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ELEPHANT GRASS PLANTING PLAN AT ERUPTION-AFFECTED AREAS IN MOUNT MERAPI: METHODS AND HARVESTING TIME

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Mount Merapi volcanic eruption in 2010 caused physical damages and left residences and hundreds of hectares of farm and plantation covered by volcanic ash. One of the immediate consequences was the inadequate supply of cattle fodder post-eruption. Elephant grass planting plan at eruption-affected areas was proposed to solve the problem. An experiment was arranged in a completely randomized design with two (2) factors and five (5) replications to assess the productivity and quality of elephant grass. The first factor comprised of the technique used to add volcanic ash to the soils: (1) Plowing or mixing method (volcanic ash mixed with soils), and (2) Planting the stolon at the beneath (volcanic ash at upper layer). The second factor consisted of three (3) harvesting periods i.e. harvesting time of 30, 45, and 60 days. The experiment revealed that volcanic ash exposure to the stolon during the planting time may suppress the grass growth, but the effects disappeared after 30-day growing time. This result indicates that elephant grass is suitable to be planted at the affected areas and it can be considered as an alternative for the dairy farmer even the soil surface has been transformed after the eruption. Sixty-day harvesting is the recommended time to produce high quality elephant grass. In this period, we found that volcanic ash offers some advantages as supplement to grow and develop. The elephant grass at the 60-day harvesting time will have the longest, widest, and greenest leaves, and also the tallest and biggest stem if exposed to volcanic ash only at the topsoil. Based on the observation, we can sugggest that the appropriate method to plant the stolon of elephant grass is to plant the stolon at the beneath without soil-mixing method.

Keywords: Elephant Grass (Pennisetum purpureum Schum.), Planting Plan, Volcanic Ash, Cattle Fodder, Mount Merapi

1. INTRODUCTION

Mount (MT) Merapi (110.442° E, 7.542° S), located approximately 25 km north of the city of Yogyakarta in Central Java, is one of most active and dangerous volcanic mountain in Indonesia. Its activity has been recorded with gravitational lava dome collapses and explosive dome pyroclastic flows (Voight et al., 2000). The eruption caused persistent damages to environment and the nearby populated areas as more demonstrated in 2010 (Gertisser et al., 2011). The survivors who decided to live in the damaged living environment were measured with high Environmental Distress Scale (EDS) (Warsini et al., 2014).

Residences and hundreds of hectares of farm and plantation were covered by volcanic ash after latest eruption in 2010. Physical damage especially on productive sectors generated an increasing number of unemployment rate and poverty, and affected to regional and local economy, even provincial finance (Hadi, 2008). The major occupation of the Merapi's survivors was farmer, and it was dominated by the dairy cattle in Daerah Istimewa Yogyakarta (DIY) Province (Muzayyanah et al., 2014). The critical problems remained a solution to focus to the environmental deterioration as the effort of economy revitalization at the affected area.

Elephant grass (*Pennisetum purpureum* Schum.) is best known as *"rumput unggul"* or superior grasses and used for cattle fodder among the Merapi's villagers (Dove, 1986). Elephant grass has high productivity, and the high nutrient contents increase the nutrient supply and cattle and milk production of the fed cattle (Aroeira et al., 1999; Kabi et al., 2005; Purbajanti et al., 2007; Rodrigues et al., 2002). The elephant grass is well known as a pioneer plant and more suitable at the affected area since its ability to grow at drought-affected farmland (Mureithi et al., 1995). Planting methods and appropriate harvesting time should be considered to address the inadequate supply of cattle fodder after eruption. This study was conducted to provide evidences that elephant grass is suitable to be planted at eruption-affected areas in MT Merapi in order to meet the demands of the farmers after the eruption.

2. RESEARCH METHODOLOGY

2.1. Design and sample

The work was started by collecting the volcanic ash deposited on the surface layer six (6) months after the eruption at Kinahrejo village. The research was designed at farming land provided by Laboratorium PAU UGM, in April to August 2011. The experiment was arranged in a completely randomized design with two (2) factors and five (5) replications. The first factor comprised of the technique used to add volcanic ash to the soils: (1) Plowing or mixing method (volcanic ash mixed with soils), and (2) Planting the stolon at the beneath (volcanic ash at upper layer). The second factor consisted of three (3) harvesting periods i.e harvesting time of 30, 45, and 60 days. The volcanic ash was added to the land approximately 5-7 cm depth to represent the affected farmland in MT Merapi areas as other researchers' observation (Suriadikarta et al., 2011). The control treatment is the group without volcanic ash posed. There is no fertilizer and pesticides applied in this study.

