Effect of Stocking Rate of Thai-Esaan Native Beef Cattle under Alternate Grazing Methods on Growth Performance and Botanical Changes in Grass-Legume Mixture Pastureland

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Received: 18 January 2018 Revised: 4 October 2018 Accepted: 7 January 2019

ABSTRACT

This experiment was carried out at the University Farm, Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand during April 2011 to September 2012. The work aimed to study effect of stocking rate of Thai-Esaan native beef cattle carried out under “cut and carry” and alternate grazing methods with respect to beef cattle growth performance and the changes in botanical composition of grass-legume mixture regime of the pastureland. Korat soil series (Oxic paleustults) was used. The experiment was laid in a Completely Randomized Design (CRD) with 3 replications and each replication had 2 heads of Thai-Esaan native beef cattle. The experiment consisted of 4 treatments, i.e. T1 (control, “cut and carry” method) had 0.25 rai/head, T2 had a grazing area of pastureland of 0.25 rai/head, T3 had a grazing area of pastureland of 0.50 rai/head and T4 had a grazing area of pastureland of 0.75 rai/head (1 hectare = 6.25 rai). The results showed that Korat soil series (Oxic Paleustults) is a poor fertility soil with an average pH value of 5.5 and most of the available soil nutrients (NPK) were relatively low. Total dry weights of grass plus legume before grazing were highest for T4 than the rest. This result was also found at the end of the experimental grazing period. Crude protein yields were highest with T3 followed by T4, T2 and least with T1 with mean values of 1,789, 1,740, 1,370 and 951 kg/ha, respectively. Feed intake values were highest with T4 followed by T3, T2 and least with T1 with the mean values of 5.65, 4.95, 3.85 and 3.43 kg/head/day, respectively. The difference was large and highly significant ($P < 0.01$). Average daily live weight gained was higher for T3 and T4 than T2 and T1 with values of 414, 456, 257 and 190 g/day, respectively. The percentages of total fat in rumen were higher for T3 and T4 than T2 and T1 with values of 0.06, 0.05, 0.02 and 0.02, respectively. The difference was large and statistically significant ($P < 0.05$). Conjugated linoleic acid values of total fat were highest with T4 followed by T3, T2 and T1 with the values of 1.50, 1.12, 0.17 and 0.11%, respectively. The difference was large and statistically significant. Alternate grazing methods significantly affected dry matter yields, botanical composition changes of the pastureland, and the beef cattle performance and also conjugated linoleic acid in the rumen of the beef cattle. Optimum stocking rate of 0.5 rai/head of T3 was the best recommended treatment for Korat soil series (Oxic Paleustults).

Keywords: Alternate grazing, beef cattle, dry matter yield, crude protein, Korat soil series, stocking rate

Thai J. Agric. Sci. (2019) Vol. 52(1): 1−19

INTRODUCTION

It revealed that the world production of beef cattle of 1,482 million heads was recorded in the 2016. An increase in numbers of beef cattle from the 2005 to 2014 was 95 million heads (6.8% increased). This was due to a high demand for meat and milk consumption as a result of the increases in world population (FAO, 2009; 2016). The FAO estimated that an increase of approximately 94 million of the world population could be possible in the 2050 where the increase of the population may undoubtedly lead to an increase in the demand for meat and milk production up to approximately 70%. If this estimated production did not come true then the world food security could be at a hazadous situation (White, 2016). Office of Agriculture Economic (2017) forcasted that there is a tendency in increasing production of world beef population up to 0.13%, if this comes true the production of 60.49 million tons could have been produced by the 2016. In connection to this circumstance, the USA, the European Union, China and India should have played their important roles in producing meat production and their increases could be up to 5.29, 2.07, 2.99 and 3.66%, respectively. For Thailand, it was found that number of beef cattle being produced within a period of the 2012 to 2015 had been decreased up to 0.76%. However, for the 2016, the beef production had increased up to 1.013 million heads. It was 2.22% higher than that of the 2015 due to the high demand for meat consumption within the country and overseas. The high demand for meat production resulted in an increase in market price of meat during the 2014 to 2015. Therefore, due to the high price of meat in the markets, a large number of farmers turned up their interests to raise beef cattle for their professional carreer.

In many circumstances, beef cattle being raised had been normally fed with low quality of roughages where the feeding materials could be easily found e.g., rice straws, many agricultural by-products derived from farm yards, and natural grasslands. It has been stated that the success in establishing livestock production for livestock business in many tropical countries depended most on suitable environmental conditions for growth of many grass species including leguminous crops (Tessema and Baars, 2006; Pholsen *et al*., 2014a; 2014b). It is generally known that grass and legume mixtures provided better soil properties than the application of nitrogen fertilizer alone. It was also found that residual effects and root nodules could remain in soil for a longer period of time (Jones and Jones, 2003). High soil fertility levels had been achieved from the application of organic materials to the soi. This circumstance was confirmed by a number of workers e.g., Celik *et al.* (2004), Pholsen *et al.* (2005; 2014a; 2014b). Thus, the use of organic materials derived from pasturelands where grass and legume plants are grown together could provide better soil properties, and at the same time it increases nutritive value and quality of fodders, and silages production. Moreover, the forage yields could be largely increased (Bamikole *et al.*, 2001; Ammed *et al.*, 2012). Grass spiecies grown together with legume crops with addition amount of cattle manure gave an increase in both dry matter yields (DMYs) and quality of the pastureland (Pholsen *et al.*, 2014a; 2014b). High quality grass-legume mixture grassland produced both structural and non-structural carbohydrates for appropriate amounts of volatile fatty acids (VFAs) ratios for a better growth performance of beef cattle (Moran, 2005). Another important factor involving in the benefits derived from grazing is the percentages of conjugated linoleic acid (CLA) since CLA has its significant role in health of animals and human beings (Suksombat and Chullanandana, 2008). Some workers reported that crude protien production being produced in the grass-legume mixture regime was much higher than that of the grass alone (Yoottasanong *et al.*, 2015). They also found that Purple Guinea grass gave a very high DMY in both grass alone and grass plus legume mixture when grown in the rainy season on Korat soil series (Oxic Paleustults). Furthermore, crude protein (CP) contents in the Purple Guinea-Verano stylo mixture was up to 10.8%. WTSR (2010) had also revealed that for 100–200 body live weights of Thai native beef cattle, it required amounts of protein from 254 to 363 g/d for average daily weight gained (ADG) of 250 g/d. There has been a high advantage in using Purple Guinea grass since it manifested a high resistance to drought conditions and able to grow well in various soil types and also with a high tolerance against heavy grazing of the beef cattle. With some other organic grass-legume mixture experiments, it was found that there was a huge potentiality in increasing both animal growth rate and animal production (Bamikole *et al.,* 2001; Trevor and Albrecht, 2004).

