Research article

Using Soil Improvement Materials for Enhancing Drought Tolerance of Rubber Plant

SUTTIPONG PRUANGKA*
Faculty of Technology, Udon Thani Rajabhat University, Udon Thani, Thailand
Email: dr.suttipong@yahoo.co.th

MONGKON TA-OUN
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

THANAPONG TULA
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

SOMPOSH KAEWRAHUN
Faculty of Agriculture, Khon Kaen University, Khon Kaen , Thailand

Received 20 December 2011 Accepted 18 April 2012 (*: Corresponding Author)

Abstract A study on the effects of applying a type of clay minerals on drought tolerance of rubber plant was carried out by incorporating bentonite at 0, 2, 4, and 8 percent w/w into loamy sand soil (Roi-et series). Factorial arrangement in CRD (complete randomized design) with 3 replications was performed in this research study. It was found that mixing bentonite 0-16 percent w/w with sugarcane bagasse, coconut fluff, peanut husk, black-burned rice husk, and fresh rice husk caused the water holding capacity to be in the ranges of 41.50-58.88, 44.3-105.0, 9.1-20.4, 128.6-154.2, and 3.1-21.3 percent, respectively. After 14 days of application for rubber varieties RRIM600 and RRIT251 grown on loamy sand, using bentonite 0, 2, 4, and 8 percent w/w caused the drought tolerance without irrigation to be 31-35 and 29-47 days, respectively. It was also found that small and medium sizes of rubber seedlings showed higher drought tolerance than those of big sizes because they still survived without irrigation 40-48, and 38-43 days, respectively. All sizes of RRIM600 seedling started wilting at moisture contents 4.9-5.9 percent and then showed permanent wilting at 3.30-3.39 percent w/w. Clay minerals used as basal application under field experiment significantly increased drought tolerance of young RRIM600 to be 158 days after planting whereas no application on the rubber tree could stand by the age of 92-135 days or averagely 111 days after planting. Increasing 15-15-15 concentration as basal fertilizer by the rates 100, 200, 400, and 600 g/plant significantly accelerated the termination of rubber tree. According to this, the rubber tree died at the age of 166, 149, 107, and 102 days after planting. Chemical fertilizer associated with clay mineral as basal application showed a trend of extending rubber age.

Key words soil improvement materials, bentonite, rubber, drought tolerance

INTRODUCTION

Since 2007 under the government policy, rubber plantation area in Northeast Thailand has been extended to 450,000 hectares. However, large land area of the Northeast contains various and complicated soil types and soil properties that will directly affect the success of this policy, particularly rubber tree younger than 5 years which should be intensively cultivated due to unsustainable root system during this growth stage (Office of Agricultural Economics, 2009). Naturally, 85 percent of roots are in deep zone whereas effective roots for nutrients absorption, 15 percent, are spreading in topsoil (Rubber Research Institute of Thailand, 2004). A preliminary data from survey research revealed that clay mineral used in substrate culture for seedling stage can improve drought tolerance of rubber plant. This research aimed at applying some types of organic material associated with bentonite clay mineral to improve drought tolerance of young rubber tree.

METHODOLOGY

There were 3 main methods used in this study as follows:

1. Effect of organic materials and clay mineral on soil water holding capacity

Five types of organic materials were used: sugarcane bagasse, coconut fluff, peanut husk, black-burned rice husk, and fresh rice husk. A 5x7 factorial arrangement in completely randomized design (CRD) with 3 replications was performed. Factor A was the ratio of mixing between organic materials and bentonite 0, 2, 4, 8, and 16 percent w/w, while factor B was the period of water deficit 2, 4, 6, 8, 10, 12, and 14 days, respectively.

2. Effect of bentonite on drought tolerance

Both rubber varieties RRIM 600 and RRIT251 were used as experimental materials. A 4x3 factorial arrangement in CRD with 3 replications was performed. Factor A were bentonite 0, 2, 4, and 8 percent w/w of loamy sand. Factor B were rubber sizes, small, medium, and large. Survival rate after water deficit was investigated.

3. Effect of mixed bentonite and basal fertilizers applied under field condition on drought tolerance

RRIM 600 was used as experimental material. A 2x5 factorial arrangement in CRD with 3 replications was performed. Factor A were bentonite mixed with organic matterials 0, and 10 percent w/w. Factor B were basal chemical fertilizer 15-15-15 at the rates of 0, 100, 200, 400, and 600 g/plant. Period of drought tolerance was collected.

RESULTS AND DISCUSSION

The research findings are as follows:

1. Water holding capacity

After 2 days from watering at saturated moisture content, bentonite mixed with coconut fluff showed the highest water holding capacity and then black-burned rice husk, sugarcane bagasse, peanut husk, and fresh rice husk. The remaining moisture contents were 134-205, 130-154, 72-94, 31-64, and 23-61 percent. At the day of 14^{th}, they were 46.8-100.8, 86.0-96.3, 41.6-57.2, 10.2-20.4, and 3.6-19.4 percent, respectively (Table 1).

