Technical Note

*Effect of different doses of compound fertilizer on the quality of kikuyu grass (*Pennisetum clandestinum *Hochst. Ex Chiov.)*

Ana C. Mejía-Taborda[1], R. Ochoa-Ochoa[2] and Marisol Medina-Sierra[1]

[1]*Grupo de Investigación en Ciencias Agrarias (GRICA), Escuela de Producción Agropecuaria, Facultad de Ciencias Agrarias, Universidad de Antioquia,*
Calle 70 No. 52-21, Medellín, Colombia
[2]*Ingeniero Agrónomo, consultor particular del área de pastos y forrajes*
E-mail: acmt79@hotmail.com

ABSTRACT: The effect of a chemical compound fertilizer ($N\text{-}P_2O_5\text{-}K_2O$, 20-5-5), applied in two forms (solid and liquid), on some indicators of the kikuyu grass (*Pennisetum clandestinum*) quality, was evaluated. The study was conducted at La Montaña farm, belonging to the University of Antioquia, Colombia. For that purpose, 28 plots were delimited and a randomized block statistical design was used, with the following treatments: T_0 (without fertilization); T_1, T_2 and T_3 (150, 200 and 250 kg ha^{-1} of solid fertilizer); T_4, T_5 and T_6 (150, 200 and 250 kg ha^{-1} of liquid fertilizer). Three cuttings were performed, every 45 days, and samples were taken from each plot to analyze: green forage (GF), dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), crude energy (CE) and ash. With the application of the high fertilizer doses significant differences were found ($p < 0{,}05$) in the GF (9,5 t ha^{-1} cutting^{-1}), CP (20,1 %) and DM production (1,9 t ha^{-1} cutting^{-1}). The DM and NDF percentages were 23,4 and 65,6 %, respectively, in the control. The treatments did not have effect on the ADF, energy and ash contents. It is concluded that the compound fertilizer can be applied in solid as well as in liquid form; however, to use the dose of 200 kg ha^{-1} is recommended, because the nutritional value of the pasture is similar to the one obtained with 250 kg and the cost is lower.

Key words: fertilizer application, chemical composition

INTRODUCTION

In northern Antioquia the specialized milk production systems predominate, specifically in the San Pedro de los Milagros municipality, where more than two million liters of milk are daily produced, which are processed in that same zone (Ramírez, 2013).These systems have grasses adapted to the climate and the prevailing pasture in the area is kikuyu grass (*Pennisetum clandestinum* Hochst. Ex Chiov.), which is highly dependent on fertilizer application (Mila and Corredor, 2004).

The objective of the fertilization practice is to increase forage production and quality, as well as the stocking rate capacity and the milk production per animal. In the case of kikuyu grass, the use of nitrogen is emphasized, due to the high requirement of this species and because this element is limited under tropical conditions, where the plant responds well to the application of 50 kg of N ha^{-1} after each grazing (Dugarte and Ovalles, 1991).

The response of kikuyu grass to phosphoric fertilization is limited, except in deficient soils or when it is applied together with N, which indicates that there is an interaction between both elements (Barrera, 2001). On the other hand, the response to potassium is low, unless the plant extraction in the vegetative stage is very intense (Zapata, 2000; Barrera, 2001); the application of minor elements at least once a year is recommended.

Regarding the ways of fertilizer application (liquid *versus* solid), few works have been conducted on kikuyu grass (Carrera, 2011). The liquid application allows higher uniformity and assimilation rate by the plant and avoids nitrogen losses by volatilization (Turner *et al*., 2012); however, this is just one of the ways to supply nutrients, because when the plant absorbs them the metabolic process is the same. In this sense, the objective of this study was to evaluate different doses of a compound fertilizer, applied in liquid and solid form, on the yields and nutritional quality of kikuyu grass.

MATERIALS AND METHODS

Location. The experiment was conducted at La Montaña farm –property of the University of

Antioquia–, located in the San Pedro de los Milagros municipality (Antioquia, Colombia), on a flat to undulated topography, at 6º 27' N, 75º 33' W, at 2 475 m.a.s.l.; with 15º C of average temperature, 72 % of relative humidity, and 1 550 mm of rainfall. Such farm belongs to a life zone of low mountain rainforest (lmrf), according to the classification proposed by Holdridge (2000).

