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The Effect of Fertilizers on the Growth and the Yield of Ramie (*Boehmeria nivea* L. Gaud)

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Abstract

Ramie plant (*Boehmeria nivea* L. Gaud) bears a voluminous biomass harvested every 60 days. Much biomass is harvested and much nutrients are absorbed and removed from the soil make the nutrient scarce. To maintain the productivity of soil and to supply the requirement of plant to the level of enough nutrition, an experiment was conducted in Tanjungsari subdistrict of Sumedang regency in the month of July to Oktober 2009. The experiment design used was randomized block design with four treatments of fertilization formula (dosages) i.e. 1) A 10 ton Sheep Dung (25 kg N + 25 kg K); 2) B 10 ton Sheep Dung (45 kg N + 45 kg K); 3) C 20 ton Sheep Dung (25 kg N + 25 kg K); D 20 ton Sheep Dung (45 kg N + 45 kg K). Sheep dung was applied only once in the planting time and nitrogen and potassium fertilizer were applied after every harvest. Each treatment was replicated 6 times. Variables of growth and yield which were measured were: number of stalks; length of stalk; diameter of stalk; biomass weight; fresh stalk weight; china grass weight, and; degummed fiber weight. Result showed that responses of ramie plant were significant, better growth and more yields. Potassium fertilizer gave a good effect on quality of fiber. The dosages applied to the ramie plant did not reach the maximum rate. Ramie plant requires much nutrition to support the rapid growth and the big voluminous biomass removed from soil. Ramie plant is considered as a robust plant.

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Introduction

Research on application of fertilizer based on fertilization package was aimed to examine the consistence of fertilization influence on growth and development and yield of crops on long period of time. Result of the experiment will give information to the farmer to make accurate prediction of fibre yield and ramie agronomist will be able to prepare more a good planting planning.

Ramie is perennial crop which is harvested every 60 days by cutting the mature shoot (stalks) without destructing root organ, so that the plant root system develop continuously inside the soil. The older plantation the more established the root systems is. The root

system consists of storage roots (swollen and enlarge form of root), small fibrous roots (active part of root to absorb water and soil nutrition), and rhizomes (growing laterally containing buds or eyes as reproductive organ).

Applying fertilizer is a must in agronomic point of view, specially in soil with less fertile due to scarce nutrients or unbalanced nutrition. Voluminous biomass harvested from ramie shrub has consumed a large amount of nutrients from soil. Dempsey (1963) stated ramie plant is robust plant. Annually, nutrients extracted at harvest per hectare out of 50 tons of biomass are 225.1 kg nitrogen, 21.8 kg

phosphorus, 109.7 kg potassium, 253.0 kg calcium and 55 kg magnesium, while (Qiang et al. (1989) said ramie plant absorbed soil nutrients at harvest time per hectare annually about 375 kg nitrogen, 60 kg P₂O₅, 390 kg K₂O, 450 kg Ca, 75 kg Mg, 1.5 kg Fe, 3 kg Mn, 0.41 kg Zn, 0.41 kg B and 0.15 Co.

To replenish the absorbed nutrients by plant, regular application of fertilizer with enough dosage is needed in order to maintain the land productivity and even be increased. Research Institute of Fibre and Tobacco (1997) recommended dosage of fertilizer with application of dung of 10-20 tons per ha per years supplemented every harvest with 100-150 kg urea, 25-50 kg of TSP (triple super phosphate), and 50-100 kg KCl.

The Importance of Experiment

In Indonesia, ramie has been grown since the era of Japanese occupation and in 1985 there was a policy of the West Java Province government to regulate the ramie fibre trade. The price of fresh stalk and fibre (chine grass) were set by the provincial regulation. Then, the cultivation of ramie plant and the trade of fibre took place just in short period of time. Among the planters or the producers of fibre and the fibre processors (textile factories) faced some problems and obstacles. The spinning machine and the equipments existing in the factories were prepared to process the cotton fiber only. They were not suitable and were not installed and designed for processing the long ramie fibre.