Forage utilization for beef cattle production has been defined as "cut and carry" and grazing methods. The sigificant benefit derived from grazing was the recycling of nutrients through animal excretions while that of the "cut and carry" depleted some high amount of nutrients from the grassland soils (Whitehead, 2000; McDowell, 2008). Optimal stocking rate had contributed a high weight gained of animal per unit land area and sustainable forage production for grazers (Hernandez *et al*., 1995). Alternate grazing method provided a tremendous advantage for livestock production since the beef cattle is allowed to graze alternately between the two paddocks within a specific period of time (McCarthy *et al.,* 2016). They stated that both grazing methods and stocking rate affected botanical changes in the pastureland. With the results of a six-year experiment, it revealed that a heavy continuous and alternate grazing with a high stocking rate significantly increased weed percentage, and also decreased the grass and other species percentage compared with a moderate grazing (Fuelleman *et al.,* 1949). Ibrahim and't Mannetje (1998) showed that the grass-legume mixture of two grass species significantly decreased dry matter yields of the three legume species when a high stocking rate was applied compared with the low stocking rate. With a grazing experiment carried out for 22 years, it showed that high stocking rate affected the persistency of the grass-legume mixtures when overgrazing was occurred and eventually the pasturelands were not able to survive at the end of the 12th year, whilst that of moderate stocking rate, it tended to extend and lasted for 22 years. High stocking rate grazing method gave lower body weight gained of the beef cattle than that of the lower stocking rate (Jones and Jones, 2003). High stocking rate decreased dry matter percentage of grass whilst legume and weed percentages significantly increased (Carnevalli *et al*., 2006).

The objective in carrying out this work was to compare the effect of stocking rate of the Thai-Esaan native beef cattle in relation to the "cut and carry" and alternate grazing methods on growth performance of the beef cattle, conjugated linoleic acid (CLA) production and the changes in the botanical composition of the grass-legume mixture of the pastureland with the use of Korat soil series (Oxic Paleustults).

MATERIALS AND METHODS

This experiment was carried out at the Unversity Farm, Khon Kaen University, Khon Kaen, Thailand during April 2011 to September 2012 to investigate the effect of stocking rate of Thai-Esaan native beef cattle carried out under both "cut and carry" and alternate grazing methods on growth performance of beef cattle and botanical changes in grass-legume mixture when grown together. Korat soil series (Oxic Paleustults) was used with its initial mean values of soil pH, organic matter (OM), soil nitrogen, phosphorus (P) and potassium (K) of 4.91 (1 : 2.5 soil and water by volume), 1.06%, 0.05%, 19.45 ppm, and 48.72 ppm, respectively. Total amount of rainfalls, mean values of maximum and minimum temperature were 807.10 mm, 23.30 and 33.50^{o}C, respectively (Cf. Meteorological Division, Department of Plant Science and Agriculture Resource, Khon Kaen University). The Thai-Esaan beef cattle of 24 heads at the age of 250 ± 60 days old with an average individual live weight of 104 ± 31 kg obtained from the Department of Animal Science, Khon Kaen University were used. The experiment was laid in a Completely Randomized Design (CRD) with 3 replications and each replication had 2 heads of beef cattle. The experiment consisted of 4 treatments. They included: T1, control, without grazing, i.e. feeding was carried out with the use of "cut and carry" method with an area of 0.25 rai/head

(1 hectare = 6.25 rai), T2 had a grazing area of 0.25 rai/head, T3 had a grazing area of 0.50 rai/head and T4 had a grazing area of 0.75 rai/head. The land area of T1 was divided into 2 plots of 0.50 rai and each was used for alternate forage cuttings, i.e. altogether the land area being used was 3 rai altogether (zero grazing, i.e. 'cut and carry' was used for control treatment where cuttings were carried out twice daily, one in the morning and the other one in the evening), T2 was divided into 2 plots. They were used for alternate grazing, each had an area of 0.25 rai/head (1.0 rai/replication), thus altogether it had an area of 3.0 rai, T3 had two plots, each with an area of 0.50 rai/head (2 rai/replication), thus altogether it had an area of 6.0 rai, T4 had two plots, each with an area of 0.75 rai/head (3 rai/replication), thus altogether it had an area of 9 rai.

Land Preparation, Sowing of Grass-Legume Mixture and Alternate Grazing

The land area of 21 rai was evenly incorporated with dolomite at a rate of 625 kg/ha and was ploughed once and harrowing twice with the use of a tractor unit. One week after the first harrowing, cattle manure at a rate of 24 tons/ha (0.5 t/rai) was thoroughly applied by hand followed by harrowing once and then seedlings of 35 days old after sowing of the Purple Guinea grass (*Panicum maximum* cv. TD 58) were transplanted by hand at a distance between rows and within rows of 0.75 x 0.75 m. Thereafter, seeds of Verano Stylo (*Stylosanthes hamata* cv. Verano) at a rate of 1.6 kg/rai were broadcasted to blank spaces within the rows of the grass as to establish a grass-legume mixture pastureland. Germination of seeds of legume was successfully achieved. At day 50 after sowing, the grass-legume mixture was cut to attain the height at approximately 15 cm above ground level as to attain the growth of the grass as evenly as possible. The preparations for all treatments were carried out for one year ahead of time before the commencing of the experiment.

At day 78 after sowing, i.e. 28 days after the first cutting, the second plot of each treatment was evenly cut off, at the same time the beef cattle were allowed to graze for 28-day period at the first plots of all treatments then the beef cattle were moved out and allowed to graze at the second plots at 29-commencing day. After each grazing period, the height of the grass plus legume plants was evenly cut out to attain a height of 15 cm above ground level. These practices were carried out from time to time as to assure that the plants were allowed to grow from a similar point of the starting period and the beef cattle were allowed to graze in each plot for 28-day intervals and the process was carried on until the end of the rainy season. There were no chemical fertilizer or other plant materials added to each plot during the grazing term in all treatments. For the control plots, cuttings as fodders were carried out (cut and carry) both in the morning and evening and then fed the beef cattle promptly.

