

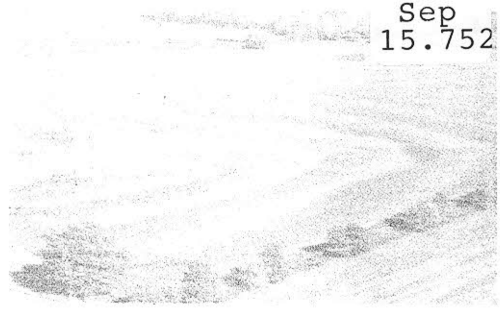

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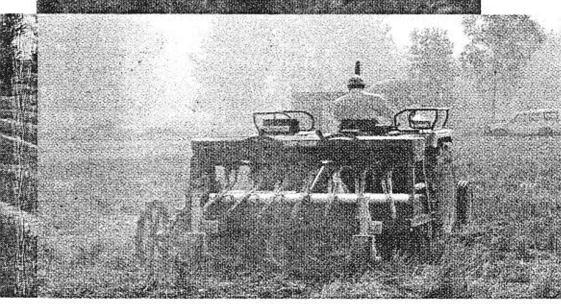
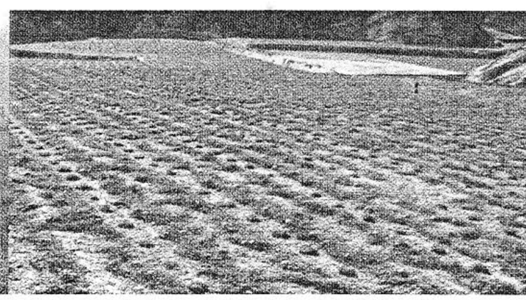
Lead Papers

4th World Congress on Conservation Agriculture

4-7 February 2009, New Delhi, India

Innovations for Improving Efficiency, Equity and Environment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The Importance of Biodiversity in Crop Rotations under Direct Drill in Controlling Weeds, Plant Diseases and Crop Pests

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Weeds in combination with insects and crop diseases, destroy an estimated one-third of the worldwide crop production potential. It has been estimated in North America that over 80,000 diseases affect crops caused from parasitism by approximately 8,000 fungal species, 200 bacterial species, 500 viral species, and 500 nematode species. An individual crop may have 100 or more known diseases affecting plant population; dying of plant tissue and destruction of leaf area resulting in decreased photosythesis; reduction of absorbing water and nutrients because of root rot; destruction or plugging of the translocation system; causing lodging, wilting, and blight; production of harmful toxins to the crop plant, to people or animals, resulting lower quality crop products.

Crop production systems in Brazil are very diversified, especially in the south region (Paraná, Santa Catarina, and Rio Grande do Sul states). In general, include crops such as soybean, corn, and rice in the summer season and wheat, barley, oat, triticale, rye, canola or annual pasture (oat and or ryegrass) during the winter. Most of annual pasture are used in very small grazing pasture which can be considered as winter cover crop or green manure. Rice is cultivated in low land areas of the middle south of Rio Grande do Sul state under irrigation. In the hill areas (500 to 1.200m a.s.l.), the soil is very well drained, crops are grown under no till system using annual grass straw, mostly oat and annual ryegrass. Besides exclusively crop systems, there is variation including animal forest production that constitutes integrated livestock-crop-forest production systems.

Average monthly rainfall in south Brazil ranges from about 120 mm (march) to 210 mm (September), and the total annual rainfall ranges from about 1.200 to 2.000 mm. Average mean temperature ranges from 12°C (June-July) to 22°C (January). Passo Fundo county, in the Rio Grande do Sul state, headquarter of National Wheat Research Center of Embrapa´s national research development systems and Londrina county in the Paraná state, headquarter of National Soybean Research Center both located on the south region of Brazil are leaders on no till system and pursuit new crops and arrangements to keep sustainability of brazilian agriculture.

Brazil´s soy fields, totaling almost 22.0 million hectares, representing about 45% of all grain planted in the country, whose total area is estimated to reach 48 million hectares, close to 40% of this area are located in the south region. Favorable climatic conditions is contributing greatly for Brazil to consolidate its position as worldwide leader in soy exports, beef, poultry and pork meats, sugarcane, coffee, cocoa etc. This paper will cover the importance of biodiversity in crop rotations under direct drill in controlling weeds, plant diseases and crop pests centered in the south Brazil crop systems.

