Integrated crop-livestock system in Dourados, Brazil - a sustainable production system

[1]Salton,J.C.; [1]Mercante,F.M.; [1]Tomazi, M.; [2]Zanatta,J.A.; [1]Concenço,G.; [1]Silva,W.M.; [1]Retore,M.
salton@cpao.embrapa.br,[1]Embrapa West Agriculture, Dourados,MS, Brazil [2]Embrapa Forestry, Colombo,PR, Brazil

Aiming to evaluate the performance of soil management systems along time, in 1995 an experiment was set up in Dourados city, Mato Grosso do Sul state, Brazil, in a clayey oxisol with the following management systems: CS - Conventional system: monocrop of soybeans followed by oats under conventional soil tillage, every crop season, by harrow disc plow; NTS – No-tillage system with crop rotation including soybean and corn grown in summer, wheat for grains, and oat or turnip as cover crops; ICLS – Integrated crop-livestock system: Rotation between crops (soybean/oats) and pasture (*Brachiaria decumbens*) conducted under no-till, rotating every two years. The pastures are grazed by heifers with stocking rate adjusted to constant supply of forage of around 7%, and PP – Permanent pasture: *B. decumbens* maintained on grazing with the same management used in ICLS.

Over time several evaluations were conducted with the purpose of comparing management systems in terms of soil attributes, crops grain yields, beef production and other agronomic aspects. The hypothesis to be tested was that the alternation of crops and pastures in intervals of two years would be more efficient and also bring beneficial effects to the environment. In Table 1 a summary is presented with the main results observed in the cropping systems; when these data were also available for the original vegetation they were used as a reference. It is expected that more complex and diversified systems would present synergy in the benefitial effects and occurrence of emergent properties. Emergent properties are those resulting from synergistic effects and only manifest when such synergy is observed. In general, crop yields in adverse weather conditions is a good indicator of the occurrence of these properties. This was true in certain situations, for soybean or beef production along the years of evaluation.

Currently much attention is given to the efficiency of production systems on the C balance in soil and reduction of GHG emission. In these respects, the crop-livestock system was very efficient, accumulating more C in the soil, reducing emissions of CO_2 and N_2O while maintaining productivity.

There was also evident the higher soil quality under complex system (ICLS) compared to simple systems (CS, NTS). Thus, based on the chemical, physical and biological attributes evaluated, it can be affirmed that the proposed crop-livestock system is agronomically efficient and environmentally sustainable.

Table 1 - Summarization of the main results already obtained in the cropping systems (CS: conventional, NTS: no-till, ICLS: integrated crop-livestock, PP: pasture) and the native vegetation (NV) in the Dourados experiment.

Attribute		Systems					Ref
		CS	NTS	ICLS	PP	NV	
Soil physical	Aggregation DMP (mm)	2.19	3.18	4.12	4.93		Salton *et al.* (2008)
	Index of aggregate stability - IEA	0.72	0.77	0.91	0.97		
Soil chemical	CEC, 0-5cm, 2011 (cmolc dm^{-3})	12.82	15.07	14.72	14.35		Salton *et al.**
	Basis saturation on CEC, 0-5cm, 2011 (%)	51.24	64.21	60.56	67.30		
	Al saturation on CEC, 15-30cm, 2011 (%)	12.40	11.76	19.28	5.04		
	P Mehlich, 0-5cm, 2011 (mg dm^{-3})	25.17	57.67	19.85	8.37		
	K, 0-5cm, 2011 ($cmol_c$ dm^{-3})	0.84	1.14	0.78	0.85		
	Ca + Mg, 0-5cm, 2011 ($cmol_c$ dm^{-3})	5.73	8.41	8.07	8.78		