With the forage sample collected from each 28-day interval of each alternate grazing before and after allowing the beef cattle to graze, the samples were collected at 28-day intervals for all plots, which was commencing at day 29. Before and after allowing the animals to carry on grazing, the experimental plots (except T1, cut and carry) were grazed alternately until the end of the experimental period throughout the rainy season.

Before and after the completion of each grazing interval, ten plant samples of each crop both grass and legume of each grazing plot were taken with the use of a quadratic square (0.75 x 0.75 m). The plant samples were weighed out for fresh weights. Approximately eight plant samples of both Purple Guinea grass and legume were collected from each plot for use in plant tissue analysis (800 g fresh weight for each crop).

Before the commencing of the experimental work, the beef cattle were acclimated to new environmental conditions similar to that of the real experimental plots. They were allowed to get acquanted to such environments for 28 days (from 5th May to 1st June 2012) where five temporary shades within the fencing units were built up in each acclimated plot. The beef cattle were adequately supplied with cleaned water throughout the experimental period. Medicinal injection against internal parasites were carried out including injections of vitamins A, D and E through underneath of skin (2 ml/head) before the commencing of the experiment (Chuntrakort *et al.,* 2014). Records of individual weighing of body weights of the beef cattle were carried out before the starting of the first grazing and after each interval of 28 days.

By definition, alternate grazing is a method of grazing in allowing animals to graze the two paddocks alternatedly, i.e., allowing the animals to graze the first paddock (grassland plot) for 28 days and then move them to the second paddock for 28 days grazing period. The grazed forages were allowed to grow for 28 days before moving the animals back to graze on the plot of the former commencing date. Altogether the number of days in grazing was 112 days (four intervals) within the rainy season. The first grazing interval was started from the 2nd to 29th June, the second one was started from the 30th June to 27th July, the third from the 28th July to 24th August, and the fourth from the 25th August to 21st September. At 21st September, rumen fluid was collected with the use of the method described by Chuntrakrot *et al.* (2014).

Soil Analysis

Initial soil samples were randomly collected for soil chemical analysis properties by divided each plot into 4 replications and each with an area of 20 x 20 m, this area of land was used for the collection of 4 soil samples and then they were thoroughly mixed together to form 1 unit of soil sample. This was aimed to attain single value of initial soil fertility of each replication. The soil samples were collected again annually at the end of the second year of the experimental period. The soil samples were oven dried at 105−110^{o}C for 24 hrs and weighed out when cooled. Soil samples were used for soil pH determinations (1 : 2.5; soil : water by volume) by the Standard Glass Electrode, organic matter (OM%) by the method of wet oxidation (Black, 1965), total nitrogen by Kjeldahl method, extractable phosphorus (P) by the Bray II method (Drilon, 1980) and exchangeable potassium (K) by NH_4Oac and atomic absorption spectrophotometer (Cottenie, 1980).

Plant Samples and Chemical Analysis

Dry weights of the grass and grass plus legume mixture were recorded (kg/ha) at 28 days intervals. Before allowing the animal to start grazing, the plant samples were collected at the age of 28 days after cutting as to adjust the forage height of 15 cm above ground level of the grassland. The samples were randomly collected 4 times at 28-day intervals before the starting of the grazing at day 29. Dry matter intake (DMI) of forage was determined using a 1 M^2 cage made from large-mesh wire ('t Mannetje, 1978). The plant samples were collected separately as grass alone (G), stem (S) and leaves (L), legume (Leg) and weeds (W). The randomly collected samples from the same treatment of each 28-day interval were pooled together as to attain the evenly mixed plant samples and they were used for tissue analysis of chemical contents. The plant samples were oven dried at 60^{o}C for 72 hrs and ground to pass through a 1 mm sieve screen and the ground samples were used for chemical analysis. Other plant materials were dried at 110^{o}C for dry weight determinations.

The determinations on crude protein (CP) were carried out by the method of AOAC (1990). Natural detergent fiber (NDF) and acid detergent fiber (ADF) were carried out with the method of Van Soest *et al.* (1991). Rumen fluid was determined at the end of the experimental period by the method described by Chuntrakort *et al.* (2014) yet the used fluid was not added with HCL and then it was analysed for fatty acid and conjugated linoleic acid (CLA) with the use of gaschromatography (Hewlett Packard GC system HP7890 A, USA) with the method described by Suksombat and Chullanandana (2008).

The collected data were subjected to statistical calculations using analysis of variance with the use of a SAS computer programme (SAS, 1998). Least significant differences were presented using the Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Meteorological Information

The results on meteorological information showed that total amount of rainfall of 807.1 mm in the year of this grazing experiment indicated adequate amount of rainfall for the growth of legume crop but it was considerably low for the growth of grass in the tropics (Cook *et al.,* 2005). Total amount of rainfall of 900 mm was considered to be optimal for the growth of Guinea grass (Humphreys and Partridge, 1995). It was found that monthly rainfalls were evenly distributed throughout the experimental period. This information was similar to those reported by Pholsen *et al.* (2014a; 2014b) and Yoottasanong *et al*. (2015) including mean values of minimum and maximum temperatures along with the mean values of relative humidity during the growth period of the crops.

