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Effect of Intercropping and Fertilizer on Growth Performance of Bamboo (*Gigantochloa brang*)

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Abstract
Agroforestry is one of the agricultural approaches that integrates the woody perennial and agricultural crop. Bamboo is one of the suitable perennial species for agroforestry practices because of its various uses and fast-growing botanical species. This study was conducted to define the best crop for integrating with *Gigantochloa brang* bamboo species and to determine the best fertilizer regime which produce highest growth performance for *Gigantochloa brang*. Three different plots were established that are; a) *G. brang* integrated with *Musa paradisiaca* L., b) *G. brang* integrated with *Orthosiphon stamineus* B., and c) consisting of only *G. brang* (control). The *G. brang* were planted with 4 m x 4 m planting distance while the *M. paradisiaca* and *O. stamineus* were planted in between of *G. brang* rows. Two types of fertilizer (chicken dung and nitrophoska) with four different rates were applied at *G. brang* clump for the analysis of fertilizer regime. Results indicate that *G. brang* integrated with *O. stamineus* gave the highest growth for number of culms, DBH, and height of shoot compared with another plot including the control plot. For the fertilizer's application, there were significantly different on all parameter, but further analysis of different fertilizer rates indicates that only two parameters (number of culm and DBH) were found significantly different ($p<0.01$) In conclusion, *O. stamineus* is the most suitable crop to integrate with *G. brang* and the application of 0.5 kg nitrophoska was the best rate of fertilizer applied to produce the highest growth for *G. brang* bamboo species.

Keywords: Agroforestry, fertilizer rate, *Gigantochloa brang*, *Musa paradisiaca*, *Orthosiphon stamineus*.

INTRODUCTION

According to [1] agroforestry is a method of land use involving a combination of woody and non woody plants in crop or animal farms and these interactions provide benefits in terms of economy and ecological aspect. Basically, the success of agroforestry is extremely depending on the selection of agricultural component and application of inputs. In Malaysia, among agroforestry systems that have been developed are direct inter row integration, block planting, perimeter or border planting, and hedge planting system [2]. Essentially, inter row system involves intercropping of agricultural crops, mainly annual, in the available spaces of the tree plantation. The objectives are to maximize land use and to subsidize income during the non-productive phase of main perennial plant. Among the good examples of this system are rubber with short term crops in Malaysia and Thailand, Albizia with food crops in Philippines and cocoa with maize, yam, and cassava in West Africa [3]. Intercropping affects vegetative growth of element crops depends on adaptation of planting design and choice of well-matched crops. The selection of compatible crops for an intercropping system depends on growth pattern, terrestrial, light, and water and fertilizer application [4].

In current years, integrated farming has been promoted actively among Malaysian farmers. In corporate short-term crops such as pineapple, chili, maize, livestock rearing especially sheep and poultry, apiculture and mushroom cultivation with perennial crops and forest trees. Normally, this system applied at the most three years before the canopy closes in. For agroforestry system to be sustainable, correct designs and technique of planting crops, short-term crop and forest trees and choice of forest was established [3].

There are a lot of agroforestry benefits such as maximize land use and increase productivity, and thereby enhance the production of timber, non-timber product and food. The cultivation of herbal and medicinal plants in the agroforestry system in both forest plantation and agricultural land was increased national production and thereby ensure sustainability in supply [5]. [6] proposed intercropping as a significant approach to applied N efficiently and to reduce the risks of leaching. Commonly, an advantage of intercropping is the greater production of a given piece of land by creating efficient usage of the growth resources using a combination of different rooting ability of plant, canopy structure, height, and nutrient requirements of crops [7].

Demand on bamboo shoot for international market increases much more than their availability. Meanwhile the demand for local market was still billed from China, Taiwan and Thailand. Bamboo shoot industrial prospect can be developed if systematic management and planting in an agroforestry system are implemented [8]. In Malaysia, there is insufficient systematic management for bamboo plantation; not even for shoot production. Bamboo clump with shoots usually grow in the wild and will be sparsely distributed in which it can be economically exploited. The morphological characteristics and hence the growth performance of bamboo also known to be affected by different intrinsic site condition such as temperature, radiant, plant-animal and plant-plant interaction, and also influence by different silvicultural practices [9, 10].