Grasslands constitute 85 % of the farm with predominance of kikuyu grass, and the fertilization programs are based on the application of chemical products and liquid pig manure (Tamayo-Martínez *et al*., 2012). The physical and chemical characterization of the soil at the experimental lot was conducted before the beginning of the study (table 1).

Experimental procedure. A paddock, previously established with kikuyu grass, was used, in which seven treatments were distributed in 4 x 4 m (16 m^2) plots, with an effective area of 4 m^2 each. The plots were subject to a previous three-month homogenization period. The cuttings were made every 45 days, at 5-10 cm of plant height. The treatments were selected according to the annual nitrogen extraction rate (389 kg N ha^{-1} $year^{-1}$), for the maximum production (Bernal and Espinosa, 2003); and they were immediately applied after the cutting, in the way it is done in the zone. One of the following treatments was assigned to each one of the plots:

- T_0: without fertilization
- T_1: 150 kg ha^{-1} (30 kg N; 7,5 kg P_2O_5; 7,5 kg K_2O, solid fertilizer)
- T_2: 200 kg ha^{-1} (40 kg N; 10 kg P_2O_5; 10 kg K_2O, solid fertilizer)
- T_3: 250 kg ha^{-1} (50 kg N; 12,5 kg P_2O_5; 12,5 kg K_2O, solid fertilizer)
- T_4: 150 kg ha^{-1} (30 kg N; 7,5 kg P_2O_5; 7,5 kg K_2O, liquid fertilizer)
- T_5: 200 kg ha^{-1} (40 kg N; 10 kg P_2O_5; 10 kg K_2O, liquid fertilizer)
- T_6: 250 kg ha^{-1} (50 kg N; 12,5 kg P_2O_5; 12,5 kg K_2O, liquid fertilizer).

The treatments were subject to three cutting periods. Subsamples were taken from each of the plots, per cutting; they were dried and ground in the integral laboratory of animal nutrition, biochemistry and pastures and forages, belonging to the School of Agricultural Sciences of the University of Antioquia. The bromatological analyses were conducted in the quality control laboratory in COLANTA (Dairy Cooperative of Antioquia).

The crude protein (CP) content was determined through the Kjedahl (954.01) method. For the other analyses the standard methodologies described in the AOAC (AOAC, 1995) were used. In the field, the green forage (GF) production of each experimental unit was determined, through the double sampling technique (Suárez, 2007; Sierra, 2008); for which 0,25-m^2 frames were used in the zones of maximum, medium and minimum forage production.

Statistical analysis. A completely randomized block experimental design (balanced fixed effect) was used, with four repetitions per treatment, and three successive samplings were conducted. A variance analysis, the contrast test LSD –with 5 % significance level–, as well as descriptive analysis for the response variables, were applied. The data were processed through the statistical pack SPSS® version 16.0.

RESULTS AND DISCUSSION

The ADF, energy and ash values did not have significant differences among the treatments. However, there was an inverse trend between the DM production and the ADF and ash contents, which allows to infer that as the DM content decreased the nutritional quality of the pasture increased.

On the other hand, there were significant differences in the green forage production (table 2);

Table 1. Physical and chemical analysis of the soil of La Montaña farm, San Pedro de los Milagros (Antioquia). Average of three determinations.

Texture	Type of determination*														
	pH	OM	Ca	Mg	K	CEC	P	S	Fe	Mn	Cu	Zn	B	N-NO_3^-	N-NH_4^+
		%	Cmol (+) kg^{-1} soil				mg kg^{-1}								
FAr	6,1	10,2	11,4	1,9	0,50	13,8	140	14	225	5	5	8	0,1	3	55
SE ±	0,12	2,19	1,99	0,36	0,20	1,47	15,13	2,65	11,79	2,65	2,0	2,65	0,06	1,73	6,56

*Through standard protocols. Texture: Bouyoucos; pH: soil:water (1:1 v/v); OM: Walkley-Black; CEC: with ammonium acetate 1N, pH 7,0; P: Bray II.

Table 2. Effect of a compound fertilizer (20-5-5) on the chemical composition of kikuyu grass.