Table 1 Final soil analysis data on soil pH, organic matter (OM), total nitrogen (N), available phosphorus (P), and exchangeable potassium (K) of the Korat soil series (Oxic Paleustults) carried out at the laboratory, Khon Kaen University

Items	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
pH (1:2.5)	5.18^{a}	4.95^{ab}	4.67^{b}	4.81^{ab}	*	4.00	0.113
OM (%)	0.97	1.07	1.10	1.00	ns	14.17	0.085
N (%)	0.043	0.040	0.040	0.037	ns	16.14	0.004
P (ppm)	4.65^{c}	18.82^{a}	18.22^{a}	12.30^{b}	**	14.66	1.143
K (ppm)	29.95^{b}	112.79^{a}	54.35^{b}	48.02^{b}	**	21.56	7.626

Letter (s) in each row indicated least significant differences of the Duncan's Multiple Range Test (DMRT) at probability (P) of *0.05 and **0.01, CV = coefficeint of variation, ns = non significant, SEM = standard errors of means

Soil Property

Naturally Korat soil series (Oxic Paleustults) possessed low values of soil pH (4.8–5.5) and organic matter (OM) which could be lower than 1%. In general, this great soil group is generally known as a poor soil type (Trelo-ges *et al.,* 2002). The somewhat high percentage of soil OM of the land area may be attributable to the previous history of the land where more of decomposed materials were added to the soil since this piece of land had been used as a pastureland area for a number of years. It was found that soil N, P and K were inadequately available for the crop growth. Suksri (1999) stated that total soil N, available soil P and soil exchangeable K of this Oxic Paleustults great soil group should attain values of at least 0.04%, 20 ppm and 80 ppm, respectively. Initial soil analysis data showed that mean value of soil pH was relatively low (4.91) indicated that the release of soil nutrients should have been relatively poor (Mengel and Kerkby, 1987; Suksri, 1999). Thus, this soil type may be badly required fertility programme. The results on mean values of soil pH at the end of the experimental period showed that pH values ranged from 4.67 to 5.18 for T3 and T1, respectively (Table 1). The difference was large and statistically significant. Mean values of OM ranged from 0.97 to 1.10 for T1 and T3, respectively. There were no statistically significant differences found. For total nitrogen%, mean values of total N ranged from 0.037 to 0.043 for T4 and T1, respectively. Again, there were no significant differences found. With available phosphorus (P), mean values of P ranged from 4.65 to 18.82 ppm for T1 and T2, respectively.

The difference was large and highly significant. For exchangeable potassium (K), mean values of K ranged from 29.95 to 112.79 ppm for T1 and T2, respectively. The difference was large and highly significant. These evidences of soil property may obviously indicate previous history of many inorganic soil types in most tropical areas (Suksri, 1999). At the end of the experimental period, mean values of soil pH, OM, total soil N were similar to that of the initial soil. The available P of T2 and T3 were similar to the initial soil but significantly higher than T4 while T1 had the lowest value of 4.65 ppm. The result indicated that P of T1 is most inadequately available and it could signify an inadequate amount of energy of Adenosine triphosphate (ATP) in the plant tissues hence reflected yield of T1.

The results on the changes of exchangeable K for initial and final values were having a similar trend to that of the changes in mean values of available P. This could be due to the the nutrients derived from the dung of the grazing beef cattle being recycled or added to the grassland while T1 (cut and carry) was not. The lower P value of T4 than T2 and T3 could have been possibly due to the fact that the wider grassland area for the distribution of excretion of T4 than both T2 and T3 did cause the dilution of the soil nutrients. The nutrient recycling in the grazing pasture had been reported by a number of workers, e.g., Whitehead (2000) and McDowell (2008).

In general, cattle manure contained more K than both P and N (Gill *et al.,* 2008; McRoberts *et al.*, 2016). Yoottasanong *et al.* (2015) reported that the Thai native cattle manure gave 1.47% for total N, 1.07% for available P and 3.84% for exchangeable K. However, with the attained information of soil conditions of the present work, it may be of a tangible value to point out that this soil type must be improved before the next growing season of the crop. That is to attain mean values of soil pH, OM, total N, available P and exchangeable K of 6.5 (1 : 2.5; soil : water by volume), 1.00, 0.04, 20 ppm and 80 ppm, respectively (Kasikranan, 2011; Pholsen *et al.,* 2014a; 2014b). With this soil pH value (6.5), the soil environment could easily ease the release of soil nutrients more rapidly otherwise some large amount of nutrients would have fixed within the clay minerals when the soil pH is relatively low (Mengel and Kirkby, 1987; Suksri, 1999). It could have been possible that a mean value of initial soil organic matter of 1.06% attained with this investigation did facilitate the release of soil nutrients otherwise the growth of both grass and legume plants could have been relatively poor (Tiessen *et al.,* 1994). Dry matter yields of the present work were much higher than the work reported by Pholsen *et al.* (2014a; 2014b).

Plant Dry Weight Yields Before Grazing

With two ways analysis data on grass alone, dry weights of grass dead materials were significantly highest with T3 where mean values ranged from 2,002 to 3,124 kg/ha for T1 and T3, respectively (Table 2). This may be partly attributable to an inadequate amount of Ca since soil pH values indicated high levels of soil acidity (Mengel and Kirkby, 1987; Pholsen, 2010). The amounts of dead leaves of the grazing treatments were much higher than that of the cut and carry treatment (T1). This could have been attributed to animal trampling during the grazing activities.

Stem dry weights were not significantly difference with mean values ranged from 5,090 to 5,402 kg/ha for T2 and T3, respectively. This result suggested that the growth of stems was not affected by the grazing activities because at the end of each grazing period, all of the grassland plots were trimmed out as to attain the same height of 15 cm above ground level. Another reason for this may be attributable to the grass tipped with more young leaves have caused a preference between leaves and stems where young leaves provided perhaps more palatability than stems since they had tender tissues and somewhat higher palatability (Ehrlish *et al., 2003*) and greater CP content than stems (Hare *et al.,* 2015).