	P organic, 0-5 cm, 2009 (mg kg^{-1})	26.4	30.5	31.3	43.1		Venâncio *et al.* (2009)
	Relation P organic/P total, 5-15 cm, 2009	0.55	0.63	0.76	0.87		
Soil organic matter	TOC, 0–5cm, 2011 (g kg^{-1})	15.89	19.01	22.49	27.06		Salton *et al.**
	TOC, 0–5cm, 2004 (g kg^{-1})	18.94	19.01	23.04	26.75	25,83	Salton *et al.* (2011)
	TOC, stocks, 0-30 cm (Mg ha^{-1})	44.1	42.6	48.02	50.11	44,49	
	POC, 0-30cm (g kg^{-1})	22.04	21.71	28.05	39.89	34,51	
	Lability (%)	9.22	10.76	12.12	15.60	10,47	
	C in the light free organic matter fraction (g kg^{-1})		1.15	1.28	2.52	2,70	Boeni (2007)
	C in the light occluded organic matter fraction (g kg^{-1})		3.89	6.04	7.53	3,60	
	C in the heavy organic matter fraction (g kg^{-1})		13.19	17.16	20.42	19,53	
	C O-alquil (%)		46.7	50.2	52.0		
	Carbon retention rate after 10 years, 0-30 cm (Mg ha^{-1} $year^{-1}$)	-0.002	-0.169	0.440	0.909		Salton *et al.* (2011)
Soil biological	Carbon on soil microbial biomass C-BMS (µg C g^{-1})	320.4	421.0	507.9	542.0	965.1	Borges *et al.* (2009)
	Basal respiration (µg C-CO_2 g^{-1} soil day^{-1})	14.1	22.4	24.3	24.6	53.2	
	Metabolic quotient - qCO_2 (µg C-CO_2 $µg^{-1}$ C-BMS h^{-1})	17.3	24.7	23.5	22.7	22.4	
	Microbial quotient - qMIC (%)	2.0	2.1	2.3	2.4	2.4	
	Density of soil invertebrate macrofauna (ind m^{-2})	279		1102	1261	3715	Silva *et al.* (2008)
		662	1144			3349	Aquino *et al.* (2008)
	Macrofauna diversity (groups nº)	6		11	15	19	Silva *et al.* (2011)
		9	19	15	15	21	Silva *et al.* (2006)
	Abundance of nematode *Rotylenchulus reniformis* (nº ind 300 cm^{-3})	3424	24	4	0	0	Sereia *et al.* (2007)
	Area covered with weeds (%)	30	25	20	5		Concenço *et al.* (2011b)
	Plants from weed species (nº m^{-2})	155	170	95	5		
	Dry mass of the weedy community (g m^{-2})	30	40	28	45		
	Soil covered by weed species after 20 days of soil disturbance %	25	56	8	2		Concenço *et al.* (2011a)
	Total number of seedlings and plants of weed species after four soil disturbances spaced in 20 days (nº m^{-2})	400	510	120	50		
	Total dry mass of weed species after four soil disturbances spaced in 20 days (g m^{-2})	18	38	5	3		
Grains production	Soybean yield in years with good rainfall distribution – 2006/07 (kg ha^{-1})	3875	3981	3910			Salton *et al.**
	Soybean yield in years with bad rainfall distribution – 2010/11 (kg ha^{-1})	1642	2882	2866			
Beef production	Grazing from sept to may/99 - Gain animal (kg $an^{-1}day^{-1}$)			0.814	0.749		Machado *et al.* (2001)
	Grazing from sept to may/99 -Gain area (kg ha^{-1})			582.0	515.6		
	Grazing on winter (may to aug/2011), only in pasture with severe frost – Gain/animal (kg/an/day)			-0.047	-0.273		Retore *et al.**
Greenhouse Gases	Emission during soybean season 2009/10 - N_2O (kg $EqCO_2$ ha^{-1})	275	234.8	223.9			Zanatta *et al.* (2011)
	Emission during soybean season 2009/10 - CH_4 (kg $EqCO_2$ ha^{-1})	-21.2	-14.2	-10.2			
	Emission during soybean season 2009/10 - CO_2 (kg ha^{-1})	0	-385	-1229			
	Total GHG balance during soybean season 2009/10 - (kg $EqCO_2$ ha^{-1})	253.8	-164.4	-1015.3			
Index of soil quality	IE - stratification ratio (Franzluebbers, 2002)		1.33	1.64	2.00	1.70	Salton (2009)
	IMC - Management Carbon Index (Diekow *et al.*, 2004)		82	104	136	100	

	Nord – Ordination level (Vezzani, 2001)		85	124	135	100	

*np: unpublished

References

Aquino A.M., Silva R.F., Mercante F.M., Correia M.E.F., Guimaraes M.F., Lavelle P. (2008) Invertebrate soil macrofauna under different ground cover plants in the no-till system in the Cerrado. *European Journal of Soil Biology* 44, 191-197.

Boeni M. (2007) *Proteção Física da Matéria Orgânica em Latossolos sobSistemas com Pastagens na Região do Cerrado Brasileiro,* 136pp.. Tese (Doutorado) – Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS.