Table 1 Effect of bentonite mixed with organic materials on water holding capacity (percentage of moisture contents)

Organic materials used for mixing with bentonite 0-16 percent w/w	Remaining moisture contents at the days after saturation (percent)		CV (%)
	2 Days	14 Days	
Sugarcane bagasse	72.0-98.1	41.5-58.8	3.30
Coconut fluff	132.9-207.7	44.3-105.0	4.74
Peanut husk	30.4-62.9	9.1-20.4	10.24
Black-burned rice husk	128.6-154.2	89.3-106.1	4.12
Fresh rice husk	20.6-65.6	3.1-21.3	2.70

2. Effect of bentonite on drought tolerance

Applying bentonite, 0, 2, 4, and 8 percent w/w on loamy sand increased drought tolerance of both RRIM600 and RRIT251 rubbers averagely from 31 to 55 days after water deficit for RRIM600 and 29 to 47 days for RRIT251. Small and medium sizes of rubber seedling showed better drought tolerance than large size. The period of surviving could last until 40-48 days for RRIM600 and 38-43 days for RRIT251 (Table 2). Increasing the amount of clay mineral can increase soil micropores and then reduce bulk density. This will increase available water capacity (Russell, 1973; Brady and Well, 2002).

Table 2 Number of the days that rubber died after water deficit among rubber varieties and sizes, and bentonite application rates

Rubber sizes of RRIM600	Bentonite application rates				Average*
	0%	2%	4%	8%	
Small	31.67	41.67	46.67	55.00	43.75b
Medium	35.00	43.33	51.67	61.67	47.92a
Large	28.33	38.33	45.00	48.33	40.00c
Average*	31.67d	41.11c	47.78b	55.00a	43.89
CV = 9.30%	LSD bentonite rates = 3.972, LSD rubber sizes = 3.440 at 95% level				
Rubber sizes of RRIT251	Bentonite application rates				Average*
	0%	2%	4%	8%	
Small	33.33	43.33	48.33	46.67	42.92a
Medium	28.33	43.33	48.33	48.33	42.08a
Large	26.67	38.33	43.33	45.00	38.33b
Average*	29.44c	41.67b	46.67a	46.67a	41.11
CV = 7.58%	LSD bentonite rates = 3.033, LSD rubber sizes = 2.627 at 95% level				

**Means in the same column/row followed by the same letter are not significant difference ($p<0.05$) under DMRT (Duncan's New Multiple Range Test)*

3. Effect of mixed bentonite and basal fertilizers applied under field condition on drought tolerance

In case of applying bentonite mixed with organic materials and basal fertilizer applied under field condition on drought tolerance of rubber, it was found that RRIM600 significantly increased survival period for all sizes (small, medium, and large) of young rubber tree, particularly the small size could last until 158 days comparing with no application that could last for only 92-135 days or averagely 111 days (Table 3).

Table 3 Number of the days that rubber (RRIM600) died after planting among rubber sizes, application rates of bentonite mixed with organic materials, and basal fertilizer rates of 15-15-15

Small size	15-15-15 (g/plant)					Average*
	0	100	200	400	600	
No application	134.7	128.7	115.0	84.7	91.7	110.9b
Mixed bentonite	162.7	202.3	182.3	129.0	113.0	157.9a
CV = 23.71%	148.7a	165.5a	148.7a	106.8b	102.3b	134.4
Medium size	15-15-15 (g/plant)					Average*
	0	100	200	400	600	
No application	131.0	140.0	119.3	96.7	72.0	111.8b
Mixed bentonite	214.0	208.7	169.7	112.0	112.0	163.3a
CV = 18.47%	172.5a	174.3a	144.5a	104.3b	92.0b	137.5
Large size	15-15-15 (g/plant)					Average*
	0	100	200	400	600	
No application	135.0	144.0	132.0	89.0	72.0	114.4b
Mixed bentonite	168.7	202.7	167.7	101.0	94.0	146.8a
CV = 28.61%	151.8ab	173.3a	149.8a	95.0bc	83.0c	130.6

**Means in the same column/row followed by the same letter are not significant difference ($p<0.05$) under DMRT (Duncan's New Multiple Range Test)*

Because of high specific surface areas, clay mineral as inorganic colloid generally increases cation exchange capacity (CEC); therefore, it induces the sustainability of soil fertility. Plant nutrient retention and availability are increased (Brady and Well, 2002). When organic materials are decayed, cementing agent will increase soil aggregation process and then increase soil water holding capacity (Tester, 1990; Asher et al., 2002). Applying 15-15-15 as basal fertilizer at the rate of over 200 g/plant increased the termination of RRIM600 at 92-102 days after planting. Medium size seedling could stand for drought tolerance better than the other small and large sizes. Averagely, rubber died within 138, 134, and 131 days for medium, small, and large sizes, respectively.

CONCLUSION

Bentonite 0-16 percent w/w mixed with coconut fluff showed the highest water holding capacity and then black-burned rice husk, sugarcane bagasse, peanut husk, and fresh rice husk. The remaining moisture contents were 46.8-100.8, 86.0-96.3, 41.6-57.2, 10.2-20.4, and 3.6-19.4 percent, respectively. Bentonite 2-8 percent w/w increased drought tolerance 29.81-50.86 percent for RRIM600 and 41.54-58.52 percent for RRIT251. Small and medium sizes of rubber seedling showed better drought tolerance than large size. They were 42.9-43.3, 42.1-45.0, and 38.3-39.1 days, respectively. RRIM600 was better than RRIT251 in terms of drought tolerance. They were 31.6 days, and 29.4 days, respectively. Applying bentonite mixed with organic materials and basal fertilizers under field condition increased survival period for all sizes (small, medium, and large) of young rubber tree. Applying over 200 g/plant of 15-15-15 as basal fertilizer increased the termination of seedlings. Averagely 88-100 days or 3 months after planting with no rainfall, rubber died.

ACKNOWLEDGMENTS

This research project was funded by The National Research Council of Thailand (NRCT) under 2008-2010. Thanks are extended to the Division of Land Resource and Environment, Faculty of Agriculture, Khon Kaen University for the conveniences and equipments in laboratory test.

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