Characterization of major crop management in the buffer zone of Vila Velha State Park, state of Paraná, Brazil

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ABSTRACT. The objective of this paper is to contribute to the implementation of less-impacting farming practices in environmentally sensitive areas. Vila Velha State Park is located in Campos Gerais, a region of high-technology agriculture. Typical farming systems in the park's buffer zone were identified in visits, and characterized in consultations with experts, agronomists, retailers and stakeholders. Three major systems (A, B and C) were described, considering the most common practices in crop rotation, choice of products and machinery operations for soybean and corn production. Systems A and B are characterized by high investment and technology level, though System A has more capital for investment. System C is typified by the use of service packages offered by commissioned retailers. Alternatives to mitigate environmental impact could potentially arise in experiments conducted in association with Farmers A and B, and through economic studies with Farmer C.

Key words: corn, soybean, production systems.

RESUMO. Caracterização de manejos das principais culturas agrícolas na área de entorno do Parque Estadual de Vila Velha, Paraná, Brasil. O objetivo deste trabalho é contribuir para a implementação de práticas agrícolas de menor impacto em áreas ambientalmente sensíveis. O Parque Estadual de Vila Velha está localizado nos Campos Gerais, Paraná, região de agricultura altamente tecnificada. Os sistemas de produção da área de entorno do Parque foram identificados em visitas e caracterizados em consultas com especialistas, engenheiros agrônomos, representantes comerciais e produtores. Três sistemas de produção de soja e milho (A, B e C), típicos da região, foram descritos, considerando-se as práticas mais comuns em rotação de culturas, escolha de produtos e operações de maquinário. Os sistemas A e B foram caracterizados como de alto nível de investimento e tecnologia, sendo que o primeiro seria mais capitalizado. O sistema C diferencia-se pela utilização de pacotes de serviços oferecidos por revendas comissionadas. Alternativas para diminuir o impacto ambiental dos manejos observados poderiam potencialmente surgir a partir de experimentos desenvolvidos com os produtores dos sistemas A e B, e estudos econômicos junto aos produtores do sistema C.

Palavras-chave: milho, soja, sistema de produção.

Introduction

Vila Velha is a set of wind-sculpted sandstone formations of significant scientific, cultural and ecological value, located in Southern Brazil (25°15' S, 50°00' W), state of Paraná, in the region called Campos Gerais ("General Grasslands"). The 3,270-hectare Vila Velha State Park (VVSP) was created in 1953, with the objective of preserving a valuable site of natural heritage. Conservation units such as VVSP require a delimited buffer zone, where human activities are subject to specific norms and restrictions with the purpose of minimizing negative impacts (Strey, 2003).

Typical summer crop rotations in Campos Gerais are 1/3 corn (*Zea mays* L.) and 2/3 soybeans (*Glycine max* (L.) Merrill); winter rotations consist of 1/3 wheat (*Triticum aestivum* L.) and 2/3 bristle oat (*Avena strigosa* S.). The region is known for its leading efforts in no-tillage farming, which consists of planting in non-revolved soil, protected by a mulch of residues of harvested grain crops, cover crops, and desiccated weeds. The utilization of crop rotation is imperative, considering characteristics of soil and climate.

Brazil is the third largest corn producer in the world, harvesting up to 41 million tons in the 2000/2001 season; 50% of that is produced in the southern States of Paraná, Santa Catarina, and Rio Grande do Sul. In 2003/2004, Paraná grew about 6.5 million tons of corn grains, reaching an average yield of 5.1 Mg per hectare; whereas the average yield in Campos Gerais was 6.5 Mg per hectare in the same season (Seab/Deral, 2005). Factors contributing to increasing corn yield in Campos Gerais are careful choice of hybrid, raise of N application rates, best climatic conditions, uniform and precise stand, and use of weed control alternatives (Sá, 1993).

Soybeans are the main farming product of Brazil, responsible for 1/3 of the agricultural portion of the Gross National Product (GNP). Agricultural activities correspond to 1/3 of the whole GNP (Dias, 2005). Brazil is the second largest soybean producer, after the U.S., growing about 26% of the world's production in 2003/2004 (USDA/FAS, 2005). In 2004/2005, the State of Paraná grew about 9.5 million tons of soybean grains, with an average yield of 2.3 Mg per hectare. The average yield in Campos Gerais was 2.4 Mg per hectare (Seab/Deral, 2005).