Leaf dry weights among treatments were highly significant, with mean values ranged from 8,189 to 16,830 kg/ha for T1 and T4, respectively. T1 was significantly lower than the rest. This must be attributable to the excretions of both urine and dung in the grazing plots supplied more nutrients for growth of the crops (McDowell, 2008). The results also indicated the significant effect of grazing, i.e. grazing contributed better growth of the crops due to the additional amounts of cattle dung derived from the beef cattle aided the growth of leaves of the crops (Hansen, 1996; Pholsen *et al.*, 2005; 2014a; 2014b; Yoottasanong *et al.*, 2015) The significant effect due to higher value of the ratio between leaf and stem (L : S) of T4 than T1, T2, and T3 could be attributable to the stocking rate where the lower stocking rate gave the higher leaf dry weight of the crops than the lower ones (Busque and Herrero, 2001). This indicated that the more the undergrazing the higher the ratio between leaf and stem. The present work confirms the work reported by Ehrlich *et al*. (2003). They found that the low stocking rate allowed the forages to produce more leaves and gave higher dry matter yields after the grazing. The higher stocking rate of T2 gave significantly lower dry matter yield than T3 and T4. This may be attributable to the frequency in grazing of the beef cattle of T2 which was higher than T3 and T4, resulted in a lower dry matter yield of T2. The results agreed with the works reported by Sebastein *et al.* (2013) and Giacomini *et al.* (2014). They reported that the higher the cutting frequency the lower the dry matter yields of the Guinea and Purple Guinea grass. The results also confirmed the work carried out with the use of other tropical forages which was reported by Yoottasanong *et al*. (2015), they reported that the mixture of the Purple Guinea grass cv. TD 58 and Verano stylo grown on Oxic Paleustults great soil group added with 24 tons/ha of the cattle manure, it gave dry matter yield of 10,296 kg/ha which was lower than that of the present work. This must be partly attributable to the better soil fertility of the present work than that of the work reported by Yoottasanong *et al*. (2015), and also partly due to the benefit derived from the excretion of the grazing animals.

Total dry weights (S + L) of the grass alone were highly significant with mean values ranged from 13,432 to 22,015 kg/ha for T1 and T4, respectively. Ratio between leaf and stem (L : S) of T4 was significantly higher than T1 and T2 but was not significantly differed from T3, with mean values ranged from 1.54 to 3.23 for T1 and T4, respectively. The differences amongst treatments could be attributable to the higher stocking rate of T2 than T3 and T4 where it caused overgrazing with T2. The results of the present work confirmed the previous work carried out at Khon Kaen University farm during the period from 1978 to 1980 where the Thai native beef cattle were used and allowed to feed with the use of Signal grass + Siratro + Caribbean Stylo mixture (Gutteridge *et al.,* 1983). They reported that the effect of stocking rate influenced botanical composition of the grassland, i.e. the low stocking rate favoured the increases in dry matter yields of the crops.

Table 2 Dry matter yields (kg/ha) of grass alone (G), grass + legume (G+Leg), weeds (W) and total plant dry weights (G+Leg+W) before grazing, measured during the rainny season, grown on Korat soil series (Oxic Paleustults) at Khon Kaen University Farm, Khon Kaen, Thailand

Items	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
Grass							
Dead materials	2,002^{b}	2,068^{ab}	3,124^{a}	2,624^{ab}	**	22.21	314.84
Stem dry weights (S)	5,282	5,090	5,402	5,185	ns	13.77	416.68
Leaf dry weights (L)	8,189^{c}	13,003^{b}	15,158^{ab}	16,830^{a}	**	11.45	878.08
Total dry weights (S+L)	13,432^{b}	18,094^{a}	20,560^{a}	22,015^{a}	**	10.95	1,171.39
L:S ratio	1.54^{c}	2.60^{b}	2.85^{ab}	3.23^{a}	*	11.62	0.17

Table 2 Continue

Items	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
Grass+ legume							
Legume dry weights	2,128^{a}	1,653^{b}	2,483^{a}	2,479^{a}	**	9.35	117.98
Grass+Legume	15,559^{c}	19,747^{b}	23,042^{ab}	24,494^{a}	**	9.84	117.63
Grass:Legume ratio	6.35^{b}	11.13^{a}	8.27^{b}	8.93^{ab}	*	16.25	0.81
Weed dry weights (W)	1,526	1,162	1,152	987	ns	23.18	161.50
Total plant dry weights							
Grass+Legume+W	17,086^{c}	20,909^{b}	24,194^{ab}	25,481^{a}	**	8.94	1,131.84
Grass+Legume:W	10.29^{b}	18.20^{ab}	21.22^{a}	25.79^{a}	*	28.99	3.16

Letter (s) in each row indicated least significant differences of the Duncan's Multiple Range Test (DMRT) at probability (P) of *0.05 and **0.01, CV = coefficeint of variation, ns = non significant, SEM = standard errors of means

Total legume dry weights alone were highly significant, with the values ranged from 1,653 to 2,483 kg/ha for T2 and T3, respectively. Total dry weights of the grass plus legume were highly significant with the values ranged from 15,559 to 24,494 kg/ha for T1 and T4, respectively. The ratio between grass and legume of T2 was significantly higher than T1 and T3 but it was not significantly differred from T4 with the values ranged from 6.35 to 11.13 for T1 and T2, respectively. The results showed that growth of the legume crop was smaller than that of the grass. This may be attributable to the overgrazing of T2 whilst that of T3 and T4 did not. Other reason for this could have been attributed to the competition in growth which was better for the grass than the legume crop since tropical grass is commonly known as a carbon cycle of C4 plant where the grass crop may possess a faster growth rate than that of the legume crop which is known as a C3 plant (Skerman and Riveros, 1990; Pholsen, 2005; Pholsen *et al.,* 2014b).There was no statistical difference found due to weed dry weights, with mean values ranged from 987 to 1,526 kg/ha for T4 and T1, respectively. Total dry weights of the grass plus legume and weeds were significantly different with mean values ranged from 17,086 to 25,481 kg/ha for T1 and T4, respectively. The ratio between grass plus legume and weeds of T1 was significantly lower than T3 and T4, with mean values ranged from 10.29 to 25.79 for T1 and T4, respectively. The results indicated not only the grazing effect but also the trampling effect damaged the legume plants whereas no trampling activity was occurred with that of T1. Grazing and trampling effects tremendously decreased legume yields were also found with weed dry matter yields. The results also showed that grazing phenomena can create more changes on the botanical composition of the pastureland (Hernandez *et al.,*1995; Carnevalli *et al.,* 2006).