The economic turmoils started in 1997 had affected Indonesian textile industry and the textile product industries. Many textile factories had sent their workers home due to their difficulty to import cotton fibre as raw material. Textile industry is very susceptible to the imported raw material. Domestic production of cotton fibre is just represent less than 4 % of the whole industry requirement, means that more than 96% cotton fibre must be imported.

Minister of Trade and Industry of the RI on February 2004 has officially opened a ramie processing plant in Wonosobo of Central Java, and a privately owned and renovated ramie

processing factory was opened in Garut of West Java. These events indicated that there is a growing attentions of the government and some private agents to ramie cultivation and processing.

Cooperatives and Small and Medium Enterprises Service Office of West Java Province in 2003 released a statement of industrial notes stated that the requirement of textile raw material (cotton fibre) was 453,300 ton or 75% of the national requirement. The cotton fibre must be imported because Indonesia produced only approximately 6,100 ton or just 1% of the total national fibre requirement.

Sastrosoeparno (2003) said that textile industry and the product of textile industry contributed to the national revenue second only the the revenue from gas and petroleum. Detail of textile and Product of Textile Export Value in 1998-2002 is presented in Table 1. Table 1 shows that textile and product of textile export in the period of 1998 to 2002 reached 6,8 billions dollars. In the period of January to July 2002 reached 4,07 billions, while in the period 2002 reached 4,3 billions.

Cotton fibre is still imported, Table 2 shows annual expend for the import of fibre. On the average one billion dollar is expended for cotton. Value of Textile and Product of Textile Import in 1998-2002 is presented in Table 2.

Most Indonesian regions are not suitable for fibre cultivation in view of agromatical characteristics. Only in some limited regions in Eastern Indonesia, for instance in the island of Sulawesi cotton is cultivated with unsatisfactory yield.

Our experiments in 1999 and 2002 showed that in C type rainfall region (slightly wet), ramie plant can be cultivated commercially with some addition supply of irrigation water in several months of dryer period. The plantation in this region can be harvested 4 to 5 crops. Ideally, ramie is cultivated in A or B rainfall type regions. By this criterion, ramie can be planted in almost throughout Indonesian region.

Research Institute for Textile of Bandung (2003) stated that ramie fibre possesses the same characteristic with cotton fibre and fulfils the condition for human clothes. The function of cotton can be substituted with this easily produced fibre. According to Sastrosoparno (2003), if textile industries in Indonesia utilize ramie fibre as raw material, this will give more employment for people. Based on calculation, if it is 10% reduction in cotton utilization it will require 65,000 ton of ramie fibre as substitution. To produce as much as 65,000 ton of ramie fibre will need 11,000 ha area of ramie plantation and will employ workers as many as 85,000 people working in post-harvest processing and spinning and uncouneted people dealing with clothings or garmen industries.

However, ramie fibre industry is not stable yet. There are many obstacles both in the post harvest processing and in the fibre producing. So that, this experiment on fertilization application will give confirmed intention to promote production to achieve the goal of substitution of cotton import. This means the solution for the current economic turmoil.

The success in agronomic technology to increase yield will innitiate the development of agroindustry. There will be no significant development in post harvest or in the sector of crop marketing when there is no sifnificant increase in the sector agronomy and vice versa.

Fertilization

Aji Sastrosupadi, et al. (1993) said that the best result of fertilizer is a package of 10 ton sheep dung per ha annually supplemented with 45 kg N, 10 kg P₂O₅ and 30 kg K₂O per every harvest. Prior study conducted by Subandi (2002) showed in inceptisol of Jatinangor of C rainfall type based on Schmidt and Ferguson classification, the package of 20 ton sheep dung per ha per annum added with 45 kg N and 45 K per ha each crop (after harvest application) gave fibre yield with a trend to increase with linear pattern of encrement. That study showed that the crop utilized package of fertilization of higher dosage.