This paper is derived from a larger multidisciplinary project, when the overall idea was to diagnose the current condition of the park's buffer zone and suggest actions towards sustainable development. Results of the original project showed that land use in the buffer zone is fragmented: a patchwork of crop fields, degraded native grasslands, remnant native forests, timber forests, installations, and remnant native grasslands. Although most farms are managed without qualified supervision, risking the preservation of local ecosystems, local farming is still cost-effective (Colet *et al.,* 2005). This paper focused on regional corn and soybean production systems.

Material and methods

This research was developed in 2005, in cooperation with the research group of the Agricultural Mechanization Laboratory, at the State University of Ponta Grossa (Lama/UEPG), in the State of Paraná. The study area is the region surrounding the limits of VVSP, a buffer zone represented by the drainage basins of Quebra-Perna and Guabiroba rivers. Soils are sandy and naturally poor in nutrients. A prior assessment showed that the buffer zone is characterized by agricultural use of the land, and the main cash crops are soybeans, corn and wheat (Colet *et al.,* 2005). The objective of this paper is to characterize typical farming systems in the buffer zone of Vila Velha State Park.

The characterization of local farming systems was based on a previous study developed by Lama/UEPG, when several properties in the buffer zone were visited and local farmers were interviewed. In order to obtain details about each system regarding choice of products and machinery operations, further consultations with professors, researchers, agronomists, sales representatives and other region experts were necessary.

Systems A and B

System A is characterized by constant agronomic supervision and monitoring, crop rotation program, regular soil analysis, and diagnosis-based product recommendations. Farmers within this system represent the typical no-tillage, high technology, high investment farming of Campos Gerais; very often they are very knowledgeable and recognize the value of research and technology. The typical farmer is descendent of European colonists arrived in the first half of the 20th century, owns by heritage and constant acquisition large tracts of land (although many rent additional faming land), and is connected to one of the main Farming Cooperatives in the region, from where he can get technical and financial support for the cropping season. Crop management scenarios for these systems were often determined in technical conferences with researchers and agronomists who have vast experience in consulting, and work as independent advisors at different properties in the park's buffer zone. Farmer A makes the highest investments on plant enhancement. It is customary to make preventive applications and use the latest releases, which are generally more expensive than long-established products.

System B farmers are similar to System A concerning investments in high technology, access and use of agronomic information, and farming management practices, but they are not as capitalized as System A farmers. Often they own smaller tracts of land and many rely on hiring additional cropping land, which makes the farming enterprise less profitable. Renting cropland may also inhibit investments on land enhancement practices such as fertility management through the adoption of appropriate crop rotation systems or by green or animal manure application. Agronomists and farming experts cultivating rented land can be included in this system. The general crop management pattern is to observe the economic level of damage when deciding on pesticide applications, and to choose generic, usually less expensive products.

System C

Farming system C is characterized as medium level of technology and investment, exemplified by poor planning, last-minute decisions, breach of crop rotation plan, utilization of prescheduled pesticide applications, and lack of expert consulting or monitoring for weeds, insects and diseases, or soil analysis. The data to represent this system was gathered with agronomists from local retailers.

Farmer C is usually a professional person of areas different than agriculture, relatively capitalized but not very knowledgeable, that has in farming a second source of income. This farmer generally overlooks the importance of research updates and technological advances. It is common for Farmer C to buy the whole "technological package" of pesticides from one company, where a commissioned sales representative makes recommendations for the entire crop cycle.

Results and discussion

Corn

The selection of seeds, pesticides and fertilizers used in all steps of corn production in the buffer zone of VVSP (Systems A, B and C) is displayed on Table 1. Products are displayed and categorized according to a general sequence of utilization that is typical to no-tillage corn production in the study region:

a. Herbicide (desiccation): no-tillage farming involves the desiccation of weeds and rests of previous crops before the planting. An insecticide may also be applied at this point as a preventive measure, depending on the history of the field and the level of technology.

b. Seeds: the following cultivars[1] are included in the study - Agroceres AG 8021®, Agroceres AG 122®, Agroceres AG 303®, Dekalb DKB 214®, Pioneer 30R50®, Syngenta TORK®.