2.2. Productivity and quality measurement

There were 6 parameters for determining the productivity of elephant grass which are number of leaves, leaf length, leaf width, height of plant, number of shoots, and stem diameter. There were 4 parameters for measuring the quality of elephant grass, based on the Association of Official Analytical Chemists (AOAC) standard methods, namely: the chlorophyll level and the percentage of lipid, water, and dry matter.

2.3. Data analysis

The data obtained from the field was analyzed using Microsoft Excel for calculation. The Mann-Whitney test was used to find the significant difference in the observed parameters.

3. RESULTS AND DISCUSSIONS

3.1. Productivity of elephant grass in planting media without volcanic ash exposure

At the 5-day observation, there were 3 of 5 stolons developed to be plants at this control group. Table 1 shows that elephant grass with no volcanic ash supplementation has the longest leaves, but the smallest stems. The shoots may grow lately, but from Table 2 we observed that the number of shoots increased if no volcanic exposure at the planting media. We found that the observed parameters on soil media with no fertilizer, ash volcanic, and pesticide application increased with an increasing of time. Furthermore, the highest productivity of elephant grass was found at 60-day harvesting time, but the significant increase was observed only at the planting media with volcanic ash exposure. The counting result shows the number of leaves of elephant grass was 55.40 ± 12.98 (mean ± std.error) at the 30-day harvesting time. The number of leaves rose with an increasing of harvesting time. The leaf number increased 15.55% and 16.67% of the leaf number at 30-day harvesting time, respectively, at 45 and 60-day harvesting time. At 60-day harvesting time, the plant grass without volcanic ash exposure has the highest number of leaves than the planting media with volcanic ash supplementation. In average, at the control group, with no exposure to volcanic ash, the leaf length at the 30-day harvesting time was 45.24 ± 6.50 cm with leaf width on the average of 1.98 ± 0.24 cm. The widest and the longest leaves were observed in 60-day harvesting. However, the increasing of harvesting time from 30 days to 60 days will only increase the leaf length - width ratio maximum from 23.87 to 26.66.

Tabel 1. The productivity of elephant grass (*Pennisetum purpureum* Schum.) at 5 and 17 days after planting at different planting media

Parameters	Mean ± Std.error					
	5 days			17 days		
	Soils	Ash at upper layer	Ash mixed with soils	Soils	Ash at upper layer	Ash mixed with soils
Number of leaves	5.67 ± 0.33	7.67 ± 1.76	4 ± 1	6.5 ± 0.65	10 ± 2.89	5.67 ± 0.33
Leaf length (cm)	17.39 ± 2.19	17.28 ± 13.66	13.66 ± 5.33	19 ± 3.54	24.28 ± 2.05	15.05 ± 4.90
Leaf width (cm)	1.35 ± 0.04	1.38 ± 0.02	1.21 ± 0.11	1.20 ± 0.1	1.41 ± 0.06	1.26 ± 0.01
Height of plant (cm)	3.67 ± 0.67	4.33 ± 1.09	2.5 ± 1.5	2.12 ± 0.51	3.5 ± 0.76	1.83 ± 0.17
Stem diameter (cm)	1.67 ± 0.44	2.2 ± 0.1	1.95 ± 0.95	3 ± 0.46	3.8 ± 0.36	2.5 ± 0.29
Number of shoots	0	0	0	2 ± 1	1.33 ±	0

The stem plants became taller and bigger progressively, and stayed green during the 60-days observation. The height of elephant grass increased gradually. In average (± std.error), the height of elephant grass at planting media with no volcanic ash exposure at harvesting time of 30 days was 11.32 ± 1.83 cm. At the harvesting time of 45 and 60 days, the mean of the plant height respectively increased 20.28% and 56.04% of the grass height at 30-day harvesting time. The stem diameter of plants harvested at 30 days was 3.36 ± 0.54 cm (mean ± std.error). The diameter increased to 4.88 ± 0.65 cm and 4.92 ± 0.54 cm, respectively, at harvesting time of 45 and 60 days. At soil media, the number of shoots per plant increased as the rate of leaf and stem growth in elephant grass tends to increase from 30 to 60 days of the harvesting time. The number of shoots at 30-day harvested elephant grass was 7 ± 1.73 (mean ± std.error). The number of shoots increased 10.26% and 12.5% of the 30-day plants, respectively, at the 45-day and 60-day plants.

