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Dry Matter Yields and Quality of Forages Derived from Grass Species and Organic Production Methods (Year lll)

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Abstract: This third year work was carried on at Khon Kaen University during the 2008-2009 to investigate dry matter yields of grass, grass plus legumes, grown on Korat soil series (Oxic Paleustults). The experiment consisted of twelve-treatment combinations of a 3×4 factorial arranged in a Randomized Complete Block Design (RCBD) with four replications. The results showed that Dry Matter Yields (DMY) of Ruzi and Guinea grass were similar with mean values of 6,585 and 6,130 kg ha^{-1} whilst Napier gave the lowest (884 kg ha^{-1}). With grass plus legume, grass species and production methods gave highly significant dry matter yields where Guinea and Ruzi gave dry matter yields of 7,165 and 7,181 kg ha^{-1}, respectively and Napier was the least (2,790 kg ha^{-1}). The production methods with the use of cattle manure gave the highest DMY (grass alone) of 10,267 kg ha^{-1} followed by Wynn and Verano with values of 6,064 and 3,623 kg ha^{-1}, respectively. Guinea plus cattle manure gave the highest DMY of 14,599 kg ha^{-1} whilst Ruzi gave 12,977 kg ha^{-1}. Guinea plus Wynn gave DMY of 7,082 kg ha^{-1}. Ruzi plus Verano gave DMY of 6,501 kg ha^{-1}. Forage qualities of crude protein were highest with those grown with grass plus legumes. Some prospects in improving production were discussed.

Key words: Cattle manure, forage legume, forage quality, organic production

INTRODUCTION

Codex Alimentarius Commission advocated that organic agriculture is a holistic production management system that avoids the use of synthetic fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people (Codex Alimentarius Commission, 2001). To accomplish this destination, organic agriculture farmers need to implement a series of practices that enable to optimize nutrient and energy flows and minimize risk, e.g., crop rotations enhanced crop diversity, different combinations of livestock and plants, symbiotic nitrogen fixation with legumes, application of organic manure and biological pest control. All these strategies seek to make the best use of local resources. Hence, organic systems are inherently adapted to site-specific endowments and limitations.

In the past decades, it was found that there are many countries have engaged in producing organic products, e.g., in Sweden packages of milk ready for drink printed at a side of the package as Aorganic up to 3% (Cederberg and Mattsson, 2000). Rosati and Aumaitre (2004) reported that in the 2003 organic farming for use in raising dairy cows in Sweden, Denmark, Switzerland and Austria has been increased up to 4.3, 7, 10 and 15%, respectively. In general, it is a common practice for farmers to increase their pasture and forage crop for use in feeding their livestock with the use of chemical fertilizers. After a number of years in using chemical fertilizers, it could turn out that their annual forage yield did not remain stable and their soils could turn into a high degree of soil acidity especially with the use of NH_4^+ as a source of nitrogen where this NH_4^+ may oxidize into NO_3^- and H^+ by soil bacteria (Miller and Donahue, 1990; Teitzel *et al*., 1991; Suksri, 1999). The high applied rate of nitrogen chemical fertilizers on pasturelands in Western Europe has been becoming a hazardous impact on the release of N_2O and NH_3 into the atmosphere (Mannetje, 2002).

Phonbumrung and Watanasak (2007) reported that Thai native beef cattle being raised under a free range system by rotating them to graze on organic pastureland

