THE INFLUENCE OF SEASON AND TOPOGRAPHY ON MANGANESE (Mn) STATUS OF GRAZING JAVA THIN-TAILED SHEEP IN THE AGRICULTURE AREA IN MIJEN OF SEMARANG-CENTRAL JAVA

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ABSTRAK

Penelitian ini bertujuan untuk mengkaji status mineral mangan (Mn) pada domba Jawa ekor tipis (DJET) yang digembalakan, interelasinya dengan status Mn hijauan dan tanah serta pengaruh faktor musim serta topografi terhadap status mineral tersebut. Sebanyak 20 ekor domba DJET jantan berumur sekitar 6 bulan dan 2 petak penggembalaan dengan vegetasi rumput lapangan digunakan dalam penelitian ini. Faktor perlakuan I adalah topografi : datar dan berlereng, sedangkan faktor perlakuan II adalah musim: kemarau dan penghujan. Domba percobaan dibagi 4 kelompok, masing-masing terdiri atas 5 ekor sebagai ulangan dan digembalakan selama 2 bulan. Variabel yang diukur adalah pH tanah, kadar Mn tanah, hijauan, feses dan plasma darah. Data yang terkumpul diolah dengan analisis ragam, pola perlakuan faktorial 2 x 2 dalam rancangan acak lengkap. Kadar Mn plasma darah domba yang digembalakan pada petak penggembalaan datar dan berlereng, masing-masing 0,62 dan 0,61 mg/l dalam musim kemarau, sedangkan dalam musim penghujan masing-masing 0,68 dan 0,52 mg/l. Topografi tidak berpengaruh pada kadar Mn plasma darah dalam musim kemarau. Kadar Mn plasma darah domba dalam musim penghujan pada topografi berlereng terendah, sedangkan pada topografi datar tertinggi ($P<0,05$). Kadar Mn tanah, hijauan, feses dan plasma darah domba percobaan menunjukkan status mineral Mn yang memadai.

Kata kunci : domba ekor tipis, topografi, petak penggembalaan, musim, mangan

ABSTRACT

The research was aimed to study the manganese (Mn) status of grazing in Java thin-tailed sheep (JTTS), its interrelation with Mn status in the forages and soil, the influence of seasonal factors and land topography upon the status of respected mineral. Twenty male JTTS of about 6 months old and 2 paddocks with field grass vegetation were used in the research. Treatment factor I was topography namely plain and slope, while treatment factor II was season, namely dry season and rainy season. The number of experimental sheep was divided into 4 groups with 5 heads of sheep for replication in each group and had been grazed for 2 months. The measured variables were soil pH, Mn content in the soil, forage, feces, and blood plasma. The collected data were processed using analysis of variance with factorial treatment pattern of 2 X 2 in completely randomized design. Mn level in blood plasma of sheep grazed on plain and slope paddocks were 0.62 and 0.61 mg/l, respectively, in dry season whereas in rainy season were 0.68 and 0.52 mg/l, respectively. Topography did not influence the level of Mn in blood plasma in dry season. Level of Mn in blood plasma of the sheep was lowest in slope area, whereas in plain area was the highest ($P<0.05$). Manganese level of soil, forage, feces and blood plasma of experimental sheep showed the adequate Mn status.

Keywords: thin tailed sheep, topography, paddock, season, manganese

INTRODUCTION

Manganese (Mn) is one of the essential microminerals which play broad roles in metabolism and physiology of animal. According to Suttle (2010), the important function of Mn among others is to support carbohydrate and lipid metabolism through the activity of pyruvate carboxylase enzyme. This respective enzyme catalyses convert pyruvic acid into oxalo-acetic acid which is an important key compound in the process of gluconeogenesis and oxidation of acetyl-Co.A through tricarboxylic acid cycle (Wesmant *et al.*, 2007). Gluconeogenesis is the main process for glucose supply in ruminant. Acetyl-Co.A formed from pyruvic acid and fatty acid oxidation will be further oxidized through the condensation with oxalo-acetate in tricarboxylic acid cycle to produce energy which are trapped in adenosinetriphosphate (ATP) (Ali *et al.*, 2005). Manganese is also the integral part of arginase enzyme, the terminal enzyme in urea cycle, as a part of dismutase-superoxide enzyme which is needed for protection of cells from damage caused by superoxide radicals (O^-_2) (StClair, 2004). Manganese plays important role as cofactor of transferase glucosilmuco-polysacharide enzyme which is required on the mucopolysacharide and lipopolysacharide synthesis, used for growth and maintenance of bone and cartilage (Leach and Harris, 1997; Moniello *et al*., 2005). Besides, Mn has great influence upon the hormones synthesis and supporting the normal function of corpus luteum and development of testicles (Hansen *et al.*, 2006).

