 458 μmol m−2s−1 compared to others while 100% of shade level gave the best chlorophyll reading. The integrated nutrient management of supplying 4.5 kg/palm (F4) recommended along with the C4 shade level showing the significant difference at ($p<0.05$) of plant height and the number of fronds. The growth parameters of the stem girth and width of leaves show significantly highest in number at F2 of NPK supplying with C4 of shade level compared to other treatments. The growth performance of coconuts seedlings at different NPK rates and different shade levels also showed significantly different from each other which it can be concluded that the increase of shade level needs for the higher amount of NPK for best growth performance of seedlings. Otherwise, the reduction number of shade levels will assist in the reducing amount of NPK because of less competition for the light and nutrient uptake between old palm and new seedlings planted. Further field evaluations are needed to determine the relationship of the level of light intensity with the total amount of NPK supply in inducing the yield of coconut seedlings under the underplanting program.

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