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for a long period of time largely increased biological diversity much better than the practices in using chemical supplies. Organic pastureland being established with the use of pasture and legume mixture could increase soil carbon more than natural pasturelands those without any interference up to 1.5 folds (Fisher *et al*., 1994). The use of organic composts or cattle manure could help in improving soil properties and increases forage production and also help in holding soil carbon more than those grasslands with the applied chemical fertilizers (Smith *et al*., 1997; Pholsen *et al*., 2005; Salazar *et al*., 2005; Gil *et al*., 2008). Organic forage of natural grasslands where grass and legume crops are grown together, the legume plants could be able to supply some adequate amount of nitrogen from root nodules sufficient to produce organic meat production (Kumm, 2002). Nitrogen fixation in roots of legume crops could provide adequate amount of nitrogen for growth of the legume crops as well as providing nitrogen for grass plants and it revealed that the mixture of legume and grass together largely increased nitrogen contents in the grass plant materials (Johansen and Kerridge, 1979). Furthermore, it largely improved forage quality where Crude Protein (CP) in grass materials tremendously increased. Some other workers have also advocated the large benefits derive from the growth of grass species and legume together in terms of high quality of forage feeding materials, safety products and friendly environmental conditions such as Shehu and Akinola (1995) and Bamikole *et al*. (2001). Therefore, the objectives of this investigation include (1) The search for an ideal grass species, (2) The most suitable method on organic production to be recommended to farmers where cattle manure and legume crops were used, (3) The ultimate yield and quality of pasture and forage producion when cattle manure, grass species and legume crops were used for their combinations.

MATERIALS AND METHODS

The experiment was carried out at the Experimental Farm, Khon Kaen University, Khon Kaen, Thailand during the 2006-2008 in searching for the most suitable grass species and legume crops combination for use in establishing a high output pastureland for livestock production. For this work, only the results of the third year (April 2007-2008) are included. The experiment was laid in a 3×4 factorial arranged in a Randomized Complete Block Design (RCBD) with four replications. Three grass species were used, i.e. Ruzi (*Brachiaria ruziziensis*), Purple Guinea (*Panicum* maximum cv. TD58) and Hybrid Napier (*Pennisetum purpureum* cv. Taiwan) and four organic systems were used, i.e., (1) Control (no fertilizer added), (2) Cattle manure at a rate of 25 tons ha^{-1}, (3) Verano legume (*Stylosanthes hamata* cv. Verano) and (4) Wynn legume (*Chamaecrista rotundifolia* cv. Wynn). Thus there were 12 treatment combinations and 48 plots were used and each plot has a dimension of 3.50×4.50 m in width and length, respectively. The Korat soil series (Oxic Paleustults) was used. The land area was ploughed twice and harrowing once then measured the 48 replicated plots separately and allowing 1 m walking path in between the plots then evenly applied cattle manure by hand to its respective plots and left out for two weeks. Soil sample of each replicated plot was taken out to the depth of 25 cm. The soil samples were used for the analysis of soil property. Seeds of Ruzi and Purple Guinea grasses were sown separately by hand into the soil under a transparency plastic tunnel. Cuttings of Napier grass were carried out leaving three buds for each cutting and then buried the cuttings into the soil leaving one bud above the ground level for germinations. This was taken under a transparency plastic tunnel. Watering was carried out daily with the use of a mini sprinkler system. Three weeks after emergence, seedlings of both Ruzi and Purple Guinea grasses were transplanted into polythene bags, one seedling for each bag and each bag has a dimension of 10×15 cm in width and length, respectively. Four weeks after transplanted into the bags, seedlings were transplanted again into their respective plots of treatments. Two weeks later seeds of Verano and Wynn legumes each at a rate of 10 kg ha^{-1} were evenly broadcasted by hand into their respective plots of treatments. The seeds were incorporated into the soil by mechanical means. Daily irrigation water near field capacity (13%) was given to the plots for one week by a mini sprinkler irrigation system, thereafter the rainy season provided rainwater to the plants in plots in the month of June hence some yearly required meteorological data were recorded. The germination of seeds was taken place within a few days and then the plants were allowed to grow for three weeks. The height of the three grass species in the plots was cut down at 10 cm above ground level as initial cutting. This was to provide a similar amount of growth for the beginning of the experimental period. The third year cuttings for dry matter yields in the rainy season were carried out for four times at 42 days intervals where the commencing of the counting on the number of days was started from the day of initial cutting from 11 June to 18 October 2008. The cuttings for dry matter yields were carried out twice in the dry season (2 December 2008-28 April 2009). A 0.50×0.50 m quadrat was used for sampling area for dry matter yields. Four quadratic measurements in each replication were randomly carried out. The plant samples were oven dried at 60°C for

72 h and then weighed out for dry matter yields. A portion of each dry matter yield of each replication was ground into meshes to pass through a 1 mm sieve screen and then kept separately in plastic bags where the samples were ready for plant chemical analysis. The analysis was carried out for Crude Protein (CP) by Kjeldahl method (AOAC, 1990), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL) with the method of Van Soest *et al.* (1991). Dry Matter Degradability analysis (DMD) was carried out with the method of Orskov *et al.* (1980).