Wang Chuntao, et al. (1989) stated that nitrogen and potash significantly effected the fiber quality as for phosphorus less effective for the quality and quantity as well. Ramie plant fertilized with potash produces better quality (finer fibre) in contras with ramie plant fertilized with nitrogen fertilizer produce more fibre but with lower quality.

Multiseasons study on fertilizer packages application will give information of the effect of fertilization on semi-dormant period plant. Semi-dormant is a condition of plant in dry season in the form of inactive corm (root system). There is no bud grows out of the corm. Prior research on ramie plant in the region of C rainfall type concluded that rami plant will undergo stagnant growth under water-stressed state in mid dry season. In this period, ramie plant in the C rainfall type region give no yield and no crop is harvested. The study of growth and yield pattern in the region revealed that the application of fertilizers and the addition of water supply on the rate more than the rate of evapotranspiration (rainfall > 2 mm per day) has maintained a normal growth in the dry season.

Methodology

Research was conducted in Tanjungsari subdistrict of Sumedang Regency from July till Oktober 2007. Randomized Block Design was used as environmental design with six replication. Treatments of the research were based on fertilizing recommend by the prior research. The tretments were:

1. 10 ton of sheep dung per hectare per year supplemented with (25 kg +25 kg K) per hectar per harvest.
2. 10 ton of sheep dung per hectare per year supplemented with (45 kg +25 kg K) per hectar per harvest.
3. 20 ton of sheep dung per hectare per year supplemented with (25 kg +25 kg K) per hectar per harvest.
4. 20 ton of sheep dung per hectare per year supplemented with (45 kg +45 kg K) per hectar per harvest.

Each treatment was replicated 6 times, so there are 24 experimental plots. The size

experimental plot are 3.0 X 2.5 m and the planting space are 0.5 x 0.5 m, so for each plot are 30 plants

A, Response design

In this research are observed several plant growth and yield indicators, they are:

1. number of stalks
2. length of stalk
3. diameter of stalk
4. biomass weight
5. fresh stalk weight
6. china grass weight
7. degummed fiber weight

The indicator of growth (number of stalk variable) is measured by counting the number of stalks growing out of the plant corm. The stalks which are counted those reaching the height more than 50 cm. When harvest is done too late, there are more sprouts or younger stalks grow under the mature ones.

The length of stalk variable is measured from the root neck to the upper part of the stalk by discarding deciduous part of stalk peak. The measurement of stalk diameter is conducted by measuring diameter of stalk at the height 15 cm above soil surface. Safe meter is used to measure it.

Biomass weight variable is measured by weighing all parts of vegetation comprising of stalks and leaves. The plant shoot is cut and weighed immediately.

The Fresh stalk weight is stated by weighing stalks of the plot after clearing up all of leaves and cut off the top part of the apex. China grass is crude fibre which is gained through the process of decortication. The product is then dried on the sun for 2 or 3 days and is weight to get the variable china grass weight. Degumming fibre is china grass which is undergone the degumming process and is being dried. Dry weight degummed fiber is a variable of plant yield..

Results And Discussions

1. Number of Stalk

The result of statistical analysis on this variable showed that fertilizer application

consisting of sheep dung fertilizer which is supplemented with a package of nitrogen and potash has brought about significant effect on the growth of stalk. The number stalk is different as a result of different treatment, the highest dosage produced the most number stalk. As shown in Table 3 below:

2. Length of Stalk

Analysis on the length of stalk variable results information that the differences among the treatment are significant as shown in Table 4 below. Growth of stalk requires enough supply of soil nutrients. The more supply of sheep dung and nitrogen and potash (the more dosages) the better development tissues of plant apex forming the organ of stem. The maximum length of stalk promoted by the application of manure in the treatment is still presenting a trend of increasing growth. This is indicated by the length of stalk is still not achieving its maximum length. The response of plant to the A treatment or the package of 10 ton Sheep Dung (25 kg N + 25 kg K) as measured in the length of stalk does not significantly differ from the response of plant to the B treatment fertilizer package of 10 ton Sheep Dung (45 kg N + 45 kg K), but the response of plant to the B treatment is significantly different from the plant response to the treatments of C and D. The application of different dosages of sheep dung give a significant difference of plant responses. And so do the treatments of nitrogen and potash, different plant responses are detected.

