Contribution to the study of soil fertility and its relation to pastures and forages production

G. Crespo, I. Rodríguez and S. Lok
Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque
Email: gcrespo@ica.co.cu.

Five well differentiated periods are recognize, that show qualitative changes that have taken place in the researches conception developed in Instituto of Ciencia Animal concerning soil fertility and its relation with pastures and forages production. In the first stage, corresponding to 1965-1970, the studies were centered in nutrients identification that limited pastures production and ways for their correction and appropriate fertilization .The fact that N was identified as the main nutrient that limits soil fertility motivated the development of many researches from 1970-1980, related with the effect of N application on the production and pasture quantity used in the country, as well as the best way of distributing this fertilizer to decrease the seasonal effect of pastures production. The influence of nitrogenous fertilization was also studied in different indicators production and animal health and in the action of continuous applications in soils agro-chemicals properties. This type of researches continued developing in 1980- 1990, stage in which was deepened in the high incidence factors to elevate the efficiency of N use, mainly the influence of climatic factors. In this period the researches were also intensified about laboratory methods for the determination of N assimilable contents from the soil and the influence of Cuban natural zeolite in the improvement of the efficiency of N use by grasses. By the middle of 1981-1990 decade researchers related with the role of animals excrements in the soil fertility and pastures production began. In 1983was clear the effect of quantity and distribution of animals excrete on soil fertility and grassland productivity, and in 1984 different ways of use of this resource and synergy of it with the fertilizer are described. With the new paradigm of the agro-ecological conception in the agricultural use, an original approach in soil fertility topic was opened. In this sense more than twelve researches during the years 1995 and 2000 were developed, that were use as database to form a program that allows knowing the result of nutrients balance in different systems of animal production. More recently, from the beginning of this century, researches have been centered in system studies, mainly related with the impact of animal production technologies in grassland and soil indicators. The researches have shown an evolutionary satisfactory development, which have gone in agreement with the imposed necessities by the new scientific tendencies. Furthers researches will allow to propose alternatives for the adoption of technologies that constantly increase the general soils fertility in cattle areas of the country.

Key words: tropical pastures, fertilization, recycling, systems.

INTRODUCTION

This paper shows the main results reached at the Instituto de Ciencia Animal since its creation, which are related to studies on soil fertility and its effect on grass and forage production.

STUDIES RELATED TO CHEMICAL FERTILIZERS APPLICATION

In the first researches the response of most extended pastures in the country to the application of growing doses of nitrogenous fertilizer were studied. Doses varied between 0 and 750 kg/ha/year of N. The maximum fertilizer conversion (kg of DM per kg of N) was produced with the mediation doses of N application, between 350 – 500 kg/ha, in spite of the productions was higher, with the highest application dose (Crespo 1974).

To specify even more the optimum dose of N application, experiments with guinea grass (*Megathirsus máximus*, Jacq.) and pangola grass (*Digitaria decumbens*, Stent) were carried out, considered the most extended in cattle areas of the country(Crespo *et al.* 1975).The results showed that with 300 kg/ha/year of N applications approximately higher efficiency is obtained.

The variations in grass production in a year decisively influence in the distribution of the availability and quality of these as animal food and, therefore, in the distribution of milk and meat during the year.

Experiments with this purpose were developed (Crespo 1976) in Havana and East to study the effect of different distribution systems of nitrogenous fertilizations (deferred fertilization) on the annual distribution of yields of pangola and guinea grass. In both grasses doses of 200 and 400 kg/ha of N were applied.

The higher yield percentage in the dry season was get when fractioning the whole fertilizer from November to April, with irrigation. However, guinea produced more uniform yields in Havana, with the application of 20% in the rainy season (May to October) and 80% in the dry one. In East this same system was applied or it was fractioned per cut all year. Pangola produced more uniform yields in Havana, with the 20-80 % and 40-60 % systems .In East the 20-80 %

system was applied.

Another group of experiments (Crespo *et al.* 1974) were carried out for studying the influence of basal application of phosphorous and potassium fertilizer on the recovery percentage of the nitrogenous fertilizer by grasses. For this, two levels of P+K (75+200 and150+ 400 kg/ha/year) and several doses of N (0. 150, 300, 450 and 600 kg/ha/year) were applied in pangola grass. The higher N recovery (approximately 60%) was achieved with150 kg/ha of N, plus 150 and 400 kg/ha/year of P and K, respectively.