Plant Dry Weight Yields After Grazing

Dry weights of dead materials were highly significant where mean values were ranging from 1,081 to 5,318 kg/ha for T2 and T4, respectively (Table 3). Stem dry weights were highly significant, with mean values ranged from 2,742 to 9,013 kg/ha for T2 and T4, respectively. Leaf dry + weights of the grass alone were highly significant, with mean values ranged from 1,038 to 12,132 kg/ha for T1 and T4, respectively. Total dry weights of the grass alone (S + L) were highly significant, with mean values ranged from 3,859 to 21,145 kg/ha for T1 and T4, respectively. The ratio between leaf and stem (L : S) of T4 was significantly higher than the rest while the lowest was found with T1 and T2, with the values ranged from 0.36 to 1.37 for T1 and T4, respectively. The results on crop dry weights among the four treatments clearly showed that after the grazing activities of the cattle, dry weights of T2 was the lowest and highest for T4. The differences could have been attributed to numbers of cattle per unit land area where higher stocking rate of T2 gave lower dry matter yield than T3 and T4. That is grazing frequency of T2 was much higher than the rest. Other reasons for this may be attributable to the larger land area of T4 than the rest thus grazing and trampling activities were relatively lower than other treatments. The results agree with the works reported by many workers e.g., Sebastein *et al.* (2013) and Giacomini *et al.* (2014). Dry weights of the legume alone were highly significant, with the values ranged from 688 to 2,806 kg/ha for T2 and T4, respectively. Total dry weights of grass plus legume were highly significant with the mean values ranged from 4,752 to 23,951 kg/ha for T2 and T4, respectively. The ratio between grass and legume of T4 was significantly higher than the rest, the lowest was found with T1, with the mean values ranged from 2.68 to 11.00 for T1 and T4, respectively. The differences on total dry weights and the ratio between grass and legume could possibly be attributable to the differences in plot size and stocking rates as previously discussed.

Table 3 Dry matter yields (kg/ha) of grass alone (G), grass + legume (G+Leg), weeds (W) and total plant dry weights (G+Leg+W) after grazing, measured during the rainny season, grown on Korat soil series (Oxic Paleustults) at Khon Kaen University Farm, Khon Kaen, Thailand

Items	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
Grass							
Dead materials	1,758[c]	1,081[d]	2,999[b]	5,318[a]	**	12.05	193.99
Stem dry weights (S)	2,820[c]	2,742[c]	6,248[b]	9,013[a]	**	21.81	655.54
Leaf dry weights (L)	1,038[c]	1,322[c]	4,635[b]	12,132[a]	**	15.93	439.90
Total dry weights (S+L)	3,859[c]	4,064[c]	10,883[b]	21,145[a]	**	18.20	1,049.32
L:S ratio	0.36[c]	0.51[c]	0.75[b]	1.37[a]	**	16.35	0.07
Grass+ legume							
Legume dry weights	1,432[b]	688[c]	1,004[cb]	2,806[a]	**	17.16	146.92
Grass+Legume	5,291[c]	4,752[c]	11,888[b]	23,951[a]	**	14.94	989.53
Grass:Legume ratio	2.68[c]	5.97[b]	7.71[b]	11.00[a]	**	23.89	0.95
Weed dry weights (W)	741[a]	285[bc]	108[c]	435[b]	**	29.32	66.37
Total plant dry weights							
Grass+Legume+W	6,031[c]	5,037[c]	11,995[b]	24,386[a]	**	14.60	999.83
Grass+Legume:W	7.57[c]	16.53[c]	109.26[a]	57.05[b]	**	24.85	5.06

Letter (s) in each row indicated least significant differences of the Duncan's Multiple Range Test (DMRT) at probability (P) of **0.01; CV = coefficient of variation; SEM = standard errors of means

Total weed dry weights were highly significant with the mean values ranged from 108 to 741 kg/ha for T3 and T1, respectively. Total plant dry weights of the grass plus legume plus weeds were highly significant with the mean values ranged from 5,037 to 24,386 kg/ha for T2 and T4, respectively. There was a trend on the ratio between grass plus legume and weeds on total dry weights after the grazing which were similar to that found before the grazing i.e., T1 and T2 were significantly lower than T3 and T4, with the values of 7.57 and 109.26 for T1 and T3, respectively. It revealed that the ratio between grass plus legume : weeds of the medium stocking rate of T3 was significantly higher than the rest. This may be attributable to the evenly grazing of the optimal stocking rate of T3 led to the evenly grown of both grass and legume crop which in turn dominated the growth of weeds. The higher weed population in the low stocking rate of T4 could be attributable to its larger grazing area of land where the cattle manifested their own preferences, particularly with the available favourite forages.Therefore, undergrazing had occurred within T4 hence it favours the growth of weeds of T4 greater than T3. The highest weed population of T1 must be attributable to the undisturbed area where weeds could have grown freely hence it was clearly indicated the botanical changes in the pastureland (Gardener, 1982; Hernandez *et al.,* 1995; Carnevalli *et al.,* 2006).

Nutrients and Chemical Composition of Grass and Legume

For grass alone, N concentration of T1 was significantly lower than the rest, with mean values ranged from 0.81 to 1.09% for T1 and T3, respectively (Table 4). The lowest P concentration was found with T2 and the highest was T3 with mean values ranged from 0.19 to 0.38% for T2 and T3, respectively. The difference was large and highly significant. The lowest K concentration was found with T1 and the highest was T3 and T4, with the values ranged from 1.93 to 3.67% for T1 and T3, respectively. The difference was large and highly significant. This may be attributable to the differences in the amounts of excretions of both urine and dung added to the grazing treatments whereas none for T1 (cut and carry) hence the confinement of the land area affected concentration of nutrients (Pholsen *et al.,* 2005). With grass crude protein (CP), it was found that T1 was significantly lower than the other treatments, with mean values ranged from 5.05 to 6.78% for T1 and T3, respectively. The differences among the treatments may be attributable to better soil fertility of those confined in its specific area where soil fertility increased due to the excretions of both urine and dung added to the soil (Whitehead, 2000; Pholsen *et al.,* 2005; McDowell, 2008).