The broad metabolic role of Mn shows the important role of this micromineral on the various processes of life and animal production especially for growth and reproduction. Deficiency, the excess and imbalance of respected mineral can lead to problem on animal health and productivity (Suttle, 2010). Deficiency of Mn in sheep and goat can cause joint diseases, deformity of foot, difficulty of movement and balancing disturbances (Lassiter and Morton, 1968; Anke *et al.*, 1986). Hansen *et al.* (2006) argued that deficiency of Mn in cow will cause joint disorders and abnormality of calve birth weight. Other problem that is not less serious than these problems is subclinical deficiency which is reflected among other things in the low body weight gain, low conception rate and infertility (Hansen *et al*., 2006). This phenomenon often get less attention because it does not show the clinical symptom, but the impact of it is huge because it can cover a wide area and a large number of animal, causing big losses. Toxicity due to the excess of Mn and imbalance in its interaction with other minerals, especially Fe, Ca, and P also needs attention and careful handling in relation to livestock health and productivity. Grace (1973) showed that sheep fed with Mn more than 400 mg/kg DM decreased the body weight by 40%. Feeding with about 2000 mg/kg of Mn content, besides suppressing the growth it also can lower hemoglobin level and leads to death. Deficiency of iron (Fe) increases the toxicity of Mn, while the excess of Fe will reduce the utility of Mn. The high level of Ca and P in the ration can decrease the absorption of Mn (Suttle, 2010)

Fulfillment of nutritional needs of the grazing livestock depends on forage quality of pastures. Forages in pastures are rarely able to meet the livestock needs for all minerals (McDowell *et al*. 1997; Ben Salem *et al*., 2008). Forage mineral levels are mostly determined by the mineral status of the soil which is affected by the topography and the season (Aregheore *et al.*, 2007; Bassirani *et al.*, 2011). McDowell *et al.* (1983) stated that in the tropical countries, especially in the upland areas, mineral deficiency is very common due to erosion and leaching. High rainfall could worsen the conditions, whilst drought can also reduce the availability of minerals for plants that have an impact on the low levels of minerals in the forage which cause mineral deficiency in animal (Ibrahim *et al.*, 2011). Manganese is one of minerals that its availability for plants is strongly influenced by the condition of the land associated with the season, such as pH and soil moisture (Sowande *et al.*, 2008; Fardous *et al*., 2011).

Mineral supplementation is one of the effective solutions to meet the requirement of the mineral for grazing animal. On the other hand, supplementation which is not based on a proper reason will not only be ineffective and a waste, but can also create new problems, namely mineral imbalance and toxicity which lead to negative impact on animal health and, in turn, decreases productivity (Rojas *et al*., 1993). It is necessary to do research to obtain accurate information about the status of mineral of grazing animal, its interrelationships with mineral status of forage and soil, as well as the influence of season and topography in such interrelation, and the impact on animal performance. Based on this information it can be determined whether mineral supplementation is needed, as well as for a rational formula of mineral supplements, and the proper time of supplementation to increase the productivity of grazing animal.

Regarding sheep population, Central Java is put in the second rank among provinces in Indonesia. Sheep production centers in Central Java are located in upland areas, such as in the Mijen area of Semarang. All of those sheep farms are handled by farmers in traditional way of maintenance, and grazed on the common grazing places with grass field vegetation. Study of Mn status on sheep grazing in that area can be expected to provide necessary information about the necessity of Mn addition in mixed mineral supplements that might be needed to improve the productivity of sheep grazing in the farming area in Mijen, Semarang. Mijen is upland area with hilly topography, so that sensitive to erosion and mineral leaching.

MATERIALS AND METHODS

The material used in this study were 20 heads of Java thin tailed (JTT) sheep of about 6 months old, with average body weight of 12.93 ± 1.62 kg and 2 plots of paddock (the paddocks wide were 5,000 m^2, respectively) with field grass vegetation, where the plot I was the plain topography and the plot II was slope topography (nutrient composition of forage in the paddock is showed in Table 1). The main equipment used consisted of needle and venoject tube, atomic absorption spectrophotometer (AAS), soil pH meter, analytical scales, weighing scales for animal and for feedstuff, centrifuge.

There were 2 factors of treatment, namely paddock topography (factor I) and season (factor II). Factor I consisted of plain topography and slope topography, while the second factor consisted of the dry season and the rainy season, therefore there were 4 combinations of treatments. The twenty of experimental sheep were divided into 4 groups based on the treatment combination, each consisting of 5 sheep as replication. Ten sheep grazed in the dry season and the other 10 sheep grazed in the rainy season. The duration of grazing period in each season was 2 months.