A. Biodiversity in Crop Rotations under Direct Drill in Controlling Weeds

Weed Selection by Repeated Glyphosate Spraying

Soybean transgenic technology allows sprays glyphosate in post-emergency without injury. It was responsable by lower weed control cost, whose in some case lowered by 70%. Weed control problems such as roundleaf *spurge (Euphorbia heterophylla)* and common beggarticks (*Bidens pilosa*) desappear. However, farms and scientists became surprised due to the short time the weeds got resistance to repeated glyphosate applications. This situation was a surprise because new technology was adopted by farms before official government authorization. There was dissociation between adoption and research studies.

In spite of that, glyphosate is considered a low risk to weed selection resistance in a global point of view, there are at the moment 12 resistant weed species, with eight species identified in the last four years. The first case was registered in Australia in 1996, ryegrass (*Lolium rigidum*), following silver crabgrass (*Eleusine indica*), amaranth

(*Amaranthus palmeri* and *Amaranthus rudis*), common ragweed (*Ambrosia artemisiifolia*), horseweed (*Conyza canadensis* and *Conyza bonariensis*), annual ryegrass (*Lolium multiflorum*), johnsongrass (*Sorghum halepense*) and buckhorn plantain (*Plantago lanceolata*). Among such species resistante to glyphosate, horseweed (*Coniza canadensis*) is very important world wide, such as in the corn belt region of USA, and in Brazil.

Glyphosate has been used by farms in Brazil in the last 30 years, especially to make mulching to no till crop systems and apple and citrus orchards. Soy technology resistant to glyphosate becomes easy weed control. Nowadays, two or three glyphosate spray by season are enough to appropriated control (the first before seeding, and after emergency one or two more). The elimination of others herbicides, increased selection of weed resistant biotypes.

Resistant plant biotypes are not new in the south Brazil agriculture history. Tolerant plants such as *Euphorbia heterophylla* was selected by metribuzin (Sencor® and Lexone ®) in the 1990's in the Rio Grande do Sul state. This weed problem was solved by a new herbicide released, imazaquin (Scepter®). Imazaquin was used massively during some years and again allows the selection of new weed biotipe of *Euphorbia heterophylla* and *Bidens pilosa* resistants. In addition, allows tolerance *Cardiospermum halicacabrum*. These herbicides were not used anymore in some farms. Metribuzin and imazaquin resistance/tolerance characteristics are similar to what is happening nowadays with glyphosate, again the weed population dynamic was not considered.

Scientists know that herbicides promote change proportion of some biotype which results in dominance. Some herbicide molecule do not controls in the same way for different species, so some of them are benefited resulting in increased frequency. In some places this situation happens and there is appearance of new weed problems. Thus, it is necessary to manage different herbicides to avoid weed tolerance/resistance. The time of this incidence varies from two years with herbicides inhibitors of ALS to 20 years on glyphosate case. The number of weed plants resistant to glyphosate is increasing rapidly in soy transgenic in countries such as USA, Brazil and Argentine. In the Brazil, were identified two resistant species of horseweed (*Coniza canadensis*) and annual ryegrass (*Lolium multiflorum*), and four tolerant species of roundleaf spurge (*Euphorbia heterophylla*), vine (*Ipomoea* spp.), spreading dayflower (*Commelina benghalensis*), and Brazil pusley (*Richardia brasiliensis*). Fastness of new cases identification will be correlated with glyphosate uses on weed plant management.

Rio Grande do Sul (RS) State Case of Resistance Weeds

Transgenic soy is seeded in almost the totality area of the Rio Grande do Sul state. Glyphosate is used a unique herbicide and management method, resulting in ample selection pressure to tolerant/resistant weed species. We can note seeing evolution of some tolerant weed species such as vine (*Ipomoea* sp.), roundleaf spurge (*Euphorbia heterophylla*), Brazil pusley (*Richardia brasiliensis*), and spreading dayflower (*Commelina* sp.), and resistant weed species such as annual ryegrass (*Lolium multiflorum*) and horseweed (*Coniza canadensis*). Annual ryegrass in 2003 and horseweed in 2005 were the first two weed resistant cases reported to science. After that it was reported horseweed resistant to glyphosate in Paraná and São Paulo states of Brazil.