The various methods described in this investigation were applied to the plants in every year of the experimental periods where appropriate, i.e., soil samples were randomly collected including the application of cattle manure hence data collections were carried out as a repeat of the previous two years of the experimental periods. The obtained data were statistically calculated using a SAS Computer Program (SAS, 1996).

RESUTLS

Meteorological data and soil conditions: For the third year experimental period, it was found that the highest and lowest mean values of monthly rainfall were 461.6 and 0.00 mm for September and January, respectively (Table 1). Average mean values of temperature ranged from 22.2- 29.4°C for the months of January and June, respectively. Monthly mean values of relative humidity ranged from 75-91% for February and September, respectively. Monthly mean values of sunshine ranged from 5.1-9.4 h for September and February, respectively. Monthly solar radiant energy values ranged from 186.8- 230.9 cal cm^{-2} day^{-1} for the months of September and February, respectively.

With soil property values before and after the experimental period, for the plots of grasses before the experimental period, the results showed that the ranges of soil pH, Organic Matter (OM%), total nitrogen (%N), extractable phosphorous (P, ppm) and exchangeable potassium (K, ppm) were 5.00-5.50, 1.44-1.73, 0.051-0.054, 9.5-10.75 and 38.50-49.00, respectively (Table 2). With organic production system, Cattle Manure plots (CM) gave much higher values in all items than the control and the rest with the mean values of soil pH, OM %, total N %, extractable P and exchangeable K of 5.87, 3.01, 0.061, 34.67 and 109.00, respectively. For the control and legume crops, ranges of mean values of pH, OM, total, extractable P and exchangeable K were 4.83-5.20, 1.13-1.25, 0.046-0.054, 2.00-2.33 and 18.67-23.67, respectively.

Soil property values analyzed after the final sampling period for the three forage grass species on soil pH, OM, total N, extractable P and exchangeable K ranged from 4.55-4.75, 1.21-1.23, 0.045-0.051%, 12.00-15.50 and 23.00-41.25 ppm, respectively. With control, Cattle Manure (CM), Verano and Wynn legumes, soil property values for soil pH, OM, total N, extractable P and Exchangeable K ranged from 4.43-4.60, 1.03-1.20, 0.041-0.048%, 3.67-5.00, 16.00-21.67 ppm, respectively.

Dry matter yields of grass alone and grass legume mixture: With dry matter yields of the three grass species, the results showed that both grass species and organic production methods gave highly significant effect on dry matter yields ($p<0.01$). However, there was no statistical difference found between Ruzi and Purple Guinea on dry matter yields with the mean values of 6585 and 6130 kg ha^{-1}, respectively yet Ruzi grass seems to possess a tendency to give more dry matter yield than Purple Guinea whilst Napier gave the lowest with a mean value of 884 kg ha^{-1} (Table 2). The production method of Purple Guinea plus cattle manure gave the highest dry matter yield up to 14,599 kg ha^{-1} but not statistically differed from Ruzi plus cattle manure with a yield of 12,977 kg ha^{-1}. Napier plus cattle manure gave the lowest dry matter yield of 3,226 kg ha^{-1} whilst that of the control and Napier plus Verano legume treatments failed to give any dry matter yields.

For the grass plus legume mixture, the results revealed that both grass species and production methods gave highly significant effect on dry matter yields ($p<0.01$). However, Purple Guinea and Ruzi gave a similar dry matter yields with values of 7,165 and 7,181 kg ha^{-1}, respectively. Dry matter yield of Napier was the least with a value of 2,790 kg ha^{-1}. The production method on the use of cattle manure gave the highest dry matter yield (grass alone) of 10,267 kg ha^{-1} followed by the Wynn legume with a value of 6,064 kg ha^{-1} whilst that of the mixture between grass and Verano legume gave the lowest dry matter yield of 3,623 kg ha^{-1}.