c. Seed Treatment: corn seeds often receive treatment before commercialization. However, in high technology systems, extra preventive treatments with insecticide and fungicide are frequent.

e. Herbicide (postemergence): products are selective for corn and specific for broad-leaf and gramineous weeds. Regular monitoring and attention to the history of the field increase product efficiency.

f. Fertilizer (postemergence): source of N, such as urea and/or ammonium sulfate, broadcast over the surface, not incorporated to the soil. This second fertilizer application is necessary to provide the amount of N that was lacking in the first application.

g. Insecticide: products are chosen according to species found during monitoring and the history of infestations on the field.

h. Fertilizer (foliar): spraying micronutrients is becoming more common in high technology corn production systems.

Table 1. Details of products used in corn production in the study area, by farming system (crop yield 2005/2006).

Specifications	System A	System B	System C
a. Herbicide (desiccation)	glyphosate	glyphosate	2,4-D dimethylamine salt
	2,4-D ester	permethrin	-
	lufenuron	-	-
b. Seed	DKB-214®	TORK®	AG-122®
	AG 8021®	30R50®	AG-303®
c. Seed Treatment	thiodicarb	-	-
	imidacloprid	-	-
d. Fertilizer (planting)	18-46-00 (diammonium phosphate)	13-28-10 (NPK)	5-25-25 (NPK)
e. Herbicide (postemergence)	atrazine	atrazine	atrazine
	mesotrione	S-metolachlor	Nicosulfuron
f. Fertilizer (postemergence)	urea (44% N)	urea (44% N)	urea (44% N)
	KCl (58% K_2O, 45% Cl)	KCl (58% K_2O, 45% Cl)	-
g. Insecticide	novaluron	lufenuron	Chlorpyrifos
h. Fertilizer (foliar)	micronutrients (4% S, 0,5% B, 0,5% Cu, 3% Mn, 5% Zn)	-	micronutrients (10% N, 5% Zn, 4% Mn, 2% S, 0,5% Bo)

The operating costs of corn production are displayed on Table 2 (System A), Table 3 (System B), and Table 4 (System C), considering choice of products and machinery operations.

Numbers show that differences between the three systems lie in the choice of products, since costs of machinery operations are similar to all. It also shows that the difference between Systems A and B (about US$ 30.00 less per hectare) is not so great, if compared to the difference between Systems A and C (about US$ 170.00 less per hectare).

Soybeans

The selection of seeds, pesticides and fertilizers used in all steps of soybean production in the buffer zone of VVSP (Systems A, B and C) is displayed on Table 5. Products are displayed and categorized according to a general sequence of utilization that is typical to no-tillage soybean production in the study region:

a. Herbicide (desiccation): similarly to corn, no-tillage soybean production involves the desiccation of weeds and rests of previous crops before the planting.

b. Seeds: the following cultivars are included in the study; Coodetec CD 206®, Embrapa BRS 133®, Embrapa 48®, Monsanto M-Soy 5942®:

[1] The mention of brands or commercial names throughout this document does not imply suggestion or recommendation.

Table 2. Operating cost of corn production, System A (crop yield 2005/2006).

Components	Unit	Quantity per hectare	Price per unit (US$)	Price per hectare (US$)
1. Products				
limestone	kg	1500	0.01	16.84
seed 1	sc	0.58	86.33	50.07
seed 2	sc	0.58	93.89	54.46
seed treatment 1	L	0.4	34.53	13.81
seed treatment 2	L	0.07	214.97	15.05
fertilizer 1 (planting)	kg	200	0.37	74.89
fertilizer 2 (postemergence)	kg	200	0.33	66.56
fertilizer 3 (postemergence)	kg	200	0.29	58.71
fertilizer 4 (foliar)	L	3	1.73	5.18
herbicide 1 (desiccation)	L	2	3.89	7.77
herbicide 2 (desiccation)	L	0.5	6.39	3.19
herbicide 3 (postemergence)	L	5	4.75	23.74
herbicide 4 (postemergence)	L	0.2	82.02	16.40
insecticide 1 (desiccation)	L	0.1	28.92	2.89
insecticide 2 (postemergence)	L	0.12	51.80	6.22
adjuvant	L	2	2.62	5.25
Subtotal 1				*421.04*
2. Machinery Operations				
limestone distribution	-	-	-	7.99
planting + fertilizing	-	-	-	28.97
postemergence fertilizing	-	-	-	2.55
spraying 1 (herb.1+ 2 + insect.1)	-	-	-	1.94
spraying 2 (herb. 3 + 4 + insect.2)	-	-	-	1.94
spraying 3 (insect.2 + foliar)	-	-	-	1.94
harvest	-	-	-	105.33
Subtotal 2				*150.65*
3. Other costs				
Grain cart	h	0.275	22.32	6.14
Subtotal 3				*6.14*
TOTAL (1+2+3)				577.83