Herbal medicines have received great attention as alternative medicines in recent years and are produced as dietary supplements. Malaysian government through the National Key Economic Areas (NKEA) 2010 initiative aims to develop high value herbal products to enhance the country's export capability and *Orthosiphon stamineus* or locally known as 'misai kucing' is considered as one focused herb. This species was expected to be grown successfully in the agroforestry system, as it was easy to plant and grow.

Musa paradisiaca L. (banana) is one of the most important fruit crops grown in Malaysia, both for the local and export markets. The production covers a wide spectrum of systems ranging from small plot subsistence farming and local market supply to plantations producing quality fruits for export. Banana cultivation supports the current National Agricultural Policy 3 (NAP3) 1998-2010 which stresses on maximizing land use, increasing private sector involvement, increasing farmer's income and export earnings (MOA, 1998). The systems that were adopted by the farmers for banana cultivation such as mix cropping (different fruit types) and mix farming (crop animal farming) contribute to maximum land use (Siti Hawa, 1999).

Thus, the objective of this study was to determine the best species between *O. stamineus* and *M. paradisiaca* that suitable for integrating with *G. brang* in term of growth performance and to determine the best fertilizer between chicken dung and NPK with different rates produce highest growth performance for *G. brang* in Negeri Sembilan, Peninsular Malaysia.

MATERIALS AND METHODS

Planting material

This research was conducted at agricultural land in Kampung Pantai, Negeri Sembilan, Malaysia. Planting materials of *G. brang* were prepared using branch cutting from healthy culm. Propagation using branch cutting was used as it is effective and practical compare to other method such as rhizome offset. The planting materials were transferred to the field four month after planting in nursery. *O. stamineus* planting materials were taken from a good mother tree which was healthy, free from any diseases and vigour. The cutting parts (shoot) were sowed in sowing pod and after one month in the nursery, the seedlings were planted to the field. Cutting at the shoot part gave better growth performance as it helps the root system and enhance the plant growth stability and comfortably (Norhidayah et al., 2018). *M. paradisiaca* planting materials were obtained from tissue culture method. Planting materials of three months old with average height of 60 cm were selected for planting in the field. The average numbers of *M. paradisiaca* leaves were found to be three to four before planting at the field.

Research design

In this study, the experimental design used was factorial design. There were eight replicates with three factors and 24 treatments involved in this research. Three plots were assigned for planting, two types of fertilizers and four rates for each type of fertilizer were applied in this study.

Development of plot

The planting area was divided into three plots. The first plot was *G. brang* bamboo species integrated with *M. paradisiaca*, second plot was *G. brang* integrated with *O. stamineus* while third plot was planted only with *G. brang* meant as a control plot. *G. brang* was planted with 4 m x 4 m planting distance at each plot. In Plot 1, the *M. paradisiaca* was planted within the row of *G. brang*. In Plot 2, the *O. stamineus* was planted within *G. brang* row with 1 m x 1 m planting distance. *M. paradisiaca* and *O. stamineus* was planted in that arrangement to avoid their crowns overlap with each other in competition for the sunlight. For Plot 3 or control plot, the *G. brang* alone was planted. There were eight replicates consist in each plot with a total of 192 number of *G. brang* bamboo clumps were used in this study.

Application of fertilizer

Chicken dung and nitrophoska (NPK) fertilizers were used in this study. Four rates of each fertilizer that are 0.0 kg, 0.5 kg, 1.0 kg and 1.5 kg has been applied every six months starting after three months after planting. The fertilizer was applied using the broadcast technique around the *G. brang* clumps.