The application of cattle manure to both grass species gave highly significant effect on dry matter yields, purple Guinea plus cattle manure gave the highest dry matter yield up to 14,599 kg ha^{-1} whilst that of Ruzi gave dry matter yield up to 12,977 kg ha^{-1}. There was no statistical significant difference between the two grasses on dry matter yields. Purple Guinea plus Wynn legume gave dry matter yield of 7,082 kg ha^{-1} whilst Ruzi grass plus Verano legume gave dry matter yield of 6,501 kg ha^{-1}.

Dry matter yield of weeds: The results showed that organic production methods gave highly significant effect on dry matter yield of weeds ($p<0.01$) where the Napier

Table 1: Third year soil property values as influenced by forage grass species and production methods, grown on Korat soil series (Oxic paleustults) at Khon Kaen University, Thailand

	Forage grass species			Production methods			
Items	Ruzi	Guinea	Napier	Control	CM	Verano	Wynn
Initial							
pH (1:2.5)	5.50	50.00	50.15	4.83	50.87	40.97	50.20
OM (%)	1.73	10.73	10.44	1.13	30.01	10.14	10.25
Total N (%)	0.054	00.051	00.054	0.049	00.061	00.046	00.054
Extrt. P (ppm)	9.50	10.75	10.50	2.00	34.67	20.00	20.33
Exch. K (ppm)	43.00	38.50	49.00	18.67	109.00	22.67	23.67
After							
pH (1: 2.5)	4.55	40.55	40.75	4.47	40.97	40.60	40.43
OM (%)	1.21	10.21	10.23	1.03	10.45	10.18	10.20
Total N (%)	0.046	00.045	00.051	0.043	00.057	00.041	00.048
Extrt. P (ppm)	12.00	13.75	15.50	3.67	42.00	40.33	50.00
Exch. K (ppm)	27.50	23.00	41.25	16.00	65.33	19.33	21.67

CM: Cattle manure

Table 2: Dry matter yields (kg ha^{-1}) as influenced by forage grass species (G): Ruzi, Purple guinea and Napier and production methods (PM) of grass alone and grass plus legumes, grown on Korat soil series (Oxic paleustults) at Khon Kaen University, Thailand

	Forage grass species (G)			
Production methods (PM)	Ruzi	Purple guinea	Napier	Means
Grass				
Control	4601^{b}	4082^{bc}	0^{d}	2894^{Y}
Cattle manure	12977^{a}	14599^{a}	3226^{bc}	10267^{X}
Verano	3942^{bc}	1783^{cd}	0^{d}	1908^{Y}
Wynn	4821^{b}	4055^{bc}	311^{d}	3062^{Y}
Means	6585^{a}	6130^{a}	884^{b}	
Grass+legume				
Control	4601^{bcd}	4082^{cd}	0^{e}	2894^{Z}
Cattle manure	12977^{a}	14599^{a}	3226^{d}	10267^{X}
Verano	4645^{bcd}	2897^{d}	3327^{d}	3623^{z}
Wynn	6501^{bc}	7082^{b}	4609^{bcd}	6064^{Y}
Means	7181^{a}	7165^{a}	2790^{b}	
Weed				
Control	1105^{cd}	2140^{cd}	5093^{b}	2779^{XY}
Cattle manure	166^{d}	171^{d}	11449^{a}	3929^{X}
Verano	590^{d}	1638^{cd}	2239^{cd}	1489^{Y}
Wynn	88^{d}	768^{cd}	3726^{bc}	1527^{Y}
Means	487^{b}	1179^{b}	5627^{a}	

	Significant levels				
Items	G	PM	G×PM	CV (%)	SEM (±)
Grass	**	**	**	35	804
Grass+legume	**	**	**	29	832
Weed	**	**	**	77	933