Treatments	GF*	DM	DM	NDF	ADF	Ash	CE
	t ha^{-1}		%				kcal kg^{-1} DM
T0	3,65[a]	0,84[a]	23,36[b]	65,61[c]	30,54[a]	8,80[a]	4 131,5[a]
SE ±	1,45	0,30	1,95	2,62	1,20	0,65	28,94
T1	8,14[bc]	1,67[b]	20,50[a]	61,51[bc]	30,94[a]	9,38[a]	4 140,75[a]
SE ±	2,34	0,49	1,46	2,19	1,06	0,60	48,66
T2	9,11[bc]	1,87[b]	20,59[a]	59,87[bc]	28,06[a]	9,13[a]	4 151,75[a]
SE ±	2,77	0,59	1,83	3,20	1,42	0,54	45,69
T3	9,59[c]	1,91[b]	19,9[a]	59,04[a]	28,96[a]	9,48[a]	4 195,08[a]
SE ±	1,79	0,40	1,85	2,74	1,46	0,88	28,74
T4	6,79[b]	1,38[ab]	20,44[a]	62,09[b]	31,59[a]	9,76[a]	4 166,42[a]
SE ±	2,31	0,49	1,39	3,16	2,55	0,68	42,94
T5	7,85[bc]	1,54[ab]	19,58[a]	60,13[bc]	29,70[a]	9,71[a]	4 177,33[a]
SE ±	1,98	0,39	1,46	2,81	1,36	0,56	51,21
T6	8,21[bc]	1,63[ab]	19,89[a]	59,55[bc]	30,78[a]	9,33[a]	4 147,00[a]
SE ±	2,10	0,45	1 ,59	2,22	2,07	0,66	46,10

[a,b,c] Values with different letters in the same column significantly differ ($p < 0,05$).

the doses and application forms were significantly higher ($p < 0,05$) than the control. The dose of 250 kg ha^{-1} in solid form showed the highest production (9,59 t GF ha^{-1} cutting^{-1}) and exceeded the control in 167 %.

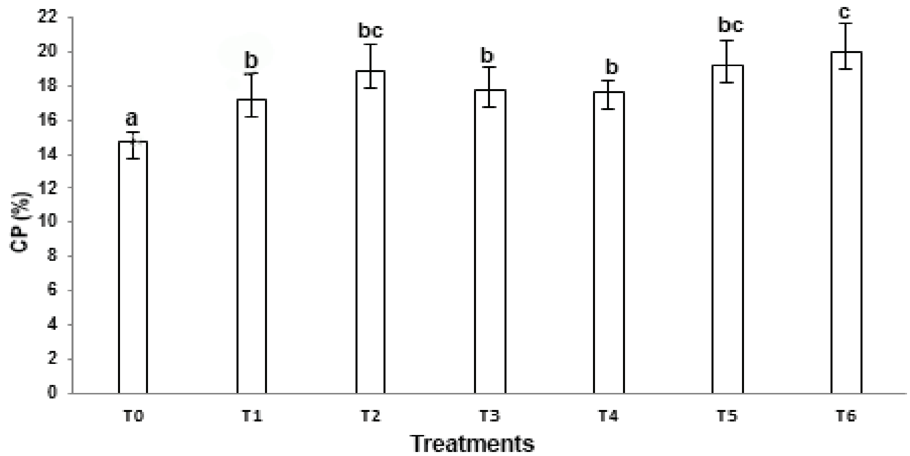
These results differ from the ones informed by Builes and Gómez (2004), in which the control produced 8,2 t GF ha^{-1} cutting^{-1} and was higher than the solid fertilization treatment (7,4 t GF ha^{-1} cutting^{-1}).

Regarding the dry forage production, the treatment of 250 kg ha^{-1} of solid fertilizer produced 1,9 t DM ha^{-1} cutting^{-1}, which was a similar result to the one obtained by Lotero (1995) with a formulation of 50-25-12,5. During the year, 15,3 t DM ha^{-1} were obtained, a value higher than the one found by this author. Other authors (Miyasaka *et al*., 2007) also suggest an increase in the production of dry forage of kikuyu grass due to fertilization –principally nitrogen–, under controlled conditions in Hawaii.

Crude protein showed significant differences ($p < 0,05$) among the treatments. The dose of 250 kg ha^{-1} in liquid form contributed the highest value and did not differ from 200 kg, in liquid as well as in solid form, with 20.04 % CP (fig. 1).