Table 4 Chemical composition of grass and legume carried out during the rainy season on nitrogen (N, %), phosphorus (P, %), potassium (K, %), crude protein content (CP, %), neutral detergent fiber (NDF, %), and acid detergent fiber (ADF, %)

Chemical composition	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
Grass							
N	0.81^{b}	1.01^{a}	1.09^{a}	1.03^{a}	*	9.08	0.051
P	0.24^{b}	0.19^{c}	0.38^{a}	0.29^{b}	**	8.75	0.014
K	1.93^{c}	2.65^{b}	3.67^{a}	3.37^{a}	**	10.35	0.173
CP	5.05^{b}	6.32^{a}	6.78^{a}	6.46^{a}	*	9.10	0.323
NDF	72.06^{c}	75.11^{a}	75.11^{a}	74.50^{b}	**	0.37	2.433
ADF	39.46^{b}	42.73^{a}	42.73^{a}	42.61^{a}	*	2.00	0.485

Table 4 Continue

Chemical composition	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
Legume							
N	2.05[b]	2.20[b]	2.61[a]	2.05[b]	**	4.03	0.051
P	0.11[c]	0.13[b]	0.17[a]	0.10[c]	**	5.77	0.004
K	1.51[b]	2.34[a]	2.40[a]	1.55[b]	**	1.96	0.022
CP	12.80[b]	13.69[b]	16.28[a]	12.80[b]	**	4.07	0.326
NDF	61.71	63.22	62.75	60.80	ns	1.35	0.484
ADF	39.60	36.50	39.92	39.52	ns	2.54	0.570

Letter (s) in each row indicated least significant differences of the Duncan's Multiple Range Test (DMRT) at probability (P) of *0.05, **0.01, ns =non significant, CV = coefficient of variation, SEM = standard errors of means

For neutral detergent fiber (NDF), the results showed that T1 was significantly lower than other three treatments. T2 and T3 gave the highest NDF contents. The difference was large and highly significant with mean values ranged from 72.06 to 75.11% for T1 and T3, respectively. The lowest NDF of T1 could be attributable to the effect of cut and carry when the whole plants were taken out so leaves and stem of the crop were used together hence biomass of leaves could have diluted value of NDF. The higher NDF values of T2 and T3 could have been attributed to the grazing effect of the cattle when more of stems of the crop were not taken by the cattle (Pholsen *et al.,* 2005; Hare *et al.,* 2015). Thus NDF of T2 and T3 were higher than T1 and T4. These phenomena could be applied to the case of Acid detergent fiber (ADF) of T1 which was significantly lower than the rest yet T2 up to T4 were similar. ADF contents ranged from 39.46 to 42.73% for T1 and T3, respectively.

With legume, the results showed that N concentration of T3 was the highest and was highly significant over the rest whilst other treatments were similar with mean values ranged from 2.05 to 2.61% for T1 and T3, respectively. P concentration of T3 was the highest while T1 and T4 were similar but lower than T2 and T3 with mean values ranged from 0.10 to 0.17% for T4 and T3, respectively. The difference was large and highly significant. For K concentration, the results showed that T2 and T3 were similar but highly significant over the rest (T1 and T4) with mean values ranged from 1.51 to 2.40% for T1 and T3, respectively. The lower concentration of NP of T1 than T2 and T3 may be due to the fact that T1 did not receive any excretions being cycling from the crazing animals whilst the NP concentrations of T2 were lower than T3. This could have been attributed to the overgrazing of T2 caused lower dry matter yield of the legume which may have had decreased growth and NP concentrations in the plant tissues. K concentration of T2 was similar to T3. This may be attributable to the higher rate and concentration of K in the dung derived from the grazing animals (Pholsen *et al.,* 2014b; Yoottasanong *et al.,* 2015).

Crude protein content of the legume plants of T3 was the highest and was highly significant over the rest. There was no statistical difference found among the other three treatments (T1, T2 and T4). CP values ranged from 12.80 to 16.28% for T1 and T3, respectively. The results showed that CP contents of T3 were affected most by grazing where T3 plants were grown at a wider space hence preferences in grazing were carried out by cattle i.e. they could have preferred to graze grasses more than leaves of legume so CP content of T3 was highest. For NDF and ADF contents, it showed that there was no significant difference found among the four treatments. NDF values ranged from 60.80 to 63.22% for T4 and T2, respectively. ADF values ranged from 36.50 to 39.92% for T2 and T3, respectively. There was no statistical difference found among the treatments. Both ADF and NDF contents were similar. This must be attributable to animal behavior in choosing more of leaves of the crop rather than stems. Thus ADF and NDF contents were similar (Hare *et al.,* 2015).

Table 5 Initial and final body weights (kg/head) of cattle, total plant dry weight yields (Glass+Legume+Weeds), feed intake, weight gain, average daily gain (ADG), g/kg metabolic body weight ($BW^{0.75}$), feed conversion ratio (FCR) as influenced by grazing treatments

Items	Treatments				P-value	CV (%)	SEM (±)
	T1	T2	T3	T4			
No. of heads (n)	6	6	6	6			
Days in grazing	112	112	112	112			
Days of alternating	28	28	28	28			
Initial body weight	105	105	98	110			
Final body weight	126	134	144	161			
G+Leg+W (kg/ha)	17,086^{c}	20,909^{b}	24,194^{ab}	25,481^{a}	**	8.94	1,131.80
CP Yields (kg/ha)	951^{c}	1,370^{b}	1,798^{a}	1,740^{a}	**	9.15	5.29
Feed intake (kg/head/d)	3.43^{d}	3.85^{c}	4.95^{b}	5.65^{a}	**	4.96	0.13
Weight gained (kg/head)	21.25^{b}	28.75^{b}	46.33^{a}	51.08^{a}	**	11.07	2.36
ADG (g/d)	190^{b}	257^{b}	414^{a}	456^{a}	**	11.09	21.09
g/kg $BW^{0.75}$	1.42^{b}	1.93^{b}	3.10^{a}	3.42^{a}	**	11.05	0.16
FCR	18.07^{a}	15.17^{ab}	12.21^{b}	12.42^{b}	**	12.78	1.07
Total fat (FRF %)	0.02^{b}	0.02^{b}	0.06^{a}	0.05^{a}	*	25.10	0.01
CLA (total fat %)	0.11^{c}	0.17^{c}	1.12^{b}	1.5^{a}	**	10.26	0.04
SFA (total fat %)	61.86^{b}	71.54^{a}	74.02^{a}	61.39^{b}	**	3.90	1.51
UFA (total fat %)	38.15^{a}	28.46^{b}	26.26^{b}	38.55^{a}	**	7.96	1.51

FRF = fresh rumen fluid, CLA = conjugated linoleic acid, SFA = saturated fatty acid and UFA = unsaturated fatty acid

Letter (s) in each row indicated least significant differences of the Duncan's Multiple Range Test (DMRT) at probability (P) *0.05. **0.01, ns = non significant, CV = coefficient of variation.