The application of nitrogen and potash of different dosages at the same level of sheep dung's dosage (20 ton per ha) responded by the plants with the different growth of stalk as shown with the figure in Table 4.

3. The Stalk Diameter

The result of variable analysis of stalk diameter indicates that the influence of fertilizer treatments on diameter of stalk are different. The result of analysis is presented on Table 5.

Table 5 reads the response of plant to the A treatment which is measured in stalk diameter is not different from the response of plant to the treatment B, and the response of ramie plant to B treatment is not different from the

response of plant to the treatment C, too. However, the response of plant to D treatment is significantly different from the response of plant to the treatments B and C. The biggest increment in diameter is gained by the treatment D, it means that the application of sheep dung and the nitrogen and potassium nutrients affect the growth of ramie plant.

The growth and development of stalk is depended on supply of photosynthetic product. Accumulation of photosynthetic product is utilized for the longitudinal and radial growth of stalk.

4. Biomass weight

Result of analysis on biomass weight variable indicates that the application of fertilizer at various dosages which are arranged in the treatment design affect the weight of biomass differently as shown in Table 6.

Applying fertilizer is a must for good agronomy practice, especially for plant which is harvested its biomass. Almost all the vegetative biomass is taken out the field that no part of the biomass is left in the soil.

It is apperent in the Table 6 that the of increasing rates of nitrogen and potash fertilizers at the dosage of 10 ton of sheep dung affect the yield (biomass weight) non significantly different. As for at the rate of 20 ton sheep dung, the increase of nitrogen and potassium dosages affects the weight of biomass significantly different.

Biomass weight is the sum or accumulation of vegetative componens of growth comprising of number of stalk, the length of stalk, and its diameter. Biomass yield which is achieved with the rates applied is not yet its maximum yield. Its trend to more increase is still apperent in the figure of biomass weight as the Table 6.

The yield of ramie depend on various factors, and fertilization is the dominan factor to replace the uptake nutrients during the growing of plant and then taken out at harvest. Higher rates of nitrogen and potassium are required for nutrient deficient soil after harvest., and the application of sufficient

organic matter is required. As the evident in the Table 6, at the rate of sheep dung (organic manure) 20 ton (higher rate in this experiment), the yield of ramie plant in the form of biomass weight increases. The increment of the yield is synergistic with the presence of nitrogen and potassium element of nutrition.

5. Fresh Stalk Weight

The Fresh stalk weight is measured by weighing stalks per plot. The stalk is cleared by detaching all leaves by running the hand along the stalk and cutting off the top part of the stem. The weighing is done on the same day of the cutting. Harvest is done with a sharp sickle and the freshly cut stem is weighed.

Statistical analysis showed that the variable of fertilization treatments consisting of sheep dung (organic manure), nitrogen and potassium caused different responses of ramie plant as indicated with different fresh stalk weight. The variation of the plant response are signifcantly different, detail data in Table 7.

The pattern of increament of fresh stalk weight is linear and in accordance with the increament of ferilization dosages. Ramie plant response to the A treatment as is measured in fresh stalk weight is different from that of B treatment, but it is not significant statistically, while the treatment C affect the weight of fresh stalk significantly different from that of treatment A and D and D. The treatment D noted the highest weight. The weight can be predicted to further increase when the dosage is increased.

The fresh stalk weight is gained by weighing the biomass after detaching the leaves and topping the apec part of the stem. Potassium promotes the development of fibrous tissues. Fibrous development in the cortec is secondary process which takes place later to the development of younger stalk, and younger leaves (sprout) and newly developing flower. When these tissues are detached from the biomass to get the measurement of fresh stalk weight, the data taken will have the same pattern of variation with data of biomass weight. That is why, the result of statistical

analysis of fresh stalk weight has the same pattern with that of biomass weight.