Data collection and analysis

The first data of bamboo were collected two weeks after the third fertilizer application and continued for every month until six months period. The parameters measured were DBH and number of culms, number of shoots and height of shoots. All the data collected from the research were analyzed using SPSS statistical package. ANOVA was used for the comparison of the means square. The significant differences were further tested for best treatment by using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Analysis of bamboo growth based on plot

When analysed using ANOVA, the significant difference was present on the mean number of *G. brang* culms, DBH of culms, and height of shoots in different plots. Further analysis was carried out using Duncan analysis and the result shown in Table 1.

Table 1. Growth Performance of *G. brang* based on Different Plots

Parameter	Plot	Mean	p-value
Mean Number of culms	*G. brang* x *M. paradisiaca*	6.7±0.299ab	0.000**
	G. brang x *O. stamineus*	6.9±0.393a	
	G. brang (control)	5.7±0.257b	
Total Dbh of culm (cm)	*G. brang* x *M. paradisiaca*	17.2±0.947ab	0.011*
	G. brang x *O. stamineus*	18.8±1.395a	
	G. brang (control)	16.1±0.871b	
Mean Height of shoot (cm)	*G. brang* x *M. paradisiaca*	7.1±0.739a	0.050*
	G. brang x *O. stamineus*	7.9±0.629a	
	G. brang (control)	5.8±0.739b	
Mean Number of shoots	*G. brang* x *M. paradisiaca*	0.5±0.041a	0.760
	G. brang x *O. stamineus*	0.6±0.043a	
	G. brang (control)	0.5±0.034a	

** Significant at $p<0.01$, * Significant difference at $p<0.05$,

Values in column with similar letter at each parameter are not significant at $p<0.05$.

Results (Table 1) indicate that number of culms was found significantly different ($p<0.01$) among three experimental plots. The highest number of culms (in averages) was found in Plot 2 followed by Plot 1 and Plot 3; 6.8, 6.7, and 5.7 culms respectively. In Figure 1, from July until October, it shows that Plot 1 which is *G. brang* integrated with *M. paradisiaca* produces the highest number of culms followed by Plot 2. In November, highest increment of number of culms was found in Plot 2 compared with Plot 1 and Plot 3 which is 10.1 while Plot 1 is 9.1 culms and Plot 3 with only 7.8 culms. Result indicates that Plot 3 produces the lowest number of bamboo culms in every month compared to Plot 1 and control plot.