This percentage is similar to the ones reported by Arango and Montoya (2004); Castañeda *et al*. (2008); and Correa *et al*. (2008); as well as higher than the ones obtained by Apráez and Moncayo (2003) and Builes and Gómez (2004), varying between 15 and 17 %. Those authors also pointed out that the CP had a trend to rise as the fertilizer dose increased, which can stimulate the intake of forage with higher digestibility. However, the nitrogen fertilization involves changes in the nutritional quality of pastures, which are not visible for farmers but generate lots of negative effects on the productive (Van Horn *et al*., 1994), economic (Hanigan, 2005) and environmental (Lapierre *et al*., 2005) levels; this threatens the sustainability and the competitiveness of the production systems based on such grass. One of those modifications is the increase of the crude protein content, which occasionally reaches values higher than 25,0 % DM (Montoya *et al*., 2004; Carrera, 2011).

On the other hand, the DM tended to diminish when the fertilizer doses increased. The control showed the highest percentage (23,3 %) and significantly differed; while the treatment of 200 kg ha^{-1} of liquid fertilizer showed the lowest value (19,6 %). This performance can be due to the fact that when the N doses increased a rapid regrowth occurred, associated to a more tender and succulent foliage, which is similar to the report by Anneessens (1989) in Camerún, when evaluating the effect of different doses of a compound fertilizer on the DM production of kikuyu grass. Another reason that explains this is



Values with different letters have significant differences for $p < 0.05$.

Fig. 1. Protein content of kikuyu grass

that the nitrogen fertilization increases the protein levels, which has an inverse relation to the DM.

Likewise, Apráez and Moncayo (2003) reported that the treatment without fertilization produced 21 % DM, while the treatment with fertilization showed 15,2 %. Builes and Gómez (2004) also obtained the highest DM percentage (24 %) in the control.

Regarding the NDF, a trend to diminish was observed when the fertilizer doses increased. The lowest value was obtained in the treatment of 250 kg ha^{-1} of solid fertilizer (59 %), followed by the treatment of 250 kg ha^{-1} of liquid fertilizer (59,5 %); while the highest value was reached in the control (65,6 %). This could be due to the fact that there was a decrease in the foliage production in the plots without fertilization and, therefore, a higher development of the stems with high NDF content, which is a characteristic of kikuyu grass when it grows under low fertility conditions (Apráez and Moncayo, 2003). This indicates a positive effect of the fertilization on the NDF content, propitiating a better nutritional quality of the pasture.

The analysis of the costs of fertilizer application indicates that when increasing the doses the costs of the application times increased, in the case of solid fertilization (table 3). Although the cost/benefit ratio decreased as the doses were increased, the application of 200 kg ha^{-1} in solid form is justified because it originates a lower cost (table 3), a nutritional value similar to the one with the highest dose in a solid way is obtained (table 2) and lower pollution is generated. In this work the liquid fertilizer generated higher costs, and there were no differences in the indicators of the pasture that justify its application.

According to the results of this study, it is concluded that the fertilizer can be applied in solid as well as in liquid form without affecting the nutritional quality indicators of pasture. However, to use the dose of 200 kg ha^{-1} in solid form is recommended, because it originates lower costs and a nutritional value is obtained similar to the highest dose in solid form.

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Table 3. Cost of the application of a compound fertilizer, in solid and liquid form, in kikuyu grass.

Item	Solid application			Liquid application		
	150	200	250	150	200	250
	kg ha^{-1}			kg ha^{-1}		
Direct costs						
1. Materials and inputs						
-Fertilizer (ha^{-1} cutting^{-1})	177,060	236,080	295,100	177,060	236,080	295,100
-Water ($ cm^{-3})				4,063	4,063	4,063
2. Labor:						
-Dilution time (hours)				2,750	3,300	4,125
-Application time (wages)	2,275	2,438	2,708	6,500	6,500	6,500
Indirect costs						
1. Equipment depreciation						
- Spray pump				65,000	65,000	65,000
Total/cutting	179,335	238,518	297,808	255,373	314,943	374,788
Total/year	1 452,614	1 931,992	2 412,244	2 068,517	2 551,034	3 035,779
Pasture yield/cutting (kg ha^{-1}) in DM	1,669	1,876	1,908	1,389	1,539	1,634
Cost of the pasture kilogram in DM ($)	107,000	127,000	156,000	184,000	205,000	229,000
Commercial value of the pasture kilogram (DM)	157,000	157,000	157,000	157,000	157,000	157,000
Benefit/cost	1,46	1,24	1,01	0,85	0,77	0,68

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