Samples were taken at each end of the grazing period. Soil sample was composite of 5 subsamples taken at 5 points from 5 different places in each paddock with a depth of 15 cm. Forage samples were taken by referring to the method of hand-plucked by Lebdosoekojo *et al*. (1980). Forage species taken was the most often grazed by experimental sheep, based on a detailed investigation upon the grazing pattern by experimental sheep. Forage samples were taken at the same point with the soil sampling. Blood samples were taken from the jugular vein of every experimental sheep with needles and venoject tubes containing lithium heparin as anticoagulant. Feces samples were taken with a special bag as feces container which was mounted on each experimental sheep. The experimental sheep weighed in the beginning and the end of experiment. Forage dry matter (DM) consumption was estimated according to Ramirez-Perez (2000) using chromic oxide as external indicator.

The variables measured were soil pH, Mn levels of soil, forage, feces and blood serum of experimental sheep. Soil pH was determinated according to the instructions of the test device used for the dry soil (Setyorini *et al*., 2009). Soil preparation for Mn assay was conducted based on Rhue and Kidder method (1983), while for forage, feces, and blood samples were prepared by using the method of Fick *et al*. (1979). Measurement of Mn levels in the soil, forage, feces and blood plasma were carried out by using atomic absorption spectrophotometer (AAS).

The collected data was processed statistically by using analysis of variance, with 2 x 2 factorial treatment patterns in completely randomized design (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Manganese status of grazing sheep was the resultant of several interacting factors. These factors among others were soil pH, soil Mn, forage Mn, nutrient composition and digestibility of forages in relation to topography and season (Khan *et al*., 2004). The results of the soil pH analyses, levels of soil Mn, forage, sheep feces and blood plasma of experimental sheep were summarized in Table 2. Analysis of variance showed a significant interaction effect between the topography and season on the soil pH and soil Mn, forage, feces and blood plasma of experimental sheep ($P<0.05$).

Soil pH

Value of average soil pH in the dry season were 6.5 and 6.3 in respected paddock with plain and slope topography, whereas in the rainy season were 6.1 and 6.2 (Table 2.). The soil pH of plain paddock were lower during rainy season ($P<0.05$)

Table 1. Nutrient Composition of Forage in Research Sites Paddock

Topography	Season	Nutrient				
		CP	CF	NFE	EE	Ash
		---------------------------------(%)--------------------------------				
Plain	Rainy	10.65	27.12	46.55	2.11	13.57
	Dry	9.25	30.13	44.14	2.32	12.76
Slope	Rainy	10.77	27.93	46.35	2.05	12.90
	Dry	10.12	29.81	43.88	2.89	13.30

CP: crude protein, CF: crude fiber, NFE: nitrogen free extract, EE: ether extract

Table 2. Soil pH, Level of Mn in the Soil, Forage, Feces, and Blood Plasma

Topography	Season	Soil pH	Mn of Soil	Mn of Forage	Mn of Feces	Mn Blood Plasma mg/l
			------------- (mg/kg) -------------			
Plain	Dry	6.5^{a}	68.60^{a}	58.47^{b}	63.52^{a}	0.62^{b}
	Rainy	6.1^{c}	63.56^{b}	65.38^{a}	53.57^{c}	0.68^{a}
Slope	Dry	6.3^{b}	59.32^{c}	41.96^{c}	56.42^{b}	0.61^{b}
	Rainy	6.2^{c}	52.31^{d}	42.42^{c}	52.58^{c}	0.52^{c}

a, b, c, d: Different superscripts in the same column indicated significant difference (P<0.05)

as compared to the dry season. This was might be due to the frequent occurrence of puddle caused by high rainfall. According Adeoye and Agboola (1985), the puddle occurred due to high rainfall can cause alkaline cations such as Ca and Mg leached, that makes the soil become more acidic.

The pH soil of the sloping paddock was also higher during the dry season than in the rainy season (P<0.05), but still lower than the pH of the soil during the dry season in the plain paddock (P<0.05). In the rainy season, the soil pH of paddock on sloping topography was not significantly different from the plain paddock, although the puddle did not occur there. This could occur because of erosion which caused loss of topsoil, and the soil cultivation layer became more acidic (Lesturgez *et al*., 2006). This phenomenon was also assumed to cause lower soil pH of the slope paddock during the dry season as compared to plain paddock in the dry season.