Letter(s) indicate least significant differences of DMRT at probability of 0.05, **p<0.01, CV: Coefficient of variations, SEM: Standard error of means

grass plots gave the highest dry matter yield of weeds up to 5,627 kg ha^{-1}. Dry matter yields of weeds in Ruzi and Purple Guinea plots were not statistically significant with values of 487 and 1,179 kg ha^{-1}, respectively. Dry matter yield of weeds was highest with those of cattle manure plots with a value of 3,929 kg ha^{-1} whilst other three production methods gave a similar dry matter yield of weeds. Napier grass plus cattle manure gave the highest dry matter yield of weeds up to 11,449 kg ha^{-1} and the least was found with Ruzi plus Wynn with a value of 88 kg ha^{-1}.

Forage quality of grass and grass plus legume: The results on dry matter yields of the dry season were not included since the amounts attained were very small thus only the results of the four harvesting periods carried out in the rainy season were determined. With Crude Protein (CP), the results showed that crude protein values of both Ruzi and Purple Guinea grasses (CP, G) were similar with values of 7.20 and 7.05%, respectively (Table 3). The production methods of Wynn legume gave the highest CP of 7.55% followed by Verano legume with a value of 7.41%, respectively whereas Control and cattle manure gave CP values of 6.88 and 6.65%, respectively. There was a highly significant effect due to production methods on crude protein content. For CP of grass plus legume (CP, G+L), the results revealed that grass species and production methods gave highly significant

Table 3: Forage quality (%) as influenced by grass species: Ruzi, Guinea and Napier (G) and Production Methods (PM), grown on Korat soil series (Oxic paleustults) at Khon Kaen University, Thailand

	Forage grass species (G)				Production methods (PM)					Significant levels		
Items	Ruzi	Guinea	Napier	SEM	Control	Cattle manure	Verano	Wynn	SEM	G	PM	G×PM
CP (G)	7.20	7.05	-	0.116	6.88^{b}	6.65^{b}	7.41^{a}	7.55^{a}	0.164	NS	**	NS
CP (G+L)	8.06^{y}	8.86^{x}	-	0.110	6.88^{c}	6.65^{c}	9.71^{b}	10.59^{a}	0.156	**	**	**
NDF (G)	74.71^{y}	77.08^{x}	-	0.331	75.43	76.96	75.12	76.07	0.468	**	NS	NS
NDF (G+L)	73.07^{x}	71.89^{y}	-	0.288	75.43^{b}	76.96^{a}	69.16^{c}	68.38^{c}	0.407	**	**	**
ADF (G)	35.52^{y}	43.68^{x}	-	0.444	38.76^{b}	42.00^{a}	38.18^{b}	39.46^{b}	0.628	**	**	NS
ADF (G+L)	35.76^{y}	42.85^{x}	-	0.394	38.76^{b}	42.00^{a}	37.57^{b}	38.93^{b}	0.557	**	**	NS
ADL (G)	5.22	4.75	-	0.214	4.67	5.21	4.59	5.46	0.302	NS	NS	NS
ADL (G+L)	5.55	5.43	-	0.217	4.67^{b}	5.21^{b}	5.40^{b}	6.68^{a}	0.306	NS	**	NS
DMD (G)	75.10^{x}	66.75^{y}	-	0.332	71.12	71.01	71.01	70.51	0.470	**	NS	NS
DMD (G+L)	74.68^{x}	67.23^{y}	-	0.313	71.12	71.01	71.57	70.14	0.442	**	NS	*

xyz, abcd: Means of the same row with different letter (s) of its superscripts indicate least significant differences ($p<0.05$), *$p<0.05$, ** $p<0.01$, NS: Non significant, SEM: Standard error of means

differences where the Purple Guinea gave higher CP than the Ruzi grass with values of 8.86 and 8.06%, respectively. Wynn legume gave the highest CP% followed by Verano legume with values of 10.59 and 9.71%, respectively. The control and cattle manure methods gave values of 6.86 and 6.65%, respectively and no statistical difference found between two production methods, i.e., grass alone and grass plus legume.