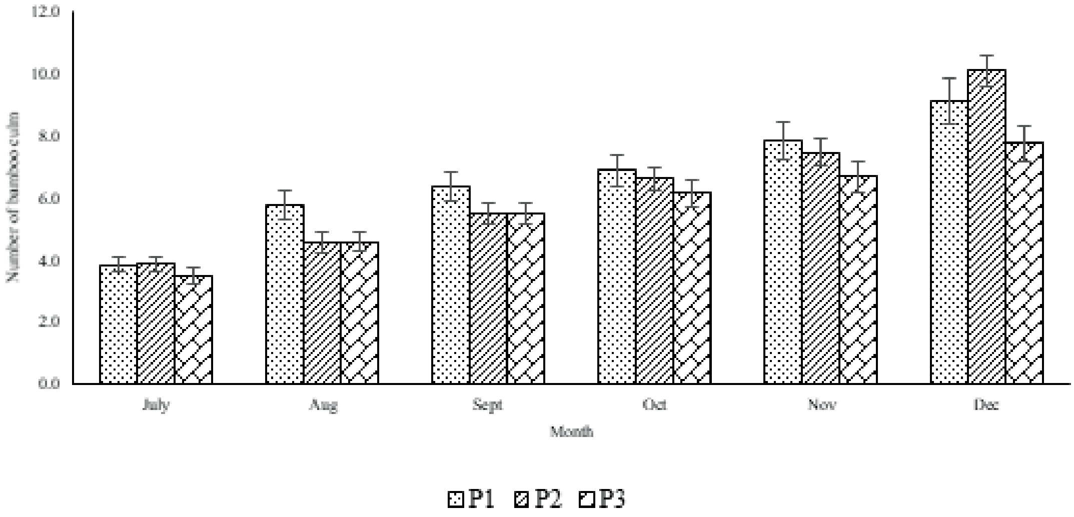

Figure 1. Number of bamboo culm based on various plots assigned

Analysis on DBH of *G. brang* culms using DMRT (Table 1) was found significantly different ($p<0.05$) among three different plots. Result indicates the integrated plot of *G. brang* and *O. stamineus* produced the highest culms DBH (in averages) which was 18.8 cm while the lowest (16.1 cm) was found in the plot of *G. brang* species alone. Anon [14], stated that grass mulch and other litters (preferably dried leaves of bamboo) can be placed around the plant to reduce water loss to avoid hardening or compaction on the top layer of the soil. Mulching also known as an effective technique to increase infiltration water into the soil, provides barriers against raindrop impacts, and hence reduces surface runoff and erosion [15, 16]. This could be associated with the results where the highest number of culms and culms DBH of *G. brang* observed in Plot 2.

The *O. stamineus* crown had become big, broad with several branches cover up to 1 m (radius) that could also prevent from direct sunlight to the soil surface. Different from *G. brang* x *O. stamineus* plot, the soil surface at *G. brang* x *M. paradisiaca* plot could lost the soil moisture due to crown partitioning that can provide room for the direct penetration of sunlight to the soil surface (Vance and Nevai, 2007). Moreover, the crown position of *G. brang* and *M. paradisiaca* are higher and far from the soil surface. The dried leaves of *M. paradisiaca* were also cut and put outside from the plot for a proper sanitation procedure to prevent from fungal infection, pest, and disease (Shah and Yadav, 2018).

Figure 2 illustrates that the total DBH of each *G. brang* culms slightly increased at the early stage (June, July, August and September) with not significant between all three study plots. But in October and November, *G. brang* culms in Plot 2 produced the highest averages culms DBH increment compared to Plot 1 and control plot.

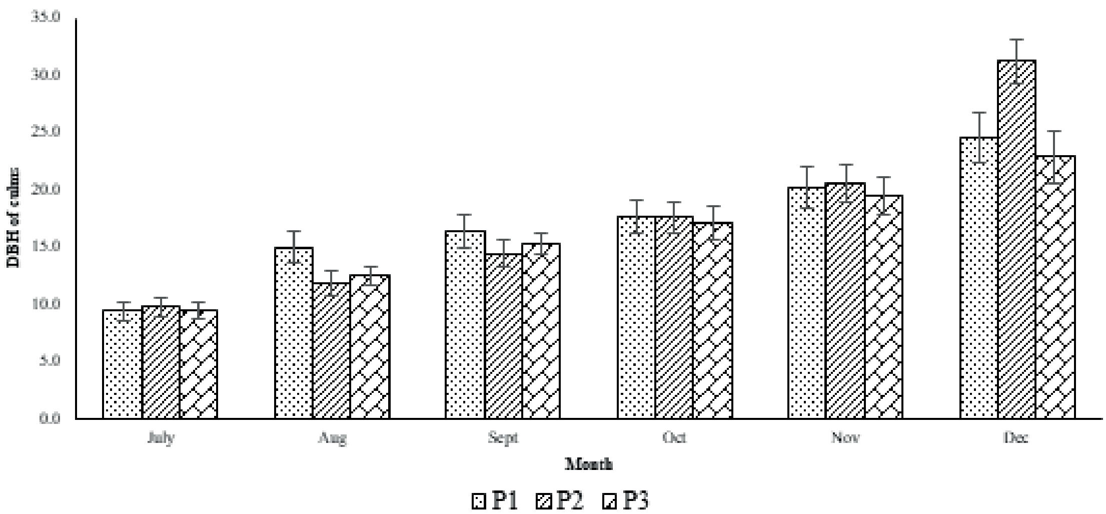

Figure 2. DBH of *G. brang* Culms Based on Various Plots Assigned

Furthermore, result (Table 1) indicates the significant different ($p<0.05$) of the shoots height among three different plots. Plot 2 produced highest height of shoots (7.9 cm) followed by Plot 1 (7.09 cm) and control plot (5.8 cm). As presented in Table 1, there were no significant different observed for number of shoots among different plots, but the significant was noted for height of shoot. Based on Figure 3, the result was indicated increasing and decreasing of shoot height for each plot in the period of six month. However, plot 2 which is *O.stamineus* plot indicated highest result for two month which is December and September. In December, the highest height of shoot was noted which is almost 13cm mean height.