A multi-institutional consortium composed of wheat research center of Embrapa's research systems, Fundacep (cooperatives research system), and Universidade de Passo Fundo are monitoring new resistance and tolerance in the RS state. During the 2006/2007 season, fifteen new events of annual ryegrass and five of horseweed resistants. Fortunately it was not found a new event of roundleaf spurge (*Euphorbia heterophylla*). Soy costs will increase with weed resistant to glyphosate because will need for a different type of herbicide that is more expensive, and in addition the efficiency of control is reduced. Thus, farms must eliminate weed resistant/tolerate using other weed control management.

What should be done?

If it is not reasonable continue use glyphosate what should be done? The main motivation not to do not acquire weed resistant/tolerant is that the actual herbicide available technology are more expensive, less efficient, and more dangerous environmentally.

The decision is under the farmer's control, because assistant agronomist are not obligated to use a specific herbicide, so must be considered other weed management options. Farms should be encouraged to use prevention management to avoid resistant weeds, because the costs will, at least be higher, as the problem increases.

Some main management recommendations:

a) Do not use in the same area more than two times herbicides with the same mechanisms of control. If was identified weed resistant/tolerant, must be adopted herbicide rotation with similar efficiency to stop the problem.

b) Do monitoring and eliminate plant suspicious. After the herbicide application plant survive must be mechanically eliminated before seed production.

c) Do crop rotation. Crop rotation plans allow more alternative management to be adopted.

B. Biodiversity in Crop Rotations under Direct Drill in Controlling Diseases

Wheat Diseases Control

Climatic conditions are suitable to plant diseases originated by fungi, bacteria, viruses and nematodes. By definition crop diseases have an impact on crop rotation. On table 1 it is summarized some important wheat diseases with typical traits used to control or to reduce its pathogenicity. These organisms are important to us and our environment in the areas, such as, biological control of pathogenic organisms; improvement to soil tilth and productivity; organic matter decomposition and nutrient recycling; symbiotic relationships improving nutrient uptake by roots and legume nitrogen fixation.

Table 1. Main control management for wheat diseases control in Brazil.

Disease	Agent	Main control methods
FOOT ROOT	*Gaeumannomyces graminis* var. *tritici*	Crop rotation
FUSARIUM HEAD BLIGHT	*Fusarium graminearum* *Bipolaris sorokiniana*	Crop rotation Healthful seeds Fungicide seed treatment
POWDERED MILDEW	*Blumeria graminis* f.sp. *tritici*	Seed treatment with systemic fungicide Resistant variety
LEAF RUST	*Puccinia triticina*	Resistant variety Spray fungicide
TAN SPOT	*Drechslera tritici-repentis*	Crop rotation Healthful seeds Fungicide seed treatment Adequate plant date
SPOT BLOTCH	*Bipolaris sorokiniana*	Crop rotation Healthful seeds Fungicide seed treatment Adequate plant date
GLUME BLOTCH	*Stagonospora nodorum*	Crop rotation Healthful seeds Fungicide seed treatment Spray fungicide
GIBBERELLA EAR ROTSCAB	*Gibberella zeae*	Resistant variety Use of different seeding dates Spray fungicide on spikes
WHEAT BLAST	*Pyricularia grisea*	Resistant variety Adequate seeding date Spray fungicide on spikes
LOOSE SMUT	*Ustilago tritici*	Resistant variety Fungicide seed treatment
BACTERIOSES	*Xanthomonas campestris* pv. *undulosa*	Crop rotation Healthful seeds
SOIL-BORNE WHEAT MOSAIC VIRUS - SBWMV	Soil-borne wheat mosaic virus – SBWMV	Resistant variety Avoid areas with traditional problem
BARLEY YELLOW DWARF VÍRUS -- BYDV	Barley yellow dwarf virus – BYDV	Resistant or tolerant variety Seed treatment to pest control

The main disease control rules constitutes that the diseases integrated management (DIM), including healthy seeds, rational fertilizations, fungicide seed treatment, crop rotations, adoption of resistant varieties, and fungicide spraying.

Crop rotation is a management to disease control which prevents survival of necrotrophic organisms due to food privation and absence of host plants. Wheat has a variety of leaf diseases (spot blotch, glume blotch, and fusarium head blight), root diseases, and foot root (*Gaeumannomyces gram*inis var. *tritici*) where crop rotation is the most efficient recommendation. Crop the same specie year after year (monoculture), to let reintroduction of path organisms each six months. Scientist of south Brazil state that is necessary, at least, one year without wheat to permit straw decomposition in order to kill agent microorganisms of these complex diseases. Species such as oat, brassica, turnip, lupine, annual clover, vetch, etc are indicated to crop rotation systems.

