The Effect of Rhizobium Inoculation and Harvesting Time on the Quality and Biomass Productivity of Peanut Straw (*Arachis hypogea*) in Sandy Soil

Nafiatul Umami[1], Bambang Suhartanto[1], Ristianto Utomo[1], Putri Dwinda Heristiningrum[1]
[1] Forage and Pasture Sci. Laboratory, Anim. Sci. Faculty, Universitas Gadjah Mada
Corresponding email: nafiatul.umami@ugm.ac.id

ABSTRACT

This study was aimed at determining the effect of rhizobium inoculant addition and harvesting time on the nutrient quality and biomass productivity of peanut straw (*Arachis hypogea)* as feed stuff in sandy soil area. The planting was conducted by using twelve polybag filled with sandy soil from Berbah, Sleman, Yogyakarta. The experimental design was 2x2 Factorial design with 3 replications. The two treatment factors were: harvesting time factor (HT), it consisted of harvest at 80 days after planting (HT1) and harvested at 90 days after planting (HT2), the second factor was rhizobium inoculation (R) consisted of not inoculated (R0) and inoculated (R1). The result of the research showed that harvesting time and inoculation were not affecting the vegetative and generative stage of growth. Harvesting time had significant effect ($P<0.05$) on chemical composition of peanut straw; crude protein 12.45% (HT1) and 11.21 (HT2), crude fiber 21.52% (HT1) and 22.83% (HT2) and ash 11.87% (HT1) and 13.83 (HT2). Rhizobium inoculant addition had effect (on nodulation, value for effective nodule for R0 was 78% and for R1 was 89% ($P<0.05$). Interaction between harvesting time and rhizobium inoculant addition yielded significant and were not different on dry matter and organic matter production. It could be conclude that inoculant and harvesting time factor had affect on vegetative stage of growth, nutrient quality and nodulation but did not have affect on biomass straw production.

Keywords: *Arachis hypogea,* Harvesting time, Rhizobium, Productivity

INTRODUCTION

The sandy soil has potential to be developed as a cultivation area for forage. According to Rao (1996) (a) textures of sandy soil are single grained, feel gritty to the touch, and has a high percentage of sand (more than 70%), (b) characteristics of sandy soil has particles that create large pore spaces to improve aeration so water flows through the large pore spaces quickly, lack the ability to hold nutrients and are not fertile. One of the methods to improve quality of sandy soil is by the addition of rhizobium bacteria. This method is used to increase the effectiveness of nitrogen fixation on legume. Legume is a plant that has high protein content than grass. Peanut is a legume crop that was grown mainly for its edible seeds. The peanut plant waste can be used for animal feed, particularly ruminants. The plant needs nitrogen nutrient for its growth because the resulted ammonium can promote growth and delay the seeds maturity, so it will extend the vegetative stage of growth (Winarso, 2005).

Symbiosis of legume and rhizobium bacteria causes the formation of root nodules that can catch nitrogen fixation from the air (Fuskhah, 2011) to fulfill nitrogen requirement of the plant. Rhizobium inoculation addition can increase nitrogen in soil, overcoming nitrogen deficiency in plant growth, and increase yield by 20 to 35% mainly on less fertile soil compared to fertilized soil (Widiastuti, 1989). The age determination is needed to get high quality seeds as food and forages as feed. This study was expected to give information about the potential of

sandy soil as medium of peanut planting, rhizobium inoculation addition and whether harvesting time factor affected biomass productivity in sandy soil.

MATERIALS AND METHODS

This study was conducted for 4 months from May to August 2007 in the field Pasture and Forage Science Laboratory, Animal Science Faculty, Universitas Gadjah Mada, Yogyakarta.