SEM = standard errors of means

Grass Plus Legume Plus Weed Dry Weight Yields, Crude Protein Yield, Fatty Acid, Conjugated Linoleic Acid, Feed Intake and Animal Performance

Initial body weights of cattle were 105, 105, 98 and 110 kg/head for T1 up to T4, respectively and the final body weights were 126, 134, 144 and 161 kg/head for T1 up to T4, respectively (Table 5). CP yields of T3 and T4 were significantly higher than T2 and T1, the lowest was found with T1 with the mean values of 1,798, 1,740, 1,370 and 951 kg/ha, respectively. An increase in CP yields depended on the increase in cattle manure application rates (Yoottasanong *et al.,* 2015). Feed intake of T4 was significantly higher than other treatments. They ranged from 3.43 to 5.65 kg/head/d for T1 and T4, respectively.

Weight gained, average daily gained (ADG) and metabolic body weight of T3 and T4 were significantly higher than T1 and T2. Mean values of metabolic body weights were 1.42, 1.93, 3.10 and 3.42 g/kg $BW^{0.75}$ for T1 up to T4, respectively. Feed conversion ratio (FCR) of T1 was significantly higher than T3 and T4. They were 18.07, 15.17, 12.21 and 12.42 for T1 up to T4, respectively. It was found that the items on growth performance of the cattle such as ADG, metabolic body weight, and FCR were affected by feed intake and CP yields.

There are two reasons for the lower growth performance of T1 and T2 than T3 and T4. Firstly, the lower values of CP yield and feed intake per day of T1 and T2 lower than T3 and T4, yet the lowest feed intake of T1 was significantly lower than T2. This could have been due to the reason that there was no application of cattle maure for T1 whilst T2 attained benefit from nutrient recycling of the grazing animals. Secondly, it may partly due to the L : S ratio of T1, which was significantly lower than T2 hence leading to a low CP yield of T1 than T2. CP yields were significantly increased with an increase in cattle manure application rates (Yootasanong *et al.*, 2015). There was no significant difference found between T3 and T4 on CP yields. This could be due to the CP yields of the grazed forages of both treatments were similar. The increased value of ADG in the high CP production for the low stocking rate (T4) of the grazed grassland of the present work confirmed the works reported by Gutteridge *et al.* (1983), it is also similar to the work reported by WTSR (2010) where the workers found that body weights were ranging from 100 to 400 kg for the Thai native beef cattle with the use of dry matter intake ranged from 2.31 to 10.97 kg DM/head. The present work suggested the preferential effect of the beef cattle as they move around to choose those high palatability portions (newly grown portions) where CP content could be relatively high. Therefore, a high CP content in the pastureland could be an ideal factor to be emphasized.

Total fat values in rumen ranged from 0.02 to 0.06% for T1 and T3, respectively. The difference was large and statistically significant. Conjugated linoleic acid (CLA) ranged from 0.11 to 1.50% for T1 and T4, respectively. The difference was large and statistically significant. For saturated fatty acid (SFA), mean values ranged from 61.39 to 74.02% for T4 and T3, respectively. The difference was large and statistically significant. With unsaturated fatty acid (UFA), mean values ranged from 26.26 to 38.55% for T3 and T4, respectively.

With the results on total fat in rumen, it was found that T3 and T4 were similar but significantly higher than T1 and T2. This may be attributable to amounts of feed intake which were higher for T3 and T4 than T1 and T2 resulted in a greater amount of CP intake and percentages of conjugated linoleic acid (CLA) which were higher for T3 and T4, although T4 was significantly higher than T3. This could have been attributed to the amount of feed intake for T4 greater than T3. Thus, amount of CLA has a significant role in health of animals and humans (Suksombat and Chullanandana, 2008). The best dietary sources of CLA are food products derived from grass-fed ruminants (Realini *et al.*, 2004). Therefore, there is a great advantage in allowing cattle to carry on grazing around rather than the use of feeding as “cut and carry” alone. For saturated fatty acid (SFA) and unsaturated fatty acid (UFA), it was found that SFA% were higher for both T2 and T3 than T1 and T4. This may be due to the greater amounts of dried feed materials of T2 and T3 than that of T1 and T4 where dried materials of T2 and T3 were also consumed by the beef cattle whilst that of T1 and T4 was not. This circumstance made it possible for beef cattle to attained higher percentages of SFA in the rumens than that of the UFA. A similar reverse pattern was found with the UFA where T2 and T3 attained the lower percentages than T1 and T4. Thus, dried feed materials those taken by the animals reflected the percentages of the UFA. Chung *et al.* (2007) showed that dried feed materials (hays) significantly increased SFA at the same time decreased the UFA. Fiber contents found in the feed intake of the beef cattle had its significant effect on fatty acid profile in the ruminant (Lambertz *et al.*, 2014).

CONCLUSIONS

The grazing of the Thai native beef cattle in the alternate grazing method provided a recycling process of nutrients from the excretions to the pastureland and hastened the growth of the grass and legume crop for animals hence soil fertility particularly soil P and K, forage dry matter yield and animal performance had simultaneously increased. The medium stocking rate of 0.5 rai/head gave the highest body weight gain from the smaller area with a small amount of forages, which was not significantly differred from the stocking rate of 0.75 rai/head. This also gave an optimal botanical change in the grass-legume mixture. Conjugeted linoleic acid in rumens of the beef cattle of the stocking rate of 0.5 rai/head was the highest. The best stocking rate under 28-day grazing period of the alternate grazing method with the use of Purple Guinea grass-Verano stylo mixture for the utmost Thai native beef cattle production on Korat soil series (Oxic Paleustults) was 0.5 rai/head.

ACKNOWLEDGEMENTS

The authors wish to express their sincere thankful gratitude to the Higher Education Research Promotion and National Research University Project of Thailand, Office of the Higher Education Commission, through the Food and Functional Food Research Cluster of Khon Kaen University for financial assistance (Ph.D. scholarship # 54128). Thanks, are also due to the Faculty of Agriculture, Khon Kaen University for facilities provided and also the staff members and the laboratory personnel in the Faculty of Agriculture for their kind assistance.

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