An interesting aspect for controlling the nitrogenfertilization on grasses is the selection of appropriate analytic methods for the N determination in the soil. To compare the effectiveness of different agro-chemical methods the procedure described by Geist *et al.* (1970) and Dinchev (1972) was fallowed, that consists on determining the relation between the annual dry matter yield or the grass N extraction and N level assimilable in the soil. With this purpose the fallowing methods and determination variants of N assimilated of soil were compared: 1) N in initial form of NH_4^+ + NO_3^- (cited by Dinchev *et al.* 1968); 2) N in alkaline hydrolysis at 40 ºC during 24 hr, with NaOH at 0.05, 0.25, 0.50, 0.75, 1.0 and 1.25 N (Cornfield 1960 modifications); 3) N in acid hydrolysis at room temperature during 16 and18 h, with H_2SO_4 a 0.04 and 0.5 N (Tiurin and Kononova 1935); 4) N in organic matter (Walkley and Black, cited by Jackson 1970). Determinations were made in duplicate and the average was accepted when the relative error was lower to 10%.

These researches showed that the methods that determine mineral initial N (NO_3^- +NH_4^+) and the organic matter level, get the highest adjustments, with quadratic and cubic equations, respectively (Cuesta and Crespo 1988).

It has been explained that continuous application of nitrogenous fertilizers can notably influence on some agrochemical soil properties. To study this effect, a research in a brown soil without carbonates was carried out, in which 400 and 800 kg of N/ha/year was continually applied in a forages area for five years (Aspiolea and Crespo 1974). At the end of the fifth year of these applications, an increase of hydrolytic acidity and decrease of K, P and Mn available was demonstrated, as well as an increase of Fe and Cu contents. On the other hand, the Ca^{++}, Mg^{++}, Zn and Mo contents did not vary.

In another experiment, conducted in a typical red ferrallitic soil, the continuous application of 50 kg N/ha/cut during two years in a forage area decreased the pH and P, K, Mg, Na contents (Ramos and Curbelo 1978).

The soil acidity increase, due to the application of high nitrogen fertilizer dose, has produced yield decreases of some species, as guinea and coast cross bermuda, while pangola and brachiarias (*Brachiaria decumbens*, *Brachiaria brizantha*) seems to accept this conditions (Aspiolea and Arteaga 1976). The adaptations of plants to a high or low pH are, considerably, the result of changes in the absorption selection and translocation of particular ions.

In the Cuban soil and climate conditions, nitrogenous fertilizers applied to culture, including grasslands, have generally shown, high N losses, so in most of cases, the recovery has not exceeded 50% (Cuesta 1986).This fact, join to the incessant increase in these fertilizers price, shows the necessity to find methods that increase it efficiency, such as the evaluation of new fertilizers types and more efficient application techniques.

The natural zeolite (aluminum and silicate minerals) has attracted some researches attention, due to they improve the fertilizers effectiveness. This is attributed, mainly, to their high capacity of cationic exchange and their affinity and selectivity for NH_4.To check these qualities a research was conducted in which the zeolite dose effect was determined on the N efficiency (as urea) applied to *Brachiaria decumbens* grass in a typical red ferrallitic soil (Crespo 1989).

There was an increase in the efficiency use of the N applied, when zeolite dose was increased. It was produce 40 g of DM per g of N when 180 g of zeolite was applied, in comparison with only 18 g of DM per g of N, when this product was not applied. The N extraction by the higher grass was increased when increasing zeolite dose in the second and fourth cut and in the total extraction.

When studying the effect of N dose on the yield and chemical composition of guinea grass and the mineral composition of bulls blood serum (Brown Swiss X Zebú), Crespo *et al.* (1981) found that grass yield significantly increase up to 500g N/ha/year (21 t/ha/year DM), although P content had a marked decrease. The nitrate content in grass significantly increases, when more than 500 kg/ha/year of N was applied, with higher values at 15 d of regrowth. The increase of N dose decrease the P and K concentration in the animal blood serum, but the Ca, Mg and Na content was not affected. The LW average gain per animal was 144kg in the non fertilized grass and 235kg with N_{250} fertilization. It was concluded that can have high safety for feed animal health with the application of 250 kg N/ha/year, fractioned in four applications.