Materials

The materials used was peanut Rabbit variety, SP-36 fertilizer (46% P_2O_5), KCl fefrtilizer (60% K_2O), insecticides Dursban brand 20 EC, rhizobium inoculant (Legin) from Microbiology Laboratory, Faculty of Agriculture, Universitas Gadjah Mada, and 12 polybag size 60 x 55 cm with diameter of 30 cm. The sandy soil was taken from Kalitirto, Berbah, Sleman.

Methodology

The soil was sieved with a 0.3 cm sieve. Filled into plastic bags in which each plastic bag was filled with 10 kg of sandy soil and placed in a greenhouse with a distance of 0.5 x 0.5 cm. Inoculation of peanut seed was conducted by spraying aquades on seed, drained, mixed legin in Erlenmeyer with dose of 0.293 g of legin for 29.3 g of seed. Planting was conducted by piercing the sandy soil in plastic bag as deep as 2 cm on 4 holes and filled 1 seed each hole. SP-36 fertilizer (60 kg/ha) and KCl fertilizer (80 kg/ha) were put together during seed planting. Fertilization is conducted by piercing the sandy soil in the middle of plastic bag with a distance of approximately 7.5 cm from each seeding hole. Thinning of plant (age 10 days). Watering plants was conducted once a day. Eradication of insect pests was conducted by spraying insecticides with dose 0.7 to 1.5 ml/l water. Observations comprised: vegetative and generative stage growth. Harvesting of plant (age 80 days and 90 days). The roots of the plant were cleaned and separated from the root nodules to calculate the percentage of effective root nodules. Chemical analysis was conducted by AOAC method. The experimental design used was 2x2 factorial design with 3 replications. The two treatment factors were: harvesting time factor (HT), consisted of harvest at 80 days after planting (HT1) and harvested at 90 days after planting (HT2), the second factor was rhizobium inoculation (R) consisted of not inoculated (R0) and inoculated (R1). Data was analyzed by using SPSS 10 program. Data of vegetative and reproductive stages growth was analyzed by using t-Test, and data of stem diameter was analyzed by using Split plot test. Data chemical composition, biomass productivity peanut straw and peanut pods was analyzed by using factorial test and the Duncan's new multiple range test was used to separate means.

RESULTS AND DISCUSSION

Peanut plant growth

Peanut plant growth was divided into two stages: vegetative and generative stage growth. According to Boote (1982), determination of the vegetative stage growth was based on the number of developed nodes on the main axis of the peanut plant, beginning with “VE” stage, “V0” stage, and “V1” stage. The “VE” stage or emergence was defined as cotyledons near the soil surface with the seedling showing some visible part of the plant. The “V0” stage began when cotyledons were flat and open at or below the soil surface. The “V1” stage was defined as one developed nodes with one tetra foliolate leaf unfolded and its leaflets were flat. Generative stage growth was based visually observable events related to flowering, pegging, fruit growth, seed growth, and maturity. In this study, the observation of the generative stage

growth related to flowering. The results of the observed vegetative and generative stage growth of peanut plant were shown in Table 1.

Table 1. Vegetative and generative stage growth of peanut planted in sandy soil with rhizobium inoculation (R) treatment

Stage growth	Days	
	R0	R1
Vegetative stage growth		
VE[ns]	4	4
V0[ns]	6	6
V1[ns]	8	8
Generative stage growth		
Start flowering[ns]	25	25
Full flower[ns]	29	29

[ns]Not significant

Table 1 showed that treatment with rhizobium inoculation has not significant effect (P>0.05) on vegetative and generative stage growth of peanut plant. The plant required nutrient from soil in vegetative stage growth and nitrogen fixation in this stage growth was not yet active. The nitrogen fixation activity for peanut plant occurred since age of the plant was 25 to 30 after planting, it reached maximum as it approaches the final stage growth and decreased at the final stage growth (Suryantini, 1993). The peanut plant started to flower at 25 days age and full flower at 29 days. Rukmana (2005) was in agreement that flowering phase of peanut plant occurred at 4 to 6 weeks age. The peanut plant flower was yellowish orange and typical peaflower in shape.