Resistant varieties are the most important experience to wheat disease control. However, adoption of this recommendation is reduced by shortage of varieties with adequate resistance level. Thus it is important to know diseases reaction of each genotype available to projecting powerful crop rotation system. Another related limitation is less resistance according to new variety areas increased. This resistance detriment is well documented related with leaf rusts which appearance of new races is common and it abbreviates variety life. Fungal races that can cause a particular disease may differ in their pathogenicity under different conditions and thus, differ in the amount of disease they cause.

Considering that fungicide spraying is the most important management strategy to control wheat leaf diseases such as powdered mildew, leaf rust, tan spot, spot blotch, glume blotch, gibberella ear rot or scab, and brusone can be considered the most important wheat diseases in Brazil. Thus it is necessary to know some specific characteristics of each disease agent to evaluate the real importance to wheat crop.

POWDERED MILDEW - appear in all plant parts, but is common in leaves. In dry years, can be a predominant disease.

LEAF RUST – practically happens every years in each area worldwide. In Brazil, *Puccinia triticina* agent survives in voluntary plants.

TAN SPOT/ SPOT BLOTCH/GLUME BLOTCH – group of diseases. In brazilian conditions at least three of them are important. Seeds and crop residues are important to the survival of microorganisms in the absence small grain crops.

GIBBERELLA EAR ROT or SCAB – it is very common in south Brazil region, especially in Rio Grande do Sul state. It is a floral fungal infection. Some crops as corn, sorghum, triticale, rye, etc are not resistant.

BRUSONE – is a disease observed in Paraná and Mato Grosso do Sul states as well as other Cerrado region states (Mato Grosso, Goiás, Federal District ,part of Minas Gerais, São Paulo, and Bahia). It has light spores with easy scattering by wind.

Soybean Diseases Threat

Asian rust is now the most serious problem for soy farms. More than forty other diseases have already been identified in Brazil. Asian rust economic implications vary year to year from 15% to 100% in losses, depending on weather conditions favoring the disease.

End-of-cycle diseases are common in all the country, especially under hot and warm conditions. This complex includes brown spot (*Septoria glycines* and *Cercospora kikuchii*), target spot (*Corynespora cassiicola*), *antracnosis (Colletotrichum truncatum*), oidium (*Erysiphe diffusa*) and blight (*Rhizoctonia solani*). The fungi survive overwinter in the crop residues. Antracnonis is a main problem in the Cerrado region due to high temperatures and precipitation. Bligth is more common in Mato Grosso, Maranhão, Tocantins, and Pará states. The end-of-cycle diseases can be controlled by fungicides used in Asian rust, but preventive management practices like crop rotation, balanced fertilization, healthy and treated seeds must be adopted by the farmers.

Virus diseases such as stem necrosis and common soy mosaic only can be controlled using resistant cultivars.

C. Biodiversity in Crop Rotations under Direct Drill in Controlling Crop Pests

Crop production systems in Brazil are very diversified, especially in the south region. In general, include crops such as soy, corn or rice during the summer season and wheat, barley, oat, triticale, rye, canola or annual pasture (oat and or ryegrass) in the winter. From each five hectares cropped in the summer, just one is cropped with small grain cereals. Most of annual pasture primarily are used as green manure. In the middle south of Rio Grande do Sul state, low land areas are cultivated rice as flood irrigation. In the upland areas (500 to 1.200 m a.s.l.) no till system is used predominantly, mostly oat and annual ryegrass straw in the winter, and soy/crop rotation in the summer season. In the Cerrado region, biggest main soy crop region of Brazil, after harvest it, peal millet is seeded in the end of rain season, during the last rains as cover crop. Crop rotation and succession are responsible to agriculture sustainability in South-America environments.

Invertebrate herbivorous animals, such as insects, acarus, diplods, and mollusks, associated with these crop systems are diversified in species, habits, biological characteristics and damage abilities. Green or crop residue managements and soil preparation affects dynamic population, depending on biotics and abiotics factors, such as time of management actions, habitat and biological cycle duration, mobility, predators etc, in addition to soil type and climatic conditions. Replacement of native vegetation, discontinued and diversified, by homogeneous coverage in extensive areas, carry out a strong pressure in the qualitative and quantitative phytophagous fauna resulting in suppression of the natural source of food, allowing the development of few species adapted to simple environment, becoming a plague, on the aerial architecture and subterranean plant parts.