3.2. The proposed method at the affected areas

3.2.1. Plowing or mixing method (volcanic ash mixed with soils)

Plowing or mixing method enables volcanic ash to expose the planted stolon of elephant grass. As the result, at the first 5-day observation, only 2 of 5 stolons succeeded to grow. At the initial time, the direct exposure of volcanic ash to the stolon suppresed the number of leaves, leaf growth (length and width), and height of grass. However, the direct volcanic exposed to the roots may not affect to a decreasing of stem diameter in the initial growing period. At this initial time there was no shoot growth, even until the 17-day observation. The productivity of elephant grass will be suppressed if volcanic ash mixed with soils at the planting media. This trend appeared until the first harvesting time alternative, the 30-day harvesting time. We revealed that at the 30-day harvesting time, the volcanic ash exposure to root plants may decrease the number of leaves, stem growth (height and diameter), and number of shoots, but it may contribute to an increasing of leaf length.

Table 2. The productivity of elephant grass (*Pennisetum purpureum* Schum.) at different planting media in harvesting time of 30, 45, and 60 days

Parameters	30 days			45 days			60 days		
	Soils	Ash at upper layer	Ash mixed with soils	Soils	Ash at upper layer	Ash mixed with soils	Soils	Ash at upper layer	Ash mixed with soils
Number of leaves									
Range	21-89	13-74	14-62	28-100	39-89	24-81	32-100	34-88	49-86
Mean±Std.error	55.40 ± 12.98	45.60 ± 11.68	35.33±7.82[5)]	65.60 ± 14.09	60.40 ± 10.93	49.83 ± 8	66.50 ± 10.51	64.2±13.05	62.20±6.49[5)]
Median	55.00	41.00	34.50	70.00	46.00	48.00	66.50	67.50	57.00
Std. Deviation	29.03	26.12	19.16	31.50	24.45	19.60	25.74	26.11	14.52
Leaf length (cm)									
Range	26.66-61.13	31.26-62.16	26.33-53.33	30.70-71.00	45.00-71.67	31.33-61.43	27.06-77.33	63.66-80.3	54.67-76
Mean±Std.error	45.24 ± 6.50	46.25 ± 5.74[2)]	44.08±3.79[6)]	52.91 ± 7.78	55.82 ± 4.88	52.28±4.65[7)]	55.00 ± 9.02	71.50 ± 3.42[2)]	66.80±3.54[6)7)]
Median	43.90	49.00	45.50	51.00	56.97	54.97	59.07	71.00	66.33
Std. Deviation	14.54	12.84	9.27	17.40	10.91	11.39	22.09	6.84	7.91
Leaf width (cm)									
Range	1.50-2.56	1.90-2.66	1.43-2.63	1.20-2.80	2.03-3.23	1.57-3.00	1.26-2.90	2.30-3.46	2.6-3.3
Mean±Std.error	1.98 ± 0.24	2.24 ± 0.14[2)]	2.24±0.18[6)]	2.03 ± 0.32	2.55 ± 0.23	2.32 ± 0.19[7)]	2.06 ± 0.29[1)]	2.95 ± 0.24[1)2)]	2.93±0.12[6)7)]
Median	1.83	2.16	2.37	1.90	2.27	2.28	1.95	3.02	2.83
Std. Deviation	0.53	0.31	0.44	0.72	0.51	0.48	0.70	0.49	0.27
Height of plant (cm)									
Range	6.30-15.80	7.50-16.20	6.00-12.00	7.50-20.00	12.00-28.50	8.50-19.90	9.50-46.00	18-65	29-50
Mean±Std.error	11.32 ± 1.83	11.06 ± 1.59[2)]	9.60± 0.96[3)6)]	14.20 ± 2.37	17.70 ± 3.13	14.65±1.57[3)8)]	25.75 ± 6.57	39.8 ± 12.21[2)]	38.5±3.84[6)8)]
Median	11.00	11.00	10.30	13.50	14.00	14.75	22.75	38.15	36.00
Std. Deviation	4.09	3.56	2.36	5.30	7.00	3.84	16.10	24.42	8.59

Number of shoots									
Range	3-12	2-9	2-9	4-13	5-10	2-9	3-13	4-11	5-10
Mean±Std.error	7 ± 1.73	5.60 ± 1.44	4.50 ± 1.12	7.80 ± 1.74	6.80 ± 0.97	5.67 ± 0.95	8 ± 1.46	6.5 ± 1.55	6.80 ± 0.92
Median	6.00	4.00	4.00	8.00	6.00	5.50	7.50	5.50	7.00
Std. Deviation	3.87	3.21	2.74	3.90	2.17	2.34	3.58	3.11	2.05
Stem diameter (cm)									
Range	2.30-5.00	2.30-4.20	2.10-4.00	3.20-7.00	3.10-6.50	3.60-5.20	3.50-7.00	5-8.50	5-6.4
Mean±Std.error	3.36 ± 0.54	3.18 ± 0.40[2)]	3.15±0.25[4)6)]	4.88 ± 0.65	4.68 ± 0.66	4.65±0.25[4)7)]	4.92 ± 0.54	6.53 ± 0.83[2)]	5.64± 0.31[6)7)]
Median	3.00	2.70	3.15	4.70	4.00	4.95	4.50	6.30	5.30
Std. Deviation	1.20	0.90	0.62	1.46	1.48	0.62	1.32	1.67	0.70