STUDIES RELATED TO THE ORGANIC MANURE AND MINERAL - ORGANIC FERTILIZERS

Generally, mineral fertilization has represented a high cost percentage of forage production in the world. That is why, researches to know the possibility to use organic manure were carried out, mainly from cattle manure, and other organic wastes of the agriculture, as complement and even as substitute of chemicals fertilizers.

In red ferrallitic soils some experiments were carried out to know the possibility to supplement or substitute chemicals fertilizers by organic manure from different sources for the intensive forage production. In a first experiment (Crespo and Oduardo 1986) was studied the effect of cattle manure dose (0, 25 and 50 t/ha/year) and N dose (0 and 60 kg/ha/cut) on the establishment and efficiency of N use in king grass forage (*Pennisetum purpureum* cv. king grass), as well as their effect on the OM content and soluble N in the soil.

In the establishment cut, three months after the sowing, forage yield was significantly increased with 25 t/ha of manure. Leaves yield in dry base showed significant interaction with the studied factors and was found that the higher value (7.6 t/ha) was obtained with 50 t/ha of manure plus 60 kg N/ha/cut. In this study, the N conversion efficiency (kg DM/kg N) was increased with the amount of manure dose and it was of 33.33, 44.9 and 56.7 kg DM/kg N for 0. 20 and 50 t/ha of manure, respectively. The application of 50t of manure and 60 kg N/ha/cut (240 kg N/ha/year) increased the OM and N contents of the soil at the end of the experiment, in depths of 0-15 and 15-30 cm.

The higher OM and N contents in the soil, due to the high manure dose application, joined to nitrogenous fertilizer, seems to favor forage radicular activity and, therefore, to improve nutrition.

In another experiment in a typical red ferrallitic soil, the effect of applying cattle manure and mineral fertilizer on king grass forage yield and in the chemical soil composition to longer period was studied (Crespo and Arteaga 1986).The yield that was obtained with the higher chemical fertilizer dose did not statistically differ of the treatments in which the fertilizer decreased and 40 t/ha of manure was applied .The soil pH was not affected by the treatments, but they significantly increase the OM, N, P_2O_5 and K_2O assimilable contents. Data showed that 40 t/ha manure dose allowed to practically substitute the effect of the dose half of chemical fertilizer that was usually recommended to apply to this forage under irrigation conditions.

It is considered that erects species from Pennisetum genus are extremely potassium extractors and, therefore, markedly respond to its application in many soils (Herrera and Ramos 1990).These authors informed that an appropriate application of this element extend the productive life of forage field and maintain more steady yields.

For similar soil and climate conditions, the experimental results showed, firstly, that is possible to reduce in a half the chemical fertilizer dose that requires this forage by means of 40 t/ha of cattle manure application in the first year and, secondly, that will be necessary to look after the potassium requirement during the exploitation years.

Later on the obtaining of organic-mineral fertilizersis beginning to study. First the effect of different excreta-zeolite proportions on the yield and chemical composition of guinea likoni (*Megatyrsus maximus*) was evaluated (Rodríguez and Crespo 1994) and it was determined that 4:1 of feces-zeolite proportion allows to achieve higher efficiency of the feces applied. Doses between 25 and 50 t/ha of manure were recommended.

STUDIES RELATED TO NUTRIENT RECYCLING

If it is taking into account that most of the papers published about this topic are from temperate and sub-tropical areas and, many times, under controlled conditions, the study of dung distribution by cattle in tropical grasslands and nutrients recycling by means of them, constitutes a topic of interest and actuality for the tropic.

In researches developed in the Instituto of Ciencia Animal (Crespo 2013), dung deposited by cow in star grass (*Cynodon nlemfuensis* cv. panameño) had diameters that were in a narrow range (23-26 cm), for 25.8 cm average value. Each cow deposited ten excretions as average in every grazing rotation, with dry weight of 0.29 kg each one.

The analysis carried out to the dung showed that N mean content was 1.52% and the average DM content 15.9% (Rodríguez and Crespo 1997). From these observations, was considered that, as average, each cow deposited a dung of 1.72 kg (b. fresh) every 1.5h of grazing, or is the same, an average of 13 dung, with 20.6 kg of total weight during 18 h of grazing. This shows that the 40 cows that grazing in the paddock defecated 840 dung, which weighed 1.64t in the two stayed days of each rotation.