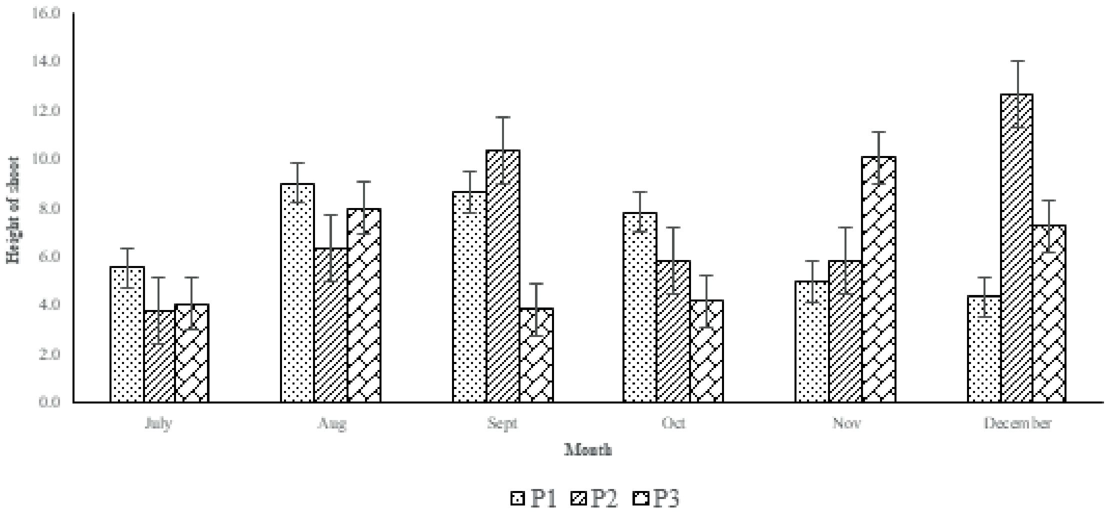

Figure 3. Height of *G. brang* shoot Based on Various Plots Assigned

Long interval period regarding data collection could be the main reason for the insignificant results and also lesser number of bamboo shoot was recorded. Perhaps the bamboo shoot had growth into bamboo culms during the data collection period. On the other hand, the amount and frequency of precipitation could also affect the production of bamboo shoot. The unpredictable precipitation causes the production number of shoots to be inconsistent.

Different types of plant with different canopy size may restrict the intensity of light acquired by other plant and affect their growth based on competition (Vance and Nevai, 2007). The *G. brang* bamboo canopy is higher and bigger than both integrated crops (*O. stamineus* and *M. paradisiaca*). Therefore, the size of canopy of both plants does not exactly affect *G. brang* growth, but it could affect the growth performance of both crops.

Analysis of bamboo growth based on fertilizer

Regardless types of fertilizer, both the number of *G. brang* culms and culms DBH were found significantly different ($p<0.01$) among different rates of fertilizer (Table 2). When fertilizer was applied at 0.5 kg, *G. brang* produced highest culms DBH compared to other fertilizer's rate. The result indicates that 0.5 kg is the most suitable rate of fertilizer application to increase culms DBH. When the application of fertilizer is more than 0.5 kg, it may not improve culms growth performance and hence not cost effective in term of economical aspect. However, *G. brang* clumps that applied with fertilizer produced higher culms DBH compared to without fertilizer (control) application. This indicates that fertilization can help to improve growth performance of culms DBH.