1) significant at p value < 0.05; 2) significant at p value < 0.05 (ash-at-upper-layer media) in 30-day and 60-day harvesting time; 3) significant at p value < 0.05 (ash-mixed-with-soils media) in 30-day and 45-day harvesting time; 4) significant at p value < 0.01 (ash-mixed-with-soils media) in 30-day and 45-day harvesting time; 5) significant at p value < 0.05 (ash-mixed-with-soils media) in 30-day and 60-day harvesting time; 6) significant at p value < 0.01 (ash-mixed-with-soils media) in 30-day and 60-day harvesting time; 7) significant at p value < 0.05 (ash-mixed-with-soils media) in 45-day and 60-day harvesting time; 8) significant at p value < 0.01 (ash-mixed-with-soils media) in 45-day and 60-day harvesting time.

The decreasing trend of the productivity of elephant grass planted with plowing method changed when growing time increased. The data suggests that at the ash-mixed-with-soil media, volcanic ash may not depress the leaf length and stem diameter at the 60-day observation, but the effect disappeared after 45 days for grass height. The grass height and diameter increased significantly at the 45-day harvesting time, respectively, at significant different of 0.05 and 0.01. When we doubled the harvesting time from 30 to 60 days, the productivity of elephant grass increased significantly including the number of leaves, leaf growth (length and width), and stem growth (height and diameter). It shows elephant grass is suitable to be planted at the affected areas and it can be considered as an alternative for the dairy farmer even the soil surface has been changed after the eruption event.

3.2.2. Planting the stolon at the beneath (volcanic ash at upper layer)

Planting the stolon at the beneath of the farmland covered by volcanic ash (after eruption) may minimize the direct volcanic ash exposure to the stolon. Soil moist is important for stolon development to be a new plant, but watering may not really be required for stolon. In this research, the first watering was scheduled at the first 5-day after planting, and during that time we found that there were 3 of 5 stolons developed to be plants. The data shows the elephant grass planted in media covered by volcanic ash at the upper layer was tallest and has the highest number of leaves, the biggest stem, and the widest leaves compared to other media at the first 5-day observation. At the 17-day observation, we found an increasing number of leaves, length and width. We also observed a growing in stem diameter and height of plant. By this event, we can highlight a role of volcanic ash to increase the grass productivity by minimizing the direct contact of stolon in the first planting time.

Among the observed media, we revealed that the elephant grass at the 60-day harvesting time will have the longest and widest leaves, and also the tallest and biggest stem if exposed to volcanic ash only at the topsoil. Even though there was no significant increased from 30 to 45 days or 45 to 60 days of planting for all parameters, the increasing of harvesting time from 30 to 60 days for this experimental group contributed significantly to an increasing of the leaf growth (length and width) and the diamater growth (height and diameter) at 0.05 significance level. Compare to the control group, we recognized that the volcanic ash supplementation at the upper layer with a minimizing effort to direct ash exposure to the roots will significantly increase the leaf width (p value < 0.05). Based on the result, we can sugggest that the appropriate method to plant the stolon of elephant grass is to plant the stolon at the beneath without soil-mixing method.

3.3. Quality of elephant grass at 60-day harvesting time

Sixty-day harvesting is the recommended time to produce high quality elephant grass. In this period, we found that volcanic ash can be used by elephant grass as supplement to grow and develop. The implementation of plowing method at the affected-farmland may result with an increasing of lipid percentage contained in elephant grass leaves. On other side, elephant grass planting plan at eruption-affected areas in MT Merapi by minimizing volcanic ash exposure to stolon will have leaves with highest water content and dry matter percentage.

Table 3. The quality of elephant grass leaves at 60-day harvesting time

Planting Media	% lipid	% water	% dry matter	Chlorophyll (mg/L)		
				Chlorophyll a	Chlorophyll b	Total
Soils	0.51	3.05	20.32	10.39	5.25	15.64
Ash at upper layer	0.40	5.08	23.41	11.97	6.18	18.15
Ash mixed with soils	0.89	4.90	20.45	7.42	3.99	11.41

We revealed that at 60-day harvesting time, elephant grasses which planted at media with ash at upper layer not only have the longest and the widest leaves, but also the greenest leaves. Table 3 shows that in that experimental group, the leaves contained the highest chlorophyll a and b. The low chlorophyll content may cause the yellowish leaves at the experimental group with direct exposure of volcanic ash to its roots.