Soil management is long been recognized as the main responsible for dynamic population of organisms, especially those related with the soil. In this particular, no till system come determining intensive changes in the spectrum of organism plagues spectrum in the dominant crop production systems.

No till systems favors growth of species population with subterranean habits, residents in the area, with low mobility and long life cycle considering short life of most crops. Production and preservation of crop residues on soil surface soil, demand to success of no till systems, changes substantially the microclima, resulting also in changes of noxious and beneficial fauna. Crop residues on soil surface can affects positive or negative effects on potential plagues.

Others processes very common in no till system, with crop rotations and herbicide uses to kill green vegetation before seeding, also can affects the soil fauna. In general, second harvest in the some season tend to increase plague problems. Dry up herbicides such as glyphosate suppress suddenly and totally the food to insects and others small animals presents in the area. Depending on the host specificity degree of them, the results can be disastrous in the following crop, mainly, if the plant density is low.

Examples of some organisms effects on crop production:

a) Soybean-tamandua, *Sternechus subsignatus* (Coleoptera: *Curculionidae*), to feed with soy and others legumes plants. It has strong soil relationship, because in south Brazil stays six months during the winter season as adult larvae. Its geographic expansion and evolution as a plague, probably follows the soybean way on no till system. In the other hand, corn rotation or another no host crop such as sorghum or sunflower, is a successful strategy to control.

b) White Grubs Complex (Coleoptera: *Scarabaeidae*), especially the pasture grub (*Diloboderus abderus*) and the wheat grub (*Phyllophaga triticophaga)*, due to one to two years biological life cycle can be related with the winter crops and the initial cycle of summer crops.

   Grubs are insects that typically damage plant roots adapted to new crops and following a meadow or sod crop. In no till system has been increased grub population. However, in soybean and corn crops it can be controlled managing the seeding date, establishing a new crop when larvae stop feeding, going to the pupa metamorphosis phase.

c) Tin-Tack (*Dichelops furcatus* e *D. melacanthus*) are insects of secondary importance as soy vegetative plague. However, live under crop residues and are found sucking corn and wheat seedlings. Elevated population of these plagues can be related with second crop during the summer and no till system. Second crop make available feed releasing insects to look for food in the native plants. Crop residues on no till system constitutes an important environmental resource to protection during winter time.

d) Crickets (Orthoptera: *Gryllidae*) are omnivorous insects with large geographic distribution, considered insect plague in small crops, such as ornamental and horticultural plants. In corn and soybean, just recently has been reported as an occasional soil surface plague. The most common specie is the brown-cricket (*Anurogryllus muticus*) which lives in soil galleries. It has nocturnal habit damaging seedling on soil surface, delaying plant development. Damages are increased on drought and high temperature periods during emergency on no till system. Again, probably the no till associated with herbicide sprayed pre-seeding that reduce opportunity to look for others feed source.

e) Besides the above insects plagues others animal species have been reported as erratic plagues such as diplopods, milipods, and gastropods (snails and spiral shell). Diplopods, normally, feed of crop residues and has been found in the farms with so much straw and no till system. Snails and spiral shell are mollusks herbivorous, which live in humid environment and with intermediate temperatures, being considered important plagues in orchards, gardens and greenhouses. In large areas growing soy, corn, bean, and wheat, several species have been recently reported in no till system, with excess much crop residues, especially in areas cultivated with brassica.

Final Considerations

In recent years, there has been increasing awareness of the importance of preserving out natural resources and the environment. As a result, it has become more important to asses the environmental impacts of agricultural production. No-till systems makes numerous positive contributions, but still also some concerns about crop rotation combinations, social and economic sustainability.

Soil improvement characteristics in no-till systems have long been recognized, but often are forgotten or ignored on many farms. After land has been devoted to no-till system for several years, the trend is for subsequent crops to produce better than otherwise have been the case.

Crop rotation can interrupt weed, disease, insect, and nematode cycles, while the deep root penetration of many species into compacted soil layers can leave channels that improve water and air movement and enhance root penetration of subsequent crops, resulting in follow crops more productive and healthy.