Note: "sc" - sack of 60.000 seeds.

c. Seed Treatment: seeds are inoculated with *Rhizobium* for N take-up; addition of Co and Mo, and possibly fungicide as preventive measure.

d. Fertilizer (planting): different formulations of NPK, according to soil analysis and expected yield. Common formulations contain mostly P and K; extra sources of K such as potassium chloride (KCl) are also in use.

e. Herbicide (postemergence): selective for soybeans and specific for broad-leaf or gramineous weeds. Constant monitoring and attention to the history of the field increase product efficiency.

f. Insecticide: products are chosen according to the species found during monitoring and considering the history of infestations on the field, according to integrated pest management.

g. Fungicide: application depends on constant monitoring and stage of the soybean plant; products to control fungal diseases, specially the "soybean rust".

Table 3. Operating cost of corn production, System B (crop yield 2005/2006).

Components	Unit	Quantity per hectare	Price per unit (US$)	Price per hectare (US$)
1. Products				
limestone	kg	1500	0.01	16.84
seed 1	sc	0.58	85.47	49.57
seed 2	sc	0.58	91.95	53.33
fertilizer 1 (planting)	kg	300	0.33	98.12
fertilizer 2 (postemergence)	kg	180	0.33	59.91
fertilizer 3 (postemergence)	kg	150	0.29	44.03
herbicide 1 (desiccation)	L	2	3.89	7.77
herbicide 2 (desiccation)	L	0.1	34.53	3.45
herbicide 3 (postemergence	L	2	15.15	30.30
herbicide 4 (postemergence	L	4	4.75	18.99
insecticide	L	0.2	28.92	5.78
adjuvant	L	1	2.62	2.62
Subtotal 1				*390.73*
2. Machinery Operations				
limestone distribution	-	-	-	7.99
planting + fertilizing	-	-	-	28.97
postemergence fertilizing	-	-	-	2.55
spraying 1 (herbicide)	-	-	-	1.94
spraying 2 (herb. + insect.)	-	-	-	1.94
spraying 3 (insecticide)	-	-	-	1.94
harvest	-	-	-	105.33
Subtotal 2				*150.65*
3. Other costs				
grain cart	h	0.275	22.32	6.14
Subtotal 3				*6.14*
TOTAL (1+2+3)				547.52

Note: "sc" - sack of 60,000 seeds

Table 4. Operating cost of corn production, System C (crop yield 2005/2006).

Components	Unit	Quantity per hectare	Price per unit (US$)	Price per hectare (US$)
1. Products				
limestone	kg	1500	0.01	16.84
seed 1	sc	0.58	40.58	23.53
seed 2	sc	0.58	40.58	23.53
fertilizer 1 (planting)	kg	200	0.36	72.69
fertilizer 2 (postemergence)	kg	150	0.33	49.92
fertilizer 3 (foliar)	L	3	2.42	7.25
herbicide 1 (desiccation)	L	1	5.31	5.31
herbicide 2 (postemergence)	L	5	4.03	20.14
herbicide 3 (postemergence)	L	0.4	35.61	14.25
insecticide	L	2	8.37	16.75
adjuvant	L	2	2.50	5.01
Subtotal 1				*255.22*
2. Machinery Operations				
limestone distribution	-	-	-	7.99
planting + fertilizing	-	-	-	28.97
postemergence fertilizing	-	-	-	2.55
spraying 1 (herb. + insect.)	-	-	-	1.94
spraying 2 (insecticide)	-	-	-	1.94
harvest	-	-	-	105.33
Subtotal 2				*148.71*
3. Other costs				
grain cart	h	0.275	22.32	6.14
Subtotal 3				*6.14*
TOTAL (1+2+3)				410.07

Note: "sc" - sack of 60.000 seeds

Table 5. Details of products used in soybean production in the study area, by farming system (crop yield 2005/2006).