Table 2. Mean DBH of *G. brang* culms based on Various Rates of fertilizer

Parameter	Rate of fertilizer (kg)	Mean	p-value
Number of culms	0.0	5.7±0.253b	
	1.5	6.2±0.376ab	0.000**
	1.0	6.7±0.380ab	
	0.5	6.9±0.447a	
DBH of culms (cm)	0.0	14.6±0.717b	
	1.5	16.5±1.307ab	0.000**
	1.0	18.4±1.236ab	
	0.5	19.9±1.500a	
Height of shoots (cm)	0.0	6.1±0.907a	
	1.5	7.0±0.799a	0.530
	1.0	7.2±0.816a	
	0.5	7.5±0.738a	
Number of shoots	0.0	0.5±0.038a	
	1.5	0.4±0.053a	0.570
	1.0	0.7±0.042a	
	0.5	0.5±0.048a	

** Significant at $p<0.01$, * Significant difference at $p<0.05$, Values in column with similar letter at each parameter are not significant at $p<0.05$.

Results also corroborated with study by Wisut (1988) on *Thyrostachys siamensis, Dendrocalamus asper, Bambusa sp.* and *Dendrocalamus strictus* bamboo species. 100 kg of 15-15-15 NPK fertilizer was adequate for increasing their production. Application at higher rates of fertilizer (up to 200 or 300 kg/ ha) seemed to increase culms yield. In order to generate the optimum growth, plant needs fertilizer at suitable rate. However, the excessive quantity of fertilizer application does not ensure higher culms growth performance. Besides, there are distinctive differences on *G. brang* culms as shown in Figure 4. Figure 4 illustrates higher culms DBH when they were applied with NPK at 0.5 kg compared to other fertilizers application especially from August to November. For instance, in November, total DBH at every clump applied with NPK 0.5 kg is almost 120 cm. In this figure, the differences between types of fertilizers are shown clearly. NPK fertilizer produced higher bamboo DBH compared to chicken dung for every rate of fertilizers used. This shows that compound fertilizer (NPK) is more efficient to increase culms DBH.