Borges C.D., Mercante F.M., Silva R.F., Salton J.C. (2009) Impacto de sistemas agropecuários na qualidade do solo. In: *O Solo e a Produção de Bioenergia: perspectivas e desafios*. XXXII Congresso Brasileiro de Ciência do Solo, SBCS, UFC, Fortaleza, 1 CD-ROM.

Concenço G., Salton J.C., Brevilieri R.C., Mendes P.B., Secretti M.L. (2011a) Soil seed bank of plant species as a function of long-term soil management and sampled depth. *Planta Daninha* 29, 725-736.

Concenço G., Salton J.C., Secretti M.L., Mendes P.B., Brevilieri R.C., Galon L. (2011b) Effect of long-term agricultural management systems on occurrence and composition of weed species. *Planta Daninha* 29, 515-522.

Diekow J., Mielniczuk J., Knicker H., Bayer C., Dick D.P., Kogel-Knabner I. (2005) Carbon and nitrogen stocks in physical fractions of a subtropical Acrisol as influenced by long-term no-till cropping systems and N fertilization. *Plant and Soil* 268, 319-328.

Franzluebbers A.J. (2002) Soil organic matter stratification ratio as an indicator of soil quality. *Soil and Tillage Research* 66, 95-106.

Machado L.A.Z., Fabrício A.C., Salton J.C. (2001)Performance of steers in *Brachiaria decumbens* pastures, permanent and in rotation with soybean. In: *Grassland Ecosystems: an outlook into the 21st century: proceedings.* XIX International Grassland Congress, SBZ, FEALQ, Piracicaba, SP,pp. 747-748.

Salton J.C. (2009) Indicadores de qualidade do solo em sistemas de integração lavoura-pecuária. In: *Soja: Fator de Desenvolvimento do Cone Sul.* 5. Congresso Brasileiro de Soja, Mercosoja, Embrapa Soja, Londrina, PR, np.

Salton J.C., Mielniczuk J., Bayer C., Fabrício A.C., Macedo M.C.M., Broch D.L. (2011) Carbono no solo e em frações da matéria orgânica do solo sob sistemas de integração lavoura-pecuária em Mato Grosso do Sul. *Pesquisa Agropecuária Brasileira* 46, 1349-1356.

Salton J.C., Mielniczuk J., Bayer C., Boeni M., Conceicao P.C., Fabrício A.C., Macedo M.C.M., Broch D.L. (2008) Agregação e estabilidade de agregados do solo em sistemas agropecuários em Mato Grosso do Sul. *Revista Brasileira de Ciência do Solo* 32, 11-21.

Sereia A.F.R., Asmus G.L., Fabricio A.C. (2007) Influência de diferentes sistemas de produção sobre a população de *Rotylenchuls reniformis* (Linford & Oliveira, 1940) no solo. *Nematologia Brasileira* 31, 42-45.

Silva R.F., Aquino A.M., Mercante F. M., Guimarães M.F. (2006) Macrofauna invertebrada do solo sob diferentes sistemas de produção em Latossolo da região do cerrado. *Pesquisa Agropecuária Brasileira* 41, 697-704.

Silva R.F., Guimarães M.F., Aquino A.M., Mercante F.M. (2011) Análise conjunta de atributos físicos e biológicos do solo sob sistemas de integração lavoura-pecuária. *Pesquisa Agropecuária Brasileira* 46, 1277-1283.

Silva R.F., Mercante F.M., Otsubo A.A. (2008) Macrofauna invertebrada do solo em sistema integrado de produção agropecuária no Cerrado. *Acta Scientiarum: Agronomy* 30, 725-731.

Venâncio J.B., Zanatta J.A., Salton J.C. (2009) Distribuição das formas de fósforo após 15 anos da adoção de sistemas de manejo. In: *Matéria Orgânica Ambiental e Sustentabilidade: resumos expandidos*. 8. Encontro Brasileiro de Substâncias Húmicas, Embrapa Clima Temperado, Pelotas. Embrapa Instrumentação Agropecuária, São Carlos, SP. 1 CD-ROM.

Vezzani F.M. (2001) *Qualidade do Sistema Solo na Produção Agrícola*. 184 pp. Tese (Doutorado) - Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS.

Zanatta J.A., Salton J.C., Bayer C., Tomazi M. , Colman I. (2011) Emissões de gases de efeito estufa em sistemas de manejo de solo durante ciclo de produção da soja no Cerrado. In: *Anais.* II Reunião Paranaense de Ciência do Solo, UFPR, Curitiba, PR, pp. 24.