With Neutral Detergent Fiber (NDF) of grass alone, the results showed that Ruzi grass significantly ($p<0.001$) produced lower NDF% than the Guinea grass. With the production methods, there was no statistical significant difference found. For grass plus legume, the results revealed that forage grass species gave a reverse result as that found with that of the grass alone. The differences were large and highly significant. For production methods, it showed that NDF% of grass plus legume of Verano and Wynn were similar ($p>0.05$) but NDF% of both were lower than that of the control and the cattle manure.

ADF% of grass alone, a similar trend as that of the NDF of grass alone was found but ADF of the grass plus legume for the Ruzi grass was significantly lower than the Purple Guinea grass. The effect due to production methods revealed that ADL% of the cattle manure was highest and highly significant over the rest. This result was similar to that of the grass alone.

For ADL values for grass alone, it showed that there were no statistical differences found in all methods of production, i.e. the forage grass species and the production methods. With ADL for grass plus legume, it revealed that only the production methods gave significant differences, i.e., the Wynn legume gave a mean value of 6.68% which was highest and highly significant over the rest.

With DMD% for grass alone, the results showed that a highly significant effect due to treatment was found with grass alone ($p<0.01$) but was not found with the production methods and also an interaction between grass species and production methods. For glass plus legume, it showed that DMD% produced a similar trend to that of the DMD% of grass alone except of the interaction between grass species and production methods where it gave a significantly result ($p<0.05$).

DISCUSSION

With the results attained at the third year experimental period, it was found that the crop plants both grass and legume were successfully grown up throughout the rainy season due to the adequate amounts of both annual rainfalls (1,611.7 mm) and total amount of radiant energy (186.8-268.0 Cal/h^{-1} day^{-}) ^{1} with mean temperatures of 28.9-35.5°C (Anonymous, 2008). It was found that soil pH values ranged from 5.00-5.50 (1:2.5 soil: Water by volume). This level of soil pH may not be suitable for the growth of the crop plants since the release of soil nutrients was relatively low (except that of cattle manure treatment) especially soil extractable P and exchangeable K where the amounts should not below 25 ppm for P and 80 ppm for K and pH values of 6-6.5 (Shelton *et al*., 1979; Mengel and Kirkby, 1987; Suksri, 1998, 1999). The high values of P and K nutrients for treatment of cattle manure must be attributable to the application of cattle manure when this manure contained total P of 1,700 ppm and total K of 1,170 ppm (from cattle manure analysis, not included) thus P and K of the cattle manure plots attained high mean values of both nutrients (Pholsen *et al*., 2005). The low mean values of soil nutrients at the third year experimental period must be attributable to the depletion of soil nutrients as a result of the previous amounts of dry matter yields harvested during the past two years.

Dry matter yields of Purple Guinea and Ruzi grasses were similar but lowest with Napier. The reasons for this may be attributable to type of grass when they possessed different growth characteristics (Cook *et al*., 2005). The

Napier plots had a high amount of weeds in the plots so there was a high competition for nutrients plus the destruction by termites then the growth was relatively low and disappeared from the plots. For grass plus legume mixture, the results showed that the treatments of Purple Guinea with cattle manure gave the highest dry matter yields (14,599 kg ha^{-1}). This could have been due to the adequate supply of nutrients from cattle manure in soil whereas the three grass species mixing with Verano and Wynn legumes gave significantly lower dry matter yields. The results indicated that both legumes contributed some certain amount of nitrogen from its root nodules (Johansen and Kerridge, 1979) yet when the supply of other macronutrients were not adequately supplied due to the low amounts available in soil, hence nitrogen derived from root nodules alone failed to provide high amounts of dry matter yields. Therefore, in any pastureland when there is a need to attain contributions from legume crops, growers must provide other nutrients apart from nitrogen, thus soil analysis is needed so that the needed amount of soil nutrients could meet the requirements for growth of the crop plants. Dry matter yields attained were lower than other published data since no chemical fertilizers were added to the soil. Ezenwa and Aken'Ova (1996) showed that common Guinea grass - Verano Stylo mixture gave dry matter yield of 6400 and 1,000 kg ha^{-1}, respectively. This study gave more grass dry matter yield than the present work but Verano Stylo gave less due to the effect of chemical fertilizer (15-15-15 NPK) application when common Guinea grass is a C_4 plant hence it grew faster than Verano (C_3) thus created shading effect. Napier grass required high amount of chemical fertilizers, particularly N for high dry matter yields (Vicente-Chandler *et al*., 1959). Tudsri *et al*. (2002) reported that Napier grass applied with 60 kg N ha^{-1} gave 6.4 folds dry matter yield greater than the present work where no chemical fertilizer was used.