Nutrient value of peanut straw

The nutrient value of peanut straw in sandy soil was shown in table 2.

Table 2. Nutrient value of peanut straw in sandy soil (%)

Treatments	CP	CF	EE [ns]	Ash	NFE [ns]
Harvesting time (HT)					
HT1	12.45 [a]	21.52 [b]	3.22	11.87 [b]	50.93
HT2	11.21 [b]	22.83 [a]	3.07	13.83 [a]	47.40
Rhizobium inoculation (R)					
R0	11.71 [ns]	21.98 [ns]	3.12	12.82 [ns]	50.36
R1	11.95 [ns]	22.37 [ns]	3.17	12.88 [ns]	47.97
Interaction between HT and R					
HT1R0	12.48 [ns]	21.21 [ns]	3.10	11.97 [ns]	50.25
HT1R1	12.43 [ns]	21.84 [ns]	3.35	11.78 [ns]	50.61
HT2R0	10.94 [ns]	22.76 [ns]	3.15	13.68 [ns]	49.47
HT2R1	11.48 [ns]	22.89 [ns]	2.99	13.97 [ns]	45.33

[a,b] Different superscripts in the same row indicate significant differences (P<0.05)

[ns] Not significant

Tabel 2 showed that harvesting time had significant effect (P<0.05) on nutrient value of peanut straw; CP 12.45% (HT1) and 11.21% (HT2), CF 21.52% (HT1) and 22.83% (HT2) and ash 11.87% (HT1) and 13.83% (HT2). According to Hartadi *et al*. (2005), the nutrient value of peanut straw were CP 12.5%, CF 25.8%, and ash 10.6%. The crude protein content of harvest at 80 days was higher than which at 90 days. It was not similar to crude fiber and ash content. The age of the plantincrease caused decrease the protein content, mineral content, and soluble carbohydrate, but increase the crude fiber and lignin content (Reksohadiprodjo, 1985).

The mineral content or ash content of the plant was variable depending on species and botanical fraction (Tillman *et al.,* 1998). Based on analysis of variance, treatments for harvesting time, rhizobium inoculation addition, and interaction of both, they had not affected extract ether and nitrogen free extract content.

Root nodules

Table 3. The effective root nodules of peanut planted in sandy soil (%)

Treatments	Effective root nodules
Harvesting time (HT)	
HT1	82.33 ^{ns}
HT2	84.67 ^{ns}
Rhizobium inoculation (R)	
R0	78.00 ^{b}
R1	89.00 ^{a}
HT x R	
HT1R0	78.00 ^{ns}
HT1R1	86.67 ^{ns}
HT2R0	78.00 ^{ns}
HT2R1	91.33 ^{ns}

^{a,b} Different superscripts in the same row indicate significant differences ($P<0.05$)
^{ns} Not significant

Table 3 showed that rhizobium inoculation treatment was significantly different ($P<0.05$). The rhizobium inoculation treatment was higher in rhizobium addition (89.00%). The plant with rhizobium addition can attach more nitrogen, which indicated the number of effective root nodules. The effective root nodule had a pink color which indicated the presence of leghemoglobin. It was a pigment which its molecule consisted of apoprotein and heme, and formed code for plant DNA and rhizobium DNA, as well as served as oxygen-carrying pigments like hemoglobin in the blood (Triwahyuningsih, 1994). This molecule was hallmark of nodule effectiveness (Buchanan and Gibbans, 1974) and was directly related to nitrogen fixation activity (Rao, 1996). The success of the symbiosis was determined by several factors: the effectiveness and efficiency of the strains of rhizobium bacteria, nutrients for host plant, and environmental (limiting factors of soil that affect bacteria of host plant) (Adimiharja, 1989).