In general, soil pH did not too vary since it laid between 6.1 to 6.5. This was due to the pH buffering capacity in the soil. Components that have this capacity was weak acid groups such as carbonates and soil colloidal complex (Oortz *et al*., 2004). The respected pH value was within the optimal range for manganese absorption by plants, which was from 5.5 to 6.5 (Dollar and Keeney, 2006).

Soil Mn status

Soil manganese levels of plain paddocks in the rainy season and dry season respectively were 63.56 and 68.60 mg/kg, while the slope paddocks were 52.31 and 59.32 mg / kg (Table 2). Soil manganese levels of plain paddock in the rainy season were lower (P<0.05) than the dry season. This condition could occur due to leaching, along with high rainfall. The amount of leaching was the greater because of the higher solubility of Mn due to the low pH of the soil in the rainy season. In line with the decrease in pH, the manganic form ($Mn^{3,4\ -7+}$) will undergoes reduction process to the manganous ($Mn^{2\ +}$) form which more soluble (Adeoye and Agboola, 1985). Decreasing of soil aeration due to puddle that occurred in high rainfall may increase the reduction of Mn oxide to soluble Mn ($Mn^{2\ +}$), thereby will increase the amount of soluble Mn and in turn will increase the leaching of Mn (Dere *et al*., 2011).

Soil Mn levels which were lower ($P < 0.05$) found on the sloping paddock both in the dry season and the rainy season, as compared to plain paddock. This was might be due to the loss of some Mn caused by soil erosion (Zhang *et al*., 2005, Brunel *et al*., 2011). The loss of Mn greater on slopes paddocks in the rainy season, this was due to the higher solubility of Mn since it had a lower pH which resulted the lowest levels of Mn. Soil Mn levels at the experimental paddocks ranged from 52.87 to 68.37 mg/kg which was above the minimum to meet the nutrient needs of the plants, namely 5 mg/kg (Rhue and Kidder, 1983).

Forage Mn status

Manganese levels of forage in the dry season and rainy season at plain paddocks were 58.47 and 65.38 mg/kg, while the slope paddocks were 41.96 and 42.42 mg/kg respectively. The result of mean difference test showed that forage Mn levels at the plain paddock were lower ($P<0.05$) in the dry season than in the rainy season. Dry soil conditions reduced the availability of Mn for plants, so that the levels of Mn forage in the dry season was lower than the levels of this mineral in the rainy season, although the Mn content of the soil during the dry season was higher ($P<0.05$) than in the rainy season (68.60 vs. 63.56). The higher availability of soil Mn in the rainy season was also supported by lower soil pH ($P<0.05$) in the rainy season than in the dry season (6.1 vs. 6.5). The decreasing of soil pH will increase the reduction of Mn in the manganic form ($Mn^{3\ -\ 7\ +}$) to $Mn^{2\ +}$ which was more soluble and absorbable by plants (Adeoye and Agboola, 1985).

Dry condition that reduced the availability of Mn and the erosion took place which decreased the soil Mn levels caused lower ($P<0.05$) levels of forage Mn at slope paddocks in the dry season compared to the levels of forage Mn at plain paddocks in both the dry and rainy seasons. Manganese availability at slope paddocks in the rainy season was higher than the dry season (based on lower soil pH), but its level was lower (52.31 vs 59.32 mg/kg), so that the levels of forage Mn during the rainy season was not different significantly from the mineral content in the dry season. Table 2 shows the levels of forage Mn in the research sites ranged from 41.96 to 65.38 mg/kg. Forage Mn level were sited within the normal range for a plant that were 30-200 mg / kg (Nafiu *et al*., 2012) that were adequate to meet the requirement of sheep, which was 15-25 mg/kg (Standing Committee for Agriculture, 1990). This condition was supported by adequate soil Mn level and optimal availability for plants.

Manganese status of grazing sheep

Levels of fecal Mn. Level of fecal Mn of the experimental grazing sheep at plain paddocks in the dry season and rainy season were 63.52 and 53.57 mg/kg, whereas at the slope paddocks were 56.42 and 52.58 mg/kg (Table 2.). Levels of fecal Mn in the dry season was higher ($P<0.05$) than the levels of fecal Mn in the rainy season, although the levels of forage Mn in rainy season were higher than that in the dry season. This phenomenon was found in both plain and slope paddocks be caused the dry matter digestibility (DMD) of forage in rainy season were sounded higher than that in dry season. The presumption was based on the levels of crude protein (CP) that were higher (10.65 and 10.77 vs 9.25 and 10.12%) and crude fiber (CF) which were lower (27.12 and 27.23% vs. 30.13 and 29.81%) of forage in the rainy season as compared to the dry season, from both plain and slope paddocks (Table 1). High level of CF also reflected an increasing of the proportion of mature plant tissues (Van Soest, 1994). Manganese is immobile mineral, so the plants accumulate it in the mature tissues (Mousavi *et al*., 2011). Mature tissues with higher CF levels had lower digestibility, thus Mn contained in it was also had lower digestibility and it was reflected in the higher levels of Mn in the feces. Level of fecal Mn in the sheep grazed at the slope paddocks were lower ($P<0.05$) than it in the plain paddocks, because the Mn level of forage taken from slope paddocks was also lower than from the plain paddocks, both in the dry season and the rainy season (41.96 and 42.42 vs. 58.47 and 65.38 mg/kg).