With forage quality, the results showed that Crude Protein percentages (CP) of grass plus legume with respect to production methods of both Verano and Wynn legumes, they gave the highest reaching a mean value of 10.59% for Wynn but Wynn was significantly higher than Verano. CP of Guinea plus legume was significantly higher than Ruzi plus legume. The high values of CP of Both Wynn and Verano must be attributable to the contribution of the legume plants. The results on CP of grass plus legume revealed that CP of Purple Guinea plus legumes gave the highest. With production methods, Wynn gave the highest CP followed by Verano. The results indicated that legume crops aided in increasing CP, hence any pastureland required grass plus legume mixture in order to attain high percentages of CP. With Acid Detergent Fiber (ADF) of grass plus legume, the results showed that the highest was found with Guinea plus legume whilst that of the production methods, Verano and Wynn was the lowest. This led to the significantly lower DMD of Guinea plus legumes than Ruzi plus legumes. This must be attributed to the high amount of legume plants in the mixture growing of the crops.

CONCLUSION

For the 3-year investigation of dry matter yields and quality of forages derived from grass species and organic production methods, it could be inferred that the Purple Guinea grass was the most suitable species to be used within the organic production method where 24 t ha^{-1} of cattle manure were used. This production method produced the highest dry matter yields of 14,599 t ha^{-1}. With grass species plus Verano Stylo and Wynn Cassia grass-legume mixtures, they gave high values of CP contents of 9.71 and 10.59% and DMD values of 71.57 and 70.14%, respectively. Therefore, the success in establishing pasturelands should be definitely involved with the use of legume crops and organic manure, especially the cattle manure.

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REFERENCES

AOAC, 1990. Official Method of Analysis. 15th Edn., Association of Official Analytical Chemists, Arlington, VA.

Anonymous, 2008. A record of meteorology of the 2008. Department of Plant Science and Natural Resources, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand.

Bamikole, M.A., I. Ezenwa, A.O. Akinsoyinu, M.O. Arigbede and O.J. Babayemi, 2001. Performance of West African dwarf goats fed Guinea grass-Verano stylo mixture, N-fertilized and unfertilized Guinea grass. Small Rumin. Res., 39: 145-152.

Cederberg, C. and B. Mattsson, 2000. Life cycle assessment of milk production: A comparison of conventional and organic farming. J. Clean Prod., 8: 49-60.

Codex Alimentarius Commission, 2001. Guidelines for the production, processing, labelling and marketing of organically produced foods. Joint Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) Food Standards Program, Rome, Italy.

Cook, B.G., B.C. Pengelly, S.D. Brown, J.L. Donnelly and D.A. Eagles *et al*., 2005. Tropical forages: An interactive selection tool. CD-ROM, CSIRO, DPI&F(Qld), CIAT and ILRI, Brisbane, Australia. http://cgspace.cgiar.org/handle/10568/33575

Ezenwa, I. and M.E. Aken'Ova, 1996. Effect of method of sowing *Stylosanthes* on forage production of a *Panicum-stylosanthes* mixture. Trop. Grassland, 30: 363-366.

Fisher, M.J., I.M. Rao, M.A. Ayarza, C.E. Lascano, J.I. Sanz, R.J. Thomas and R.R. Vera, 1994. Carbon storage by introduced deep-rooted grasses in the South American savannas. Nature, 371: 236-238.