Crop rotation is a basic, desirable agronomic practice that enhances long-term soil productivity. Because of numerous potential benefits that can be realized, many arable crops should be grown in rotation with forage grasses and grass/legume mixtures.

Agricultural production is essential, but it must also be protective of the environment. When properly planned and managed, no-till crop production systems are environmentally friendly type of agricultural production. In fact, it can be argued that agriculture and nature are rarely in better harmony than crop rotations under direct drill.

What could be more noble and satisfying than spending a lifetime living on, and caring for, the land? A good farmer is a true conservationist.

References

BALL, D.M.; HOVELAND, C.S.; LACEFIELD, G.D. Southern forages 4th ed. Norcross, GA: International Plant Nutrition Institute (IPNI), 2007. 322p.

GASSEN, D. N. O manejo de pragas no sistema plantio direto. In: EMBRAPA. Centro Nacional de Pesquisa de Trigo. Plantio direto no Brasil. Passo Fundo: Embrapa-CNPT / Fundacep Fecotrigo / Fundação ABC / Aldeia Norte, 1993. p. 129-139.

MILANEZ, J. M.; CHIARADIA, L. A. Lesma: praga emergente no oeste catarinense. Agropecuária Catarinense, v. 12, n. 1, p. 15-16, mar. 1999.

MULLEN, R.E. Crop Science: Principles and Practice. Iowa State University: Ames, 1996. 354p.

REIS, E.M.; ABRÃO, J.J.R. Effect of tillage and wheat residue management on the vertical distribuition and inoculum of *Cochliobolus sativus* in soil. Plant Disease, Saint Paul, v.67, n.10, p. 1088-1089, 1993.

REIS, E.M.; KOHLI, M.M. Wheat diseases in South America and strategies for their control. In: REGIONAL WHEAT WORKSHOP FOR EASTERN, CENTRAL AND SOUTHERN AFRICA, 8., 1993, Kampala, Uganda. Developing sustainable wheat production systems: proceeding. Addis Ababa, Ethiopia: CIMMYT, 1994. p.153-163.

REUNIÃO DA COMISSÃO BRASILEIRA DE PESQUISA DE TRIGO E TRITICALE (1.:2007: Londrina, PR). Indicaões técnicas para a safra 2008: trigo e triticale. Londrina: Embrapa Soja, 2008. 147p.

REUNIÃO DE PESQUISA DE SOJA DA REGIÃO SUL (34: 2006: Pelotas, RS). Indicações técnicas para a cultura da soja no Rio Grande do Sul e em Santa Catarina 2006/2007. Pelotas: Embrapa Clima Temperado, 2006. 240p.

RIGON et al. (eds.) Anuário brasileiro da soja 2007. Santa Cruz do Sul: Editora Gazeta Santa Cruz, 2007. 136p.

SALVADORI, J. R.; PEREIRA, P. R. V. S. Manejo integrado de corós em trigo e culturas associadas. Passo Fundo: Embrapa Trigo, 2006. 9 p. html. (Embrapa Trigo. Comunicado Técnico Online, 203). Disponível em: http://www.cnpt.embrapa.br/biblio/co/p_co203.htm

SALVADORI, J.R.; ÁVILA, C. J.; SILVA, M. T.B. da. Ed. Pragas de solo no Brasil. Passo Fundo: Embrapa Trigo; Dourados: Embrapa Agropecuária Oeste; Cruz Alta: Fundacep Fecotrigo, 2004. 544p.

SALVADORI, J. R.; PEREIRA, P. R. V. da S.; CORRÊA-FERREIRA, B. S. Pragas ocasionais em lavouras de soja no Rio Grande do Sul. Passo Fundo: Embrapa Trigo, 2007. 34 p. html. (Embrapa Trigo. Documentos Online, 91). Disponível em: http://www.cnpt.embrapa.br/biblio/do/p_do91.htm

SANTOS, H.P. dos; REIS, E.M. Rotação de culturas em plantio direto. Passo Fundo: Embrapa Trigo, 2003. 212p.

SANTOS, H.P. dos; LHAMBY, J.C.B.; PRESTES, A.M.; REIS, E.M. Características agronômicas e controle de doenças radiculares de trigo, em rotação com outras culturas de inverno. Pesquisa Agropecuária Brasileira, Brasília, v.33, n.3, p.277-288, 1998.