The high (HF) and medium (MF) fertility spots of grass take small areas in the grassland, with values of 3.2 and 3.6 %, respectively. The grass weight per m^2 was significantly high in HF and MF spots, in comparison with low fertility (LF) areas, but only represents 17% of the total paddock availability. (Crespo 2013).

In the previous research, the higher N and P concentration of grass, as well as the higher DM yield in the designed high fertility spots HF" regarding to those of low fertility LF" show, without doubts, the influence of dung and urinations in this areas. Nevertheless, the higher N and K values, as well as the lower P value in the grass of HF areas, in comparison with MF, allowed deducing that the first ones were produced by urinations and the second ones, by dung.

It was also stidied how dung disappearance is producing in the grassland (Rodríguez *et al.* 1997).In all cases; the data of disappearance rate had better fit to the quadratic regression model.

The higher values of dung disappearance rate, in the first 30 days of deposited in June, July, August and September, compared with those deposited in May and October, were corresponded with the months of more rain and higher temperature. The erosive effect of rains during the first days of dung deposition notably accelerates its decomposition process and favorable conditions are created for higher activity of the soil biota in the dung.

The speed of dung deposition during dry season was slower than in the rainy season, therefore the incorporation of recycled nutrients by this way should be lower. While the dung deposited in the months of rainy season lost among 20-70 % of initial weight in the first 60d, in the dry season, only lost between five and 30% at 90 days. This happens this way, mainly, because dungs are encrusted in this period, principally, due to the humidity lack.

The higher speed of dung depositions in the rainy season show that the incorporations of nutrients to the soil starting from them happens faster than in dry season and, therefore, its effect on the grass is quicker in this period. This reveals that large feces volumes that are accumulated in the dairy shade buildings should be applied in grazing or forage areas during this season of the year, what will make more efficient the incorporation of nutrients that they contain to the soil.

The chemical composition of a great group of cattle dungs in dry and rainy seasons was investigated by Crespo *et al.* (1998) and Rodríguez *et al.* (2005a).In a general way, nutrients contents vary with the season of the year and majority, except Ca, show high values in the rainy season.

This way, N content was 29.5 %, higher in dungs that were deposited in the rainy season. The dispersion statistics showed that in this season the samples presented values nears to the mean. P and Mg showed similar performance.

The K concentration was 57 % higher in rainy season, with wider and notably more dispersed range regarding the dry season. However, the Ca content and DM percentage were lower in the rainy season.

The results show that the dungs that were deposited by the cows in the dry season were relatively poor in water and nutrients regarding to what was found in the rainy season.

A high concentration of K in the urine was found, whose value was 1.7 times higher than the N, while the P content showed lower concentration (Crespo 2013).

The effect of dung on the grass yield was stated up to 15 cm outside its edge and, in occasions, this also happen up to 30 cm. The higher effect was founded when the dung was deposited in July (599.82 vs. 256.39 g/m^2).Urine effect on the grassland yield was positive in all deposition months and all samples dates. Those deposited on January and March increase the yield, still 100d after applied. The most market effect took place I on July and, in any case, its influence was showed beyond the physical area, initially covered by it (Rodríguez 2001).

The dungs did not exert effect on the grass N and P contents, while the K content was increased at 60 and 120 d of having deposited on January and at 60d on March. The grass Mg content was not affected by the dung, while that of Ca was increased at 120d of having been deposited on January (Rodríguez 2001).

It was observed that N was higher in the grass that grew on the urine in the samplings made 60 d after having deposited on January, March and July, while this urination increased the grass K content in all samplings and, in many cases, the influence was showed beyond the border physically taken by it (Crespo, 2013).The influence of the urine in the grass yield was not only more evident, but also more durable than the one produced by the dung.

In the soil, N was significantly increased by both types of excretions, when the deposition was carried out on July, while in all cases K content was higher in the covered soil by the urine and in P did not influence any of these excretions. The pH and Ca did not vary between treatments, but Mg and OM increased in the depositions on July and March, respectively (Crespo 2013).

The amount of ammonia losses of the feces and urine of daily cows, deposited on the grassland in January, March and June, was also stidied (Crespo *et al.* 1997).

In these three experimental periods, the data showed better adjustment to the Gauss Function in case of dungs, with R^2 values of 0.89, 0.88 and 0.89 and to the Logarithmic model in Quadratic Function, in case of urine. Their R^2 values were 0.86, 0.89 and 0.61 for the first, second and third experiments, respectively.