Gil, M.V., M.T. Carballo and L.F. Calvo, 2008. Fertilization of maize with compost from cattle manure supplemented with additional mineral nutrients. J. Waste Manage., 28: 1432-1440.

Johansen, C. and P.C. Kerridge, 1979. Nitrogen fixation and transfer in tropical legume-grass swards in south-eastern Queensland. Trop. Grasslands, 13: 165-170.

Kumm, K.I., 2002. Sustainability of organic meat production under Swedish conditions. Agric. Ecosyst. Environ., 88: 95-101.

Mannetje, L.T., 2002. Advances in grassland science. Netherlands J. Agri. Sci., 50: 195-221.

Mengel, K. and E.A. Kirkby, 1987. Principles of Plant Nutrition. 4th Edn., International Potash Institute, Berne, Switzerland.

Miller, W.M. and R.L. Donahue, 1990. Soils: An Introduction to Soils and plant Growth. 6th Edn., Prentice Hall, Englewood Cliffs, N.J.

Orskov, E.R., F.D.D. Hovell and F. Mould, 1980. The use of the nylon bag technique for the evaluation of feed stuffs. Trop. Anim. Prod., 5: 195-213.

Pholsen, S., P. Lowilai and Y. Sai-Ngarm, 2005. Effects of urea and cattle manure on yield and quality of signal grass (*Brachiaria decumbens* Stapf. cv. Basilisk) in Northeast Thailand. Pak. J. Biol. Sci., 8: 1192-1199.

Phonbumrung, T. and S. Watanasak, 2007. Biodiversity richness: Positive impact indicators of organic pasture under beef cattle grazing. In: Forage: A Pathway to Prosperity for Smallholder Farmers, Hare, M.D. and K. Wongpichet (Eds.). Ubon Ratchathani University, Thailand.

Rosati, A. and A. Aumaitre, 2004. Organic dairy farming in Europe. Livest. Prod. Sci., 90: 41-51.

SAS, 1996. SAS/STAT User's Guide. Version 6.12. Statistical Analysis System Institute Inc., Cary, New Jersey, USA.

Salazar, F.J., D. Chadwick, B.F. Pain, D. Hatch and E. Owen, 2005. Nitrogen budgets for three cropping systems fertilised with cattle manure. Bioresour. Technol., 96: 235-245.

Shehu, Y. and J.O. Akinola, 1995. The productivity of pure and mixed grass-legume pasture in the Northern Guinea Savanna zone of Nigeria. Trop. Grasslands, 29: 115-121.

Shelton, H.M., R.C. Gutteridge, N. Wilaipon, B. Wickham, D.C. Kratzing and S.W. Waring, 1979. Northern guinea savanna zone of Nigeria of Northeastern Thailand. Thai. J. Agr. Sci., 12: 235-247.

Smith, P., D. Powlson, M. Glendining and J. Smith, 1997. Potential for carbon sequestration in European soils: Preliminary estimates for five scenarios using results from long-term experiments. Global Change Biol., 3: 67-79.

Suksri, A., 1998. Effects of dolomite on growth and seed yields of soybeans (*Glycine max* L.) grown on oxic paleustult soil in Northeast Thailand. Pak. J. Biol. Sci., 1: 215-218.

Suksri, A., 1999. Some Agronomic and Physiological Aspects in Growing Crops in Northeast Thailand. 1st Edn., Khon Kaen University Press, Khon Kaen, Thailand.

Teitzel, J.K., M.A. Gilbert and R.T. Cowan, 1991. Sustaining productive pastures in the tropics. 6. Nitrogen fertilized grass pastures. Trop. Grasslands, 25: 111-118.

Tudsri, S., S.T. Jorgensen, P. Riddach and A. Poopakdi, 2002. Effect of cutting height and dry season closing date on yield and quality of five napier grass cultivars in Thailand. Trop. Grassland, 36: 248-252.

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.

Vicente-Chandler, J., S. Silva and J. Figarella, 1959. The effect of nitrogen fertilization and frequency of cutting on the yield and composition of three tropical grasses. Agron. J., 51: 202-206.