6. China Grass Weight

China grass is considered as the first marketable yield. The yield is obtained through the process of decortication. This process involves the removal of fibre from the stalk. In the ramie plant the individual fibres occur in the form of bast bundles with the ends overlapping so as to produce filaments throughout the length of the stalk. The individual fibres are held in place and to each other by gum, waxes and pectins.

Result of china grass weight variable analysis is presented in Table 8.

Table 7 reads that fertilization treated to ramie plants affect the development of fibre inside the stem. Fibre is a product of ramie. Application of fertilizer changes the growth and development of the tissues and then consequently changes the development of organ. The increase of china grass product is in line with the increase of fertilizer dosages.

Although, in view of statistical analysis, they are not significantly different between the responses of plant to the treatment A from that to the treatment B as is measured in crude fiber (china grass) weight, absolutely by figures they are different. Treatment B makes more yield than A. It means an increase in yield occurred as response to the increase of fertilizer dosage. A significant difference between treatment C and D as a result of different dosage applied.

Ramie fibre is extraxillar fibre means fibre develops outside the xylem tissue. The fibre develops inside the secondary floem tissue. For developing or differentiation of cambium forming the secondary floem and then becoming fibre is needed sufficient energy from photosynthetic product. To execute the development process, the available of enough nutrients in the soil is unavoidable. This nutrient is supplied with fertilization.

7. Degummed Fibre

Fine and clean fibre is derived from further processing after decortication, the so called

degumming process. Degumming is an effort to separate the individual fibres and leave them in a soft, clean state, with their strength and other their characteristics intact. The degumming on a commercial scale requires expensive capital and equipment which is too costly for ramie planters. There for, degumming is usually done by milling factory which spin the fibre.

Degumming is a process to remove the gum, waxes and pectins. The amount of gum, waxes and pectins removed from the china grass at the average are the same in all of the variables. So that, the variable data of the degummed fibre weight are almost the same with the variable data of china grass weight. As the result, statistical analysis on the variable resulting the same conclusion as the Table 8 above shows.

Conclusion

The application of fertilizer (sheep dung, nitrogen and potassium) with various dosages affects the growth and yield of ramie plant. Responses of ramie plant to the treatment were measured in plant growth and yield namely: 1) number of stalks, 2) length of stalk, 3) diameter of stalk. 3) biomass weight. 4) fresh stalk weight 5) china grass weight, and 6) degummed fiber weight. The various dosages applied affect the plans differently, some of the plant responses are significantly different, but some other are non significant. Growth and yield Variable tend to increase linearly. Ramie plant need more nutrients to maintain the capacity of the plant to grow well and to produce satisfactory yield, and ramie plant is a robust plant. It absorbs much soil nutrients for supporting the rapid grow of biomass. So, applying fertilizer is crucial. The dosages of sheep dung, nitrogen and potassium at the rates treated to ramie plant showed a trend of ever increasing or the maximum rate was not yet reached. The effect of sheep dung is more evident to give a good environmental condition. Sheep dung manure maintains the humidity of soil, while nitrogen affects the vegetative growth and potassium show a good effect on the quality of fibre.

Table 1: Value of Textile and Products of Textile Export in 1998-2002

No	Commodities	1998	1999	2000	2001	2002	Jan-Jul 2002	Jan-Jul 2003
1	Fibre	146.	97.	135.	122.	181.	333.	485.
2	Yarn	889.	1,177.	1,326.	1,243.	29.	1,136.	1,153.
3	Fabrics	1,345.	1,614.	1,913.	1,664.	1,404.	126.	130.
4	Clothes	2,405.	3,526.	4,281.	4,344.	3,805.	1,510.	1,626.
5	Other textiles	2,533.	740.	549.	304.	267.	966.	919.
Total		7,321.	7,157.	8,204.	7,675.	6,888.	4,074.	4,316.