4. CONCLUSIONS AND RECOMMENDATIONS

The results of this study showed that elephant grass is suitable to grow in the affected-areas at MT Mountain which covered by volcanic ash. The productivity of elephant grass increased with an increasing of harvesting time, and the suppression from volcanic ash exposure will disappeared. Sixty-day harvesting time was recommended as the result. The highest productivity and quality of the elephant grass resulted at planting media with volcanic ash supplementation at the topsoil suggested that plowing method is not required for the elephant grass planting plan at eruption-affected areas in MT Merapi. It is necessary for the Indonesian government to pay more attention to the role of elephant grass to highlight the inadequate supply of cattle fodder after eruption. Further research study can be expanded to find out the effect of cattle manure since the abundance resources in the subjected areas.

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REFERENCES

1. Aroeira, L., Lopes, F., Deresz, F., Verneque, R., Dayrell, M., De Matos, L., Maldonado-Vasquez, H., & Vittori, A. (1999). Pasture availability and dry matter intake of lactating crossbred cows grazing elephant grass (Pennisetum purpureum, Schum.). *Animal Feed Science and Technology, 78*(3), 313-324.

2. Dove, M. R. (1986). The practical reason of weeds in Indonesia: Peasant vs. state views ofImperata andChromolaena. *Human Ecology, 14*(2), 163-190.
3. Gertisser, R., Charbonnier, S. J., Troll, V. R., Keller, J., Preece, K., Chadwick, J., Barclay, J., & Herd, R. (2011). Merapi (Java, Indonesia): anatomy of a killer volcano. *Geology Today, 27*(2), 57-62.
4. Hadi, S. (2008). Improving vulnerable urban space in post-disaster in Yogyakarta and Central Java, Indonesia: Participatory and comprehensive approach *Vulnerable Cities: Realities, Innovations and Strategies* (pp. 225-240): Springer.
5. Kabi, F., Bareeba, F., Havrevoll, Ø., & Mpofu, I. (2005). Evaluation of protein degradation characteristics and metabolisable protein of elephant grass (Pennisetum purpureum) and locally available protein supplements. *Livestock Production Science, 95*(1), 143-153.
6. Mureithi, J., Tayler, R., & Thorpe, W. (1995). Productivity of alley farming with leucaena (Leucaena leucocephala Lam. de Wit) and Napier grass (Pennisetum purpureum K. Schum) in coastal lowland Kenya. *Agroforestry Systems, 31*(1), 59-78.
7. Muzayyanah, M. A. U., Syahlani, S. P., Suranindyah, Y., & Haryadi, F. T. (2014). Post Mount Merapi Eruption Recovery of Smallholder Dairy Farming: A Case Study of Disaster Management in Indonesia *Communities and Livelihood Strategies in Developing Countries* (pp. 129-142): Springer.
8. Purbajanti, E., Anwar, S., Widyati, S., & Kusmiyati, F. (2007). Kandungan protein dan serat kasar Rumput Benggala (Panicum maximum) dan Rumput Gajah (Pennisetum purpureum) pada cekaman stress kering. *Animal Production, 11*(2), 109-115.
9. Rodrigues, S., Dijkstra, J., Assis, A., France, J., & Tamminga, S. (2002). Evaluation of supplements to enhance nutrient supply and milk production of cattle fed diets based on elephant grass (Pennisetum purpureum) using a mathematical model. *Livestock Production Science, 77*(2), 273-286.
10. Suriadikarta, D., Sutono, D. E., Santoso, E., & Kasno, A. (2011). Identifikasi sifat kimia abu volkan, tanah dan air di lokasi dampak letusan gunung merapi. *Balai Penelitian Tanah (Balittanah).*
11. Voight, B., Constantine, E. K., Siswowidjoyo, S., & Torley, R. (2000). Historical eruptions of Merapi volcano, central Java, Indonesia, 1768–1998. *Journal of Volcanology and Geothermal Research, 100*(1), 69-138.
12. Warsini, S., Buettner, P., Mills, J., West, C., & Usher, K. (2014). The Psychosocial Impact of the Environmental Damage Caused by the MT Merapi Eruption on Survivors in Indonesia. *EcoHealth, 11*(4), 491-501.