In each experiments, the volatilized ammonia from the dung was low in the first days(less than 1 kg/ha/d), and gradually increased , up to 4 kg/ha/d at 8-10 days in the second experiment and 2 kg/ha/d at 8 days in the first and third experiments, respectively. Later, the values slowly decreased with the time and were not detected after 23days in all cases. The total of volatilized ammoniac-N by dungs was 25.5, 41.8, and25.5 kg/ha in the first, second and third experiments, representing 2.5, 4.1 and 2.5 % of the total N applied with the dejections, respectively.

In each of the urine experiments, the volatilized NH_3

in the first days varied from 2.95 to 4.77 kg/ha/d, and gradually decreased, up to disappearing from 15 d. The total of volatilized ammoniac-N per urine spot was of 22.3, 22.9 and 21.9 kg/ha in the first, second and third experiments, representing 1.8, 1.9 and 1.8 % of the total N applied, respectively.

Another important way of nutrients entry in grassland soils is the litter. Indeed, the return of vegetables nutrients to the soil through the grassland litter can, in occasions, to be higher than the returned by animal feces. This happens this way when the grass percentage use by ruminants in grazing is of the order of 40 – 60 %, what is common to happen under medium production conditions.

This nutrients return to the soil and recycling subsequent, vegetable consumption way, can be use by means of grasses species selection that produce high litter quantity of easy decomposition, with an animal management that allows an appropriate accumulation of it. This can be managed in such way that is possible to synchronize nutrients supply to the soil for this way and grass demand.

Crespo and Pérez (2000) demonstrated that grasses show low capacity to accumulate litter than legumes, but anyone exceeded 300 g/m^2/año. *B. decumbens* and *C. nlemfuensis* had the higher capacity of litter production, although still the natural grasses, as *P. notatum*, *D. annulatum* and *S. indicus*, accumulated up to 180 g MS/m^2, what is equal to 1800 kg/ha.

The higher litter accumulation by *Albizia lebbeck* tree, during December to March showed that, in the first weeks, the main contribution was carried out by this plant branches and leaves, but these fractions decreased with the time, until pods constituted 100% of the litter that is produced on March. In total, each tree produces 80.20 g DM of litter (Crespo and Fraga 2002). In this sense, it is considered that it is necessary to continue researches about the litter production capacity of the arborous of high interest for cattle.

To study how the decomposition in the time takes place of the produced litter by previous species, many studies with string bags, at random distributed in each of the grasslands were conducted (Crespo 2013).

Among legumes, the litter of *D. ovalifolium* and *P. phaseoloides*, showed a faster decomposition (16 %/month) than *S. guianensis* and *M. atropurpureum*/*G. wightii* (15 %/month).

The litter of perennial legumes showed faster decomposition than the grasses. This way, at 210 days all legumes litter had disappeared, while, in similar period of time, there were still in the bags more than 80% of *P. maximum*, *B. decumbens* and *C. nlemfuensis* litter,as well as 70% of litter of natural grasses and 50.5% of the corresponding to natural grasses+leucaena.

Practically the grasses litter lasted a year in completely disappearing, although in that time 30 %, 15 % and 11 % of *C. nlemfuensis*, *P. maximum* and *D. decumbens* initial weight, respectively, stayed in bags.

In general terms, N and P showed higher values in legumes, while the relation L/N (lignin/N) was higher in grasses. K showed lower values in the litter of natural grasses, as well as in the legumes *S. gracilis* and *D. ovalifolium*.

The notable differences shown between grass species in the speed of litter disappearance seem to be closely related with N content and L/N relation of it. This way, the grasses litter showed, generally, less N and higher L/N relation than legumes and their litter lasted much more time to decompose.

The obtained results show the importance that the legumes maintenance has in grasslands ecosystems to increase nutrients recycling dynamic by means of the litter that they produced, to what is added increase of the grassland quality and N contribution by means of the biological fixation of this element. This would help to accelerate the recycling process that commonly happens in grasslands only compound by grasses. These, as could be observe, produce litter of lower decomposition capacity and nutrients release, due to the low N content and to the high lignin/nitrogen relation, what spreads to the nutrients immobilizations during relatively prolonged periods of time.