Source: Ministry of Trade and Industry (2003). (Unit: Million US Dollar)

Table 2: Value of Textile and Product of Textile Import in 1998-2002

No	Commodities	1998	1999	2000	2001	2002
1	Fibre	988.690	833.647	1,009.517	1,336.115	921.617
	Silk	0.308	0.765	1.008	0.429	0.411
	Other nat.fib.	782.157	681.445	739.459	1,076.687	720.076
	Synthetic	206.224	151.436	269.050	258.999	201.128
2	yarn	220.956	195.289	276.246	261.348	220.398
3	clothes	746.010	631.057	926.411	753.265	588.649
4	fabrics	5.019	8.179	10.390	17.561	27.635
5	other textiles	59.830	47.453	61.581	72.824	69.937

Source: Ministry of Trade and Industry (2003) (Unit: Million US.Dollar)

Table 3: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium fertilizer on Stalk Number

Treatment	Average of Stalk Number per Plot
A 10 ton Sheep Dung (25 kg N + 25 kg K)	148 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	153 a
C 20 ton Sheep Dung (25 kg N + 25 kg K)	166 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	174 c

Note: The average figure preceded with the same word is not significantly different on Duncan, Test at $\alpha=0.05$

Table 4: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium Fertilizer on Length of stalk

Treatment	Average of Stalk Length (cm)
A 10 ton Sheep Dung (25 kg N + 25 kg K)	69 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	75 ab
C 20 ton Sheep Dung (25 kg N + 25 kg K)	82 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	98 a

Note: The average figure preceded with the same word is not significantly different on Duncan Test at $\alpha=0.05$

Table 5: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium Fertilizer on Diameter of stalk

Treatment	Average of Stalk Diameter (mm)
A 10 ton Sheep Dung (25 kg N + 25 kg K)	2.6 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	2.9 ab
C 20 ton Sheep Dung (25 kg N + 25 kg K)	3.1 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	4.0 c

Note: The average figure preceded with the same word is not significantly different on Duncan

Table 6: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium Fertilizer on Biomass Weight

Treatment	Average of Biomass Weight per Plot (kg)
A 10 ton Sheep Dung (25 kg N + 25 kg K)	15,2 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	16,8 ab
C 20 ton Sheep Dung (25 kg N + 25 kg K)	21,9 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	26,5 c

Note: The average figure preceded with the same word is not significantly different on Duncan

Table 7: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium Fertilizer on Fresh Stalk Weight

Treatment	Average of Fresh Stalk Weight per Plot (kg)
A 10 ton Sheep Dung (25 kg N + 25 kg K)	8.3 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	9.9 a
C 20 ton Sheep Dung (25 kg N + 25 kg K)	14.1 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	16.6 c

Note: The average figure preceded with the same word is not significantly different on Duncan, Test at $\alpha=0.05$

Table 7: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium Fertilizer on China Grass Fibre Weight

Treatment	Average of China Grass Weight per Plot (g)
A 10 ton Sheep Dung (25 kg N + 25 kg K)	414 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	493 a
C 20 ton Sheep Dung (25 kg N + 25 kg K)	710 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	825 c

Note: The average figure preceded with the same word is not significantly different on Duncan Test at $\alpha=0.05$

Table 8: Effect of Sheep Dung Supplemented with Package of Nitrogen and Potassium Fertilizer on Degummed Fibre Weight

Treatment	Average of Degummed Fibre Weight per Plot (g)
A 10 ton Sheep Dung (25 kg N + 25 kg K)	393 a
B 10 ton Sheep Dung (45 kg N + 45 kg K)	470 a
C 20 ton Sheep Dung (25 kg N + 25 kg K)	670 b
D 20 ton Sheep Dung (45 kg N + 45 kg K)	781 c

Note: The average figure preceded with the same word is not significantly different on Duncan, Test at $\alpha=0.05$

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