Specifications	System A	System B	System C
a. Herbicide (desiccation)	glyphosate -	glyphosate -	glyphosate 2,4-D dimethylamine salt
b. Seed	Embrapa 48® BRS-133®	M-Soy 5942® CD-206®	BRS-133® CD-206®
c. Seed Treatment	fludioxonil + metalaxyl-M cobalt + molybdenum *Rhizobium*	carbendazim + thiram cobalt + molybdenum *Rhizobium*	- cobalt + molybdenum *Rhizobium*
d. Fertilizer (planting)	00-30-10 (NPK) KCl (58% K_2O, 45% Cl)	00-20-20 (NPK) -	00-20-20 (NPK) -
e. Herbicide (postemergence)	chlorimuron-ethyl clethodim imazethapyr lactofen tepraloxydim	clethodim cloransulam-methyl lactofen - -	bentazon imazethapyr sethoxydim - -
f. Insecticide	diflubenzuron methamidophos	diflubenzuron -	alphacypermethrin permethrin
g. Fungicide	azoxystrobin + cyproconazole	epoxiconazole + pyraclostrobin tebuconazole	epoxiconazole + pyraclostrobin sulfur

The operating costs of soybean production are displayed on Table 6 (System A), Table 7 (System B), and Table 8 (System C), considering choice of products and machinery operations.

Table 6. Operating cost of soybean production, System A (crop yield 2005/2006).

Components	Unit	Quantity per hectare	Price per unit (US$)	Price per hectare (US$)
1. Products				
limestone	kg	1500	0.01	16.84
seed 1	kg	30	0.51	15.28
seed 2	kg	30	0.51	15.28
seed treatment 1	L	0.06	43.17	2.59
seed treatment 2	L	0.1	38.85	3.89
seed treatment 3	dose	1.2	1.51	1.81
fertilizer 1 (planting)	kg	200	0.24	48.35
fertilizer 2 (planting)	kg	100	0.29	29.35
herbicide 1 (desiccation)	L	3	3.89	11.66
herbicide 2 (postemergence)	L	0.3	33.67	10.10
herbicide 3 (postemergence)	L	0.4	22.06	8.82
herbicide 4 (postemergence)	kg	0.04	185.62	7.42
herbicide 5 (postemergence)	L	0.3	42.30	12.69
herbicide 6 (postemergence)	L	0.25	58.28	14.57
fungicide	L	0.6	77.70	46.62
insecticide 1	kg	0.06	58.28	3.50
insecticide 2	L	0.5	8.20	4.10
adjuvant	L	1	2.62	2.62
Subtotal .1				*255.49*
2. Machinery Operations				
limestone distribution	-	-	-	7.99
planting + fertilizing	-	-	-	28.97
spraying 1 (herbicide)	-	-	-	1.94
spraying 2 (herb.+ insect.)	-	-	-	1.94
spraying 3 (herb.+ fung.)	-	-	-	1.94
spraying 4 (insecticide)	-	-	-	1.94
spraying 5 (insect.+ fung.)	-	-	-	1.94
harvest	-	-	-	90.61
Subtotal 2				*137.27*
3. Other costs				
grain cart	h	0.25	22.32	5.58
Subtotal 3				*5.58*
TOTAL (1+2+3)				398.34

Table 7. Operating cost of soybean production, System B (crop yield 2005/2006).