The experiments on the litter production and N, P and K return in grasslands that differ on the species compositions of grasses showed that, in the diversified grassland, the total litter production was 73% higher than in the few species grassland (216.2 vs 124.4 t DM).The *L. leucocephala*/*P. maximum*, *C. cajan*/*C. nlemfuensis* and *L. leucocephala*/*C. nlemfuensis* areas were highlight, that contributed 63, 14 and 12 %, respectively of the total litter. In a similar way, the litter contribute in the grassland with trees 55 % plus N (41.9 vs 27.6 kg/ha), 144 % plus P (11.0 vs 4.5 kg/ha) and 174 % plus K (26.0 vs 9.7 kg/ha) than in the grassland that did not have trees (Crespo *et al.* 2004).

The existence of shrub and tree species in the grassland showed to be favorable, when reaching the highest litter production. This higher litter quantity represents an important way of nutrients recycling in these systems. Because it is an important source of nutrients this is available again to the herbaceous stratum disposition, when the biogeochemical cycle of nutrients contained in it is completed.

The biomass of grassland roots can contribute to the nutrients recycling in these systems. In this sense, researches conducted by Crespo and Lazo (2001) showed that roots system in improved grasslands contributes to the soil between 19–33 kg N/ha, 3– 5 kg P/ha and 1–2 kg K/ha annually. Rodríguez *et al.* (2013) in fifferent grasslands from Mayabeque province demonstrated that grasslands with creeping grasses had phytomass average (area + underground) of 1264.61 g. m^{-2}, five times less than the grassland were only was *Pennisetum purpureum* cv. Cuba CT-115.

These results are of great interest, because they show the organic matter contribution to the soil and their usefulness to predict indexes and diagnoses of soil resource.

Another way of nutrients entrance, mainly N, in the agricultural agro-ecosystems is rain water, whose quantity has been investigated in several countries.

It was found that the ammoniac-N concentration in the rain water has varied from 0.1 to 10.1 mg/L, representing 0.006 a 1.77 kg N/ha, respectively. The N concentration in nitrate form has fluctuated between 0.002 and 0.224 mg N/L, equivalent at 0.0002 to 0.0299 kg N/ha. The relation NH_4/NO_3 has been 324.1 as average. The obtained results show that the fallen rain in the studied period contributed 1 kg of N/ha per each 52.5 mm of rain, that is to say, each rain mm contains 0.019 kg/ha of N (Cuesta and Crespo 1990).

SIMULATION MODELS OF NUTRIENT BALANCE

Several models have been developed in animal husbandry that has looked at valuables aspects to manage systems functioning: litter effect, radicular system, and spatial distribution of animal feces, gases volatilization of greenhouse effect, nitrate washes and others. Other important factors, as food use, energy, consumption, digestibility and live weight of different animal categories, have also been modeling. Nevertheless, the models that form the interrelation between the three fundamental components of cattle system (soil-plant-animal) are limited.

Taking as database the obtained information in researches conducted in our Institute and other studies made in the country, Ortiz (2000) developed the RECYCLING model. This model allows, by means of a computational dynamic program, to estimate N, P and K balance state in different cattle systems. The analysis, design and to put in practice of the program, besides considering the predefined requirements in the specifications of a simulation model, predicted that, with their application, new studies on nutrients recycling can started, using the same program as a work tool.

This program allowed the improvement and deepening of the established knowledge about this thematic and, at the same time, to achieve higher adjustment degree of the model to the particularities that each unit cattle presents where it is applied. At the same time, the program constitutes a useful work tool of feeding technicians and agro-technique of many enterprise.

The validation of the software in the commercial cattle production was developed by Rodriguez *et al.* (2005b) with favorable results in many cattle units, mostly diary, in the western part of Cuba.

STUDIES RELATED TO THE EDAPHIC BIOTA IN GRASSLANDS AGRO ECOSYSTEMS

In grasslands, the biota carries out an important function in the organic matter decomposition and nutrients recycling in the different steps. That is why from 1995, the group begins to study the biota behavior in many cattle agro-ecosystems.

Rodriguez and Crespo (1997) and Cabrera and Crespo (2001) summarized the found results on the functions of edaphic biota in grasslands, as well as the main ways for its stimulation. Between the different groups, the earthworm and termites are responsible for the creation of appropriate conditions of soil aeration and chop of vegetables and animals materials that compose the organic remains and constitute, for that reason, the beginners of the biotic activity. The diplopods, on the other hand, feeds exclusively of vegetables waste in diverse decomposition stages, facilitating the activity of others decomposers of the trophic chain. The coprophagous fauna, represented by coleopterans, favors the active feces decomposition in the grassland and accelerates nutrients recycling, while acari and collembolan pulverize the organic material and makes it susceptible to the microbial activity. These micro-arthropods promote growth and the microorganisms and fungi distribution, carrying the decomposition products to the radicular area.

