Recommending MoA rotation in production system:

Key learnings

Thursday, October 1st – Pedro J Christoffoleti
Conservation tillage and weed management

The basis for modern Brazilian Agriculture

“a combination of cultural practices that result in the protection of soil and water by maintaining or improving productivity of crops of commercial value” (Reicosky e Dowdy, 1985)

“Herbicides are essential to continue the no till system”

“Don't get caught short on time”

“Timeliness is the key to successful management in conservation systems”

“Don’t get blindsided beginning to worry 21/30-day window prior to planting, so you might begin to lose some burndown options: Be on top of it”
Herbicide-resistant Weeds Threaten Soil Conservation Gains: Finding a Balance for Soil and Farm Sustainability

The balance between conservation tillage and herbicide-resistant weed management is the central issue addressed in this...
Double crop Rotation soybean/corn in Brazil’s Midwest

Second-season corn area is more than 50% of the first-season corn

Soybean free period (90 days)

Soybean
Corn
Chemical fallow
Soybean
Corn

Sep. to Dec.
Jan. to mid Mar.
15 Jun.
15 Sep.
Jan. to mid Mar.
15 Jun.

Rainfall in Sinop/Sorriso – MT 30 years AVG.
Double cropping system based on timely planting of the soybean and corn

Harvest and seeding at the same time are common practices in double cropping system of soybean fb second season (offseason) corn.
The message is rather simple: “Clean” crop

- Use different modes of action (MoAs)
- Provide overlapping layers of residual herbicides throughout the season
- “Zero tolerance” – expensive, time-consuming but you can’t cut back much and risk heavy infestations and yield losses
- You can’t afford to cut back on weed control

Establishment of a clean crop is essential
System approach with new MoA herbicides

“Back to the future approach” – Inserting “old” herbicides as partner of glyphosate?

and/or

“Ahead to the future” - New traits of transgenic crops resistant to non selective alternative to glyphosate herbicides?
Typical herbicide sequential applications in the Double Cropping - Soybean fb Corn

- Post harvest
- Burndown
- Residual
- Glyphosate

3 months

90-Day Soy-Free Period

Carryover???

Jan.-mid Mar.

Glyphosate + atrazine

Typical herbicide sequential applications in the Double Cropping - Soybean fb Corn
**Corn post harvest landscape**

- **Without** intercropping cover crop fallow
  - *Conyza spp* and *Digitaria insularis* resistant to glyphosate

- **Intercropping corn with cover crop** *Urophylla spp*
  - Free of resistant *Conyza* to glyphosate
Resistant Conyza to glyphosate after glyphosate alone treatment in corn post harvest conditions
Conyza is a perennial weed
Tools for corn post harvest conyza control – 6 MoAs

GLYPHOSATE – 1,080 a 1,800 g ae ha\textsuperscript{-1} - EPSPS inhibitor

Glufosinate ammonium – 2.5 L c.p. ha\textsuperscript{-1} (Oil) – GS inhibitor

2,4-D – 1.0 to 1.5 c.p. ha\textsuperscript{-1} – Auxin like

Saflufenacil - 50 to 100 g c.p. ha\textsuperscript{-1} (oil) – PPO inhibitor

Residual:
- Chlorimuron - 100 to 150 g c.p. ha\textsuperscript{-1} – ALS inhibitor
- Flumioxazin - 100 to 120 g c.p. ha\textsuperscript{-1} – PPO inhibitor
- Sulfentrazone - 0.6 to 1.2 L c.p. ha\textsuperscript{-1} – PPO inhibitor
- Diclosulan - 30 to 40 g c.p. ha\textsuperscript{-1} – ALS inhibitor
- Metribuzin – 0.75 to 1.0 c.p. L ha\textsuperscript{-1} - PSII inhibitor

pjchrist@usp.br

12
Corn post harvest treatment

Coryza in late post – 24 DAA

Glyphosate + 2,4-D (3.0 + 1.2 L c.p./ha) – EPSPS inhibitor + Auxin like

Glyphosate + saflufenacil (3.0 + 0.07 L c.p./ha) 10 days after first application – PPO inhibitor
Sequential applications of Glyphosate and/or Alternative post + Residual herbicides for Summer Weed control.