Components	Unit	Quantity per hectare	Price per unit (US$)	Price per hectare (US$)
1. Products				
limestone	kg	1500	0.01	16.84
seed 1	kg	30	0.54	16.19
seed 2	kg	30	0.50	15.06
seed treatment 1	L	0.06	18.35	1.10
seed treatment 2	L	0.1	38.85	3.89
seed treatment 3	dose	1.2	1.51	1.81
fertilizer (planting)	kg	300	0.23	69.28
herbicide 1 (desiccation)	L	2	3.89	7.77
herbicide 2 (postemergence)	kg	0.036	604.34	21.76
herbicide 3 (postemergence)	L	0.5	33.67	16.84
herbicide 4 (postemergence)	L	0.4	58.28	23.31
fungicide 1	L	0.5	40.79	20.40
fungicide 2	L	0.5	44.28	22.14
insecticide	kg	0.09	58.28	5.24
adjuvant	L	1	2.62	2.62
Subtotal 1				*244.25*
2. Machinery Operations				
limestone distribution	-	-	-	7.99
planting + fertilizing	-	-	-	28.97
spraying 1 (herbicide)	-	-	-	1.94
spraying 2 (herb. + insect)	-	-	-	1.94
spraying 3 (herbicide)	-	-	-	1.94
spraying 4 (fung.+ insect.)	-	-	-	1.94
spraying 5 (fung.+ insect.)	-	-	-	1.94
harvest	-	-	-	90.61
Subtotal 2				*137.27*
3. Other costs				
grain cart	h	0.25	22.32	5.58
Subtotal 3				*5.58*
TOTAL (1+2+3)				387.10

In contrast to corn production systems, the operating costs for soybeans on System C are higher than A and B. As earlier noted, the “technological package” offered by the companies and sales representatives includes recommendations for plant protection and crop management for the entire crop cycle. Therefore, the lack of expert consulting or monitoring for weeds, insects and diseases and the utilization of prescheduled pesticide applications, increase total costs. This is particularly evident for weed control, where knowledge and field experience are fundamental for good management practices to avoid or reduce spraying or defining correct product dosage. On Systems A and B, the general crop management pattern is to observe the economic level of damage when deciding on pesticide applications, allowing the adoption of better crop management practices and avoiding, thus, unnecessary costs.

Table 8. Operating cost of soybean production, System C (crop yield 2005/2006).

Components	Unit	Quantity per hectare	Price per unit (US$)	Price per hectare (US$)
1. Products				
limestone	kg	1500	0.01	16.84
seed 1	kg	30	0.51	15.28
seed 2	kg	30	0.50	15.06
seed treatment 1	L	0.18	1.17	0.21
seed treatment 2	L	0.15	40.71	6.11
fertilizer (planting)	kg	300	0.25	75.11
herbicide 1 (desiccation)	L	2	3.89	7.77
herbicide 2 (desiccation)	L	1	5.31	5.31
herbicide 3 (postemergence)	L	1.2	15.11	18.13
herbicide 4 (postemergence)	L	1	22.06	22.06
herbicide 5 (postemergence)	L	1.6	13.58	21.72
fungicide 1	L	1	44.28	44.28
fungicide 2	kg	2.5	1.51	3.78
insecticide 1	L	0.2	15.97	3.19
insecticide 2	L	0.15	18.00	2.70
adjuvant	L	3	2.50	7.51
Subtotal 1				*265.06*
2. Machinery Operations				
limestone distribution	-	-	-	7.99
planting + fertilizing	-	-	-	28.97
spraying 1 (herbicide)	-	-	-	1.94
spraying 2 (herbicide)	-	-	-	1.94
spraying 3 (herb.+ insect.)	-	-	-	1.94
spraying 4 (fung.+ insect.)	-	-	-	1.94
spraying 5 (fung.+ insect.)	-	-	-	1.94
spraying 6 (fungicide)	-	-	-	1.94
harvest	-	-	-	90.61
Subtotal 2				*139.21*
3. Other costs				
grain cart	h	0.25	22.32	5.58
Subtotal 3				*5.58*
TOTAL (1+2+3)				409.85

Conclusion

A general analysis of soybean and corn production systems shows that different managements are more a qualitative function than a quantitative one, which results in more interesting outcomes, both economically and environmentally.

Technical choices of System C characterize the involvement of farmers who practice agriculture as a secondary activity, and are usually professionals of other areas that are attracted to farming in periods of peaking prices.

In the case of System A, crop production is associated with public or private research and experimentation. Farmer A is constantly carrying out assays with newly developed pesticides, fertilizers, machinery or techniques.

Differences between operating costs of analyzed systems seem to lie in the choice of products, rather than in machinery operations.

Systems A and B have similar levels of management regarding research and experimentation, although System A has more capital for investment in state-of-the-art products and techniques.

Generally, Farmer C is primarily involved in other businesses, recurring to farming mostly when the economic scenario of agriculture is optimistic.

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