Blood plasma level of Mn. Manganese blood plasma level taken in the dry season and rainy season were 0.62 and 0.68 mg/l respectively at plain paddocks, whereas at the sloping paddocks were 0.61 and 0.52 mg/l respectively (Table 2). The mean difference test showed that Mn level of blood plasma taken at plain paddocks during the rainy season was higher ($P<0.05$) than in the dry season. This happened because the level of forage Mn during the rainy season was higher than the level in the dry season (65.38 vs 58.47 mg/kg). The higher blood plasma level of Mn in the rainy season than in the dry season at the plain paddocks was also caused by the higher absorptivity of Mn in the rainy season than in the dry season, which was reflected in the lower level of fecal Mn in the rainy season than in the dry season (53. 57 vs 63.52 mg / kg).

Different phenomena was occurred in the slope paddock. The Mn level in sheep blood plasma in the dry season was higher ($P<0.05$) than the rainy season (0.61 vs. 0.52 mg/l), although the levels of Mn in the forage on the dry season was not significantly different as compared to forage Mn level in the rainy season 41.96 vs 42.42 mg/kg) with a higher absorptivity, which was reflected in the lower level of fecal Mn in the rainy season than the dry season (52.58 vs 56.42 mg/kg). That case could occur because the metabolic rate of sheep grazed in the dry season was lower than in the rainy season, so the requirement of Mn to support metabolism was lower, thus level of Mn in the blood plasma was higher. The lower of that metabolic rate was reflected in the lower daily body weight gain (DBWG) of experimental sheep in dry season compared to DBWG in rainy season at slope paddock (76 vs 82 g). Effect of metabolic rate on blood plasma level of Mn had also been demonstrated in the investigation by Khan *et al*. (2004), which showed that blood plasma of lactating goats had lower Mn levels than non-lactating goats (0.9 vs. 1.6 mg/l), while the Mn content of the lactating goat feces was lower than the level of Mn in non lactating goat feces (58 vs. 70 mg/kg).

Table 3. Consumption of Forage Dry Matter (DM) and Daily Body Weight Gain (DBWG) of Experimental Sheep

Topography	Season	Consumption of DM (g)	DBWG (g)
Plain	Rainy	488^{a}	95^{a}
	Dry	360^{c}	73^{c}
Slope	Rainy	413^{b}	82^{b}
	Dry	369^{c}	76^{c}

a, b, c: Different superscripts in the same column indicate the significant difference ($P<0.05$).

Sheep grazed at plain paddock in the rainy season had the highest blood plasma Mn level ($P<0.05$), namely 0.68 mg/l (Table 2), similarly with the highest DBWG, namely 95 g/day (Table 3). This was presumably because the level of forage DM consumed by those sheep was the highest, 488 g/day (Table 3), with the highest levels of forage Mn (65.38 mg/kg) and high absorptivity of Mn (reflected in the low of fecal Mn level among the treated groups namely 53.57 mg / kg). Manganese level in the blood plasma of experimental sheep at the research sites were adequate based on the criteria of normal blood plasma Mn level in sheep by Pamela *et al*. (2001), namely from 0.015 to 0.5 mg / l.

CONCLUSION

Soil on slope topography paddock had Mn level lower than soil plain topography, both in the rainy season and the dry season. Soil Mn level in the rainy season was lower than in the dry season, both on the plain and sloping paddocks. Manganese level of forage on slope paddock was lower than on the plain paddock. The highest forage Mn level was found on the plain paddock in the rainy season. Topography had no effect on blood plasma level of Mn in sheep grazed in the dry season. Grazing sheep on the slope paddock in the rainy season produced the lowest blood level of Mn, in contrast to the plain paddock produced the highest blood plasma levels of Mn. Manganese levels of soil, forage, feces and blood plasma of experimental sheep showed adequate manganese status in the rainy and the dry seasons, on plain or slope paddock.

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