Rodríguez *et al.* (2002) researches showed the macrofauna variable behavior in different systems (natural grasslands, with leucaena and albizia trees or not and improved grasses grasslands) and demonstrated that the system with tree species maintain more stability during the time and the biomass is higher in those that were developed in calcimorphic humic and calcium brown soils.

It was found higher mesofauna activity (Rodríguez *et al.* 2003) in 10-20 cm of soil deep on July, that was the most hottest and humid month in the year. They identified mesofauna and macrofauna groups. In this case, the coleopteran larvae and worms were more abundant.

The previous results show the necessity to carry out experiments to be able to determine the animal feces contribution in the soil fertility.

INTEGRAL EVALUATION OF THE SOIL- PLANT SYSTEM IN DIFFERENT GRASSLANDS AGRO-ECOSYSTEMS

At the beginning of 2000 decade, different experiments were carried out for evaluating the impact of bovine cattle in the soil. These researches were carry out by a multidisciplinary group constitutes by the Ecology and Systematic Institute, Soils Institute and Animal Science Institute.

The results of these experiments allowed proposing a group of indicators (physical–chemical and biological) to evaluate the soil integral fertility as well as, a methodology (Crespo *et al.* 2006) that allows evaluating technologies impact of bovine production on the resource soil by means of interpretation tables of values of different indicators of the soil fertility (O.M, N-total, P-assimilable, Ca, pH, resistance to penetration, litter, infiltration, and biological activity).This proposal is based on the radial figures production that represents, according to values scale, each indicator state, and allows to estimating the integral fertility degree of the soil in each cattle unit.

From 2006, the researchers of the group were centered in selecting indicators that allowed determining the stability of the soil-animal grass system in grasslands ecosystems (Rodríguez *et al.* 2008).The main indicators studied were: a) botanical composition, biomass availability, height, chemical composition, frequency of species appearance, density per specie, vegetal covering and soil, species appearance and death and rooting points in the grassland; b) granulometry, microstructure, apparent density, resistance to penetration, specific weight, total porosity, N content, assimilable phosphorus, Ca and Mg, OM, basal breathing, induced breathing, cellulolytic capacity, mesofauna and macrofauna the soil and c) milk production, female under plan, L/milking cows, L/total cows, L of milk/ha of grass and stocking rate in the animal component.

Lok *et al.* (2007, 2008 and 2009) studied the selection of soil and grassland indicators in different production systems of cattle livestock. A considerable group of indicators were determined that, after subjected to the multivariate statistical analysis, allowed the grouping of those that should be monitored to know the sustainability state of each evaluated system.

This way, in a silvopastoral system based on leucaena/guinea, Lok *et al.* (2007) recommended the monitored of the indicators vegetal covering, soil, base grass density and presence of natural grass in the grassland component and the distribution of stable aggregates in humid and dry, structural stability, underground phytomass, macrofauna and mesofauna in the soil.

These same authors (Lok *et al.* 2008) compared leucaena/guinea system with another system based on guinea monoculture. In this case they recommended monitoring grass density, biomass availability, vegetal covering and botanical composition in the grassland and the structure, resistance to penetration, macrofauna, mesofauna and underground phytomass in the soil.

A similar experiment was conducted by Lok *et al.* (2009) in a milk production farm with the Biomass Bank technology with *P. purpureum* Cuba CT-115.In this case, the selected indicators for monitor grassland and soil state were similar to those founded in previous studies.

In each of these researches were propose tables that contain values ranges for the selected indicators, which can constitute useful, confidential and sensitive tools to discern each system state and to take the necessary measures for their sustainability.

CONCLUSIONS

The presented results demonstrate that the investigations on the soil fertility in the Instituto de Ciencia Animal has shown an evolutionary satisfactory development, that has gone in accordance with imposed necessity by the new scientific tendencies and with the resources behavior. Further researches will allow proposing alternatives that facilitate technologies that constantly increased the soil general fertility in the cattle areas of the country.

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