Production of peanut straw

The production of dry matter and organic matter in peanut straw was shown in Table 4. Dry matter and organic matter production per plastic bag were not affected by treatments ($P>0.05$). The carbohydrates that was a part of the organic matter were used by plants for a fully-expanded fruit (full pod), and effected the age of plant since it increased crude fiber content and decrease other nutrients like protein and carbohydrate for seed development. Gardner *et al.* (1991) was in agreement that non-structural carbohydrate was the first seeds' utilized source. According to Anggorodi (1979) since the age of the plant increase, the vegetative proteins will be used by the seed to grow.

Table 4. Production of peanut straw planted in sandy soil (g/plastic bag)

Treatments	Production of dry matter ns	Production of organic matter ns
Harvesting time (HT)		
HT1	9.70	8.55
HT2	9.72	8.40
Rhizobium inoculation (R)		
R0	9.92	8.28
R1	9.50	8.67
HT x R		
HT1R0	9.57	8.43
HT1R1	9.83	8.67
HT2R0	9.42	8.13
HT2R1	10.01	8.66

ns Not significant

CONCLUSIONS

The harvesting time and rhizobium inoculation treatment are not affected on the vegetative stage growth, generative stage growth, and peanut straw production, but on nutrient quality and root nodulation. The best result obtained is the one that was harvested time 90 days age.

ACKNOWLEDGEMENT

The authors would like to thank Prof. Ir. R. Djoko Soetrisno, M.Sc., Ph.D. for the kindness gave suggestion during research and writing report.

REFERENCES

Adimiharja, M. 1989. Hasil dan program penelitian penambatan nitrogen secara hayati pada tanaman kacang-kacangan di Universitas Lampung. Lokakarya Penelitian Penambatan Nitrogen Secara Hayati Pada Tanaman Kacang-kacangan. Bogor. Pp: 139-146.

Anggorodi. 1979. Ilmu Makanan Ternak Umum. PT. Gramedia. Jakarta.

Boote, K.J. 1982. Growth stages of peanut (*Arachis hypogaea* L.). Peanut Science 9: 35-40.

Buchanan, R.E. and N.E. Gibbans. 1974. Bergey's Mannual of Deterninate Bacteriology. 8th Edition. The William and Wilkins Company. Baltimore.

Fuskhah, E. 2011. The use of saline tolerant rhizobium bacteria and calcium for developing forage legumes in northern central java coast. Dissertation. Gadjah Mada University. Yogyakarta.

Gardner, F.P., R.B. Pearce, and R.L. Mitchell. 1991. Fisiologi Tanaman Budidaya. Terjemahan. Universitas Indonesia Press. Jakarta.

Hartadi, H., S. Reksohadiprodjo, and A.D. Tillman. 2005. Tabel Komposisi Pakan Untuk Indonesia. Cetakan ke-5. Gadjah Mada University Press. Yogyakarta.

Rao, N.S.S. 1996. Soil Microorganism and Plant Growth. Second edition. Indonesia University Press. Jakarta.

Reksohadiprodjo, S. 1985. Hijauan Pakan Ternak Tropik. BPFE. Universitas Gadjah Mada. Yogyakarta.

Rukmana, R. 2005. Kacang Tanah. Kanisius. Yogyakarta.

Suryantini. 1993. Pembintilan dan penambatan nitrogen pada tanaman kacang tanah. Monograf Balitas Malang No 12 Kacang Tanah. Balai Penelitian Tanaman Pangan. Malang.

Tillman, A.D., H. Hartadi, S. Reksohadiprodjo, S. Prawirokusumo, and S. Lebdosoekojo. 1998. Ilmu Makanan Ternak Dasar, Cetakan keenam. Gadjah Mada University Press. Yogyakarta.

Triwahyuningsih, N. 1994. Mekanisme fiksasi nitrogen pada legum. Agro Universitas Muhammadiyah Yogyakarta 4: 6-11.

Winarso, S. 2005. Kesuburan Tanah, Dasar Kesehatan, dan Kualitas Tanah. Gava Media. Yogyakarta.