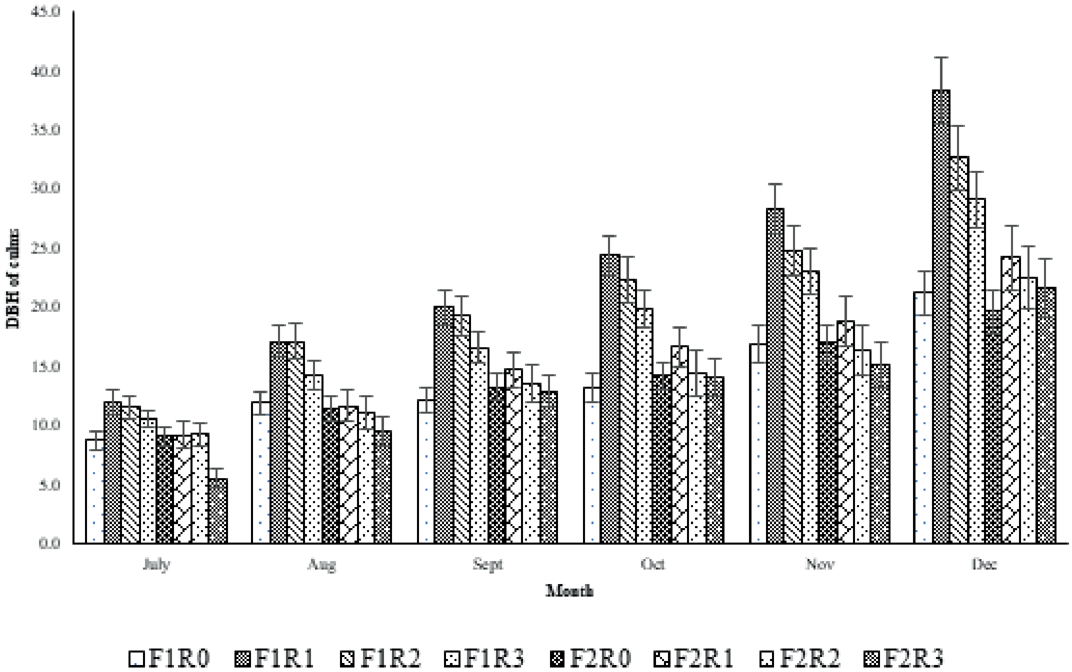

Figure 4. DBH of *G. brang* Culms Based on the Rate of Fertilizer

Results (Figure 5) further indicates that when 0.5 kg of fertilizer was applied, the first three months did not show highest number of culms. But for the last three months, it produced the highest number of culms followed by 1.0 kg and 1.5 kg of fertilizer. The control rate which is 0.0 kg remained the lowest mean number of culms.

The number of culms was found gradually increased from September until November with a total of 300 culms was recorded regarding application of 0.5 kg NPK fertilizer. On the other hand, there is a significant difference on number of culms between types of fertilizers. Clump that was applied with NPK produce a greater number of culms compared to chicken dung. The highest number of culms (210 culms) was recorded from culms that applied with 1.5 kg chicken dung.

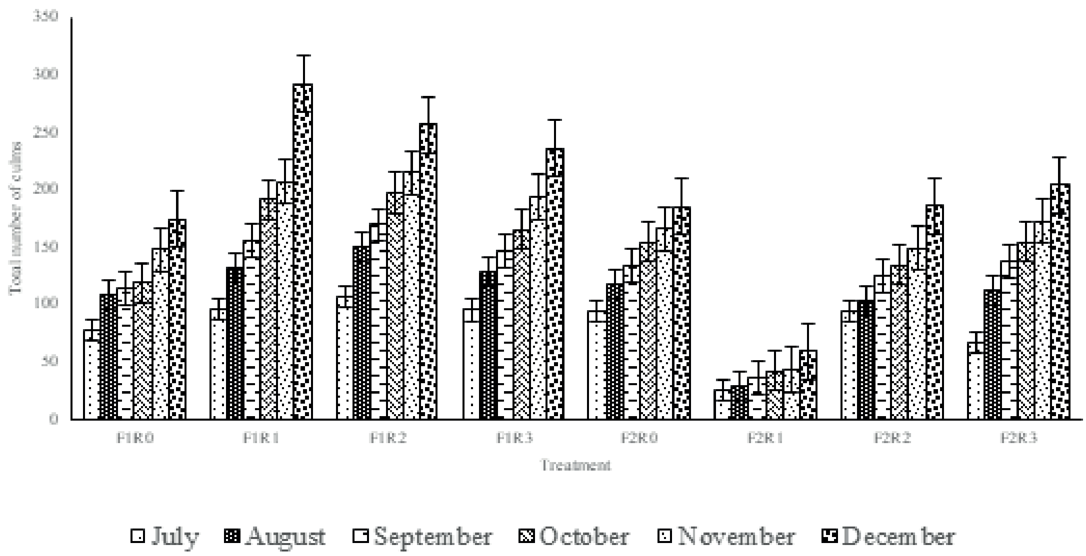

Figure 5. Total Number of *G. brang* Culms Based on Rate of Fertilizer

Therefore, application of NPK fertilizer with suitable rate can give the best result in a short period of time compared to chicken dung. Hence, for better yield of bamboo shoot, these types of fertilizers are recommended. Nonetheless, too much of application of this fertilizer would lead to plant death or injury and in terms of economic aspect it will result less efficiency.

CONCLUSIONS

There are a lot of factors that may affect the growth of a particular plant or crop. They are plant-plant interaction and competition, planting distance, soil, climate and the responses to fertilizer's application. Based on the analysis, only two parameter had shown the significant differences which are number of *G. brang* bamboo culms and total DBH for each clump while the number of bamboo shoots and its height did not shows any significant different, so the results are not included in this paper. Specifically, the best plot is the combination of bamboo with *O.stamineus* and the best fertilizer applied is NPK 0.5 kg. It is proven by two parameter growth; number of culms and culms DBH shows a great difference compared to two other plots.

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