Post-selective applications include:
- Glyphosate + Atrazine
- And/or tembotrione

Sequential application diagram showing the progression of weed control with these herbicides.
Residual Herbicide importance in the burndown treatments

<table>
<thead>
<tr>
<th>ALS inhibitors - (B group)</th>
<th>imazethapyr diclosulan chlorimuron</th>
<th>Longer residual and control spectrum, but increasing resistance systematically (easy multiple resistance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPO Inhibitors (E group)</td>
<td>sulfentrazone flumioxazin saflufenacil</td>
<td>Not many cases of multiple resistance and help ALS inhibitors weed spectrum – selectivity concerns</td>
</tr>
<tr>
<td>Acetanilidas (K3 group)</td>
<td>S-metolachlor Clomazone/isoxaflutole* Metribuzin</td>
<td>Very specific situations, limited weed spectrum and selectivity concerns</td>
</tr>
</tbody>
</table>

Lopez-Ovejero et al. 2013 – Studies in five locations in Brazil (SP, RS, PR, MG and MT), concluded residual herbicides fb glyphosate provide consistent weed control and reducing early competition.
Soybean emergence 17 days after burndown/10 days after planting

With residual treatments in the burndown

“clean” emergence
Factors that affects the Herbicide transposition through the stubble:

- Rain after application of the herbicide
- Physical-chemical characteristics of the herbicide
- Straw quantity deposited on the surface
Association of glyphosate + 2,4-D + FSII, PPO and ALS inhibitors

Autumn – Glyphosate 1.080 kg ae/ha + 2,4-D 1.008 kg ae/ha + metribuzin 1,0 L/ha
Pre sowing - summer – Glyphosate fb Glufosinate 1.0 L/ha + flumioxazin 105 g/ha (10 days before sowing)
Post sowing selective - Glyphosate 1.080 kg ae/ha – (27 days after sowing)
Argentina – Província de Washington

“One of the most high-profile problems in the US”
Will that be also in LATAM?

Foto from: Ing. Agr. Sergio Morichetti
Aceitera General Deheza
Argentina – Provincia de Del Campillo

Photo from: Ing. Agr. Sergio Morichetti
Aceitera General Deheza
Brazil – Mato Grosso State

Photo from - AMPA
**PROCURA-SE**

*Amaranthus palmeri*

*Um tipo de weed extremamente prejudicial às culturas agrícolas*

---

**PRINCIPAIS CARACTERÍSTICAS**

- Infestação em plantas de arroz, milho, soja, soja e outras culturas
- Produzir alta produtividade
- Resiste a muitos herbicidas

---

Pontos de contato:

- Tel: 0800-675-0000
- www.mdea.mt.gov.br

---

**WANTED**

DEAD or ALIVE

---

**REWARD**

$1,000,000,000,000
"New" technologies for weed management

"For foreseeable future, weed control will be trait based"

- **Clearfield®** – imidazolinone tolerant – non transgenic – Group B
- **Liberty Link®** – LL – Corn, Cotton and Soybean – Bayer – Group H
- **Cultivance** – Resistance to imidazolinones – Bayer – Group B
- **Glytol** – glyphosate resistant – Bayer – Group G
- **Enlist™** - Dow AgroScience – Soybean and corn – Groups G + O
- **Genuity™ Roundup Ready 2® Xtend™** – Monsanto – Groups G + O
- **HPPD resistance (Balance)** – Bayer and Syngenta – Group F2
- **Biodirect™** – Monsanto – (Group G)
- **STS** – sulfonylurea tolerant – DuPont – (Group B)

Transgenic and no transgenic herbicide-resistant crops:

Seven herbicide MOAs are represented in the HR crop cultivars

"Weed control in the early 2000’s was as easy as it will ever be"
Larry Steckel – Delta Farm Press 2008
Possible resistant Conyza to 2,4-D found in Brazil

However, multiple or cross-resistances may occur in important weeds to some of these MOAs, already threatens the utility of the new traits …

Solution: Stronger educational programs
Guidelines for the successful weed management in Liberty Link soybeans:

1) Use burndown herbicides to ensure a weed-free start at planting – 2,4-D; paraquat; metribuzin; etc.

2) Use residual herbicides to reduce weed populations, slow weed growth and provide flexibility in the post emergence application window.

3) Apply glufosinate post emergence at the proper time according to weed size. Observe season maximum rate.

4) Proper sprayer setup will ensure successful results: 150 to 200 L ha\(^{-1}\) of water; (250 – 350 micron spray droplets). Adjuvants might be needed.

5) Do not spray at night or under adverse conditions.
Perspectives for glufosinate in the system

- Metribuzin C1
- Sulfentrazone E
- Flumioxazin E
- Chlorimuron B
- Chloransulan B
- Diclosulan B

Seven herbicide MOAs

*Residuals

Glyphosate G + 2,4-D O

PARAQUAT + residual*

LIBERTY 2,0 L/ha

Glyphosate G + Atrazine C1 + tembotrione F2

pjchrist@usp.br
Status and Management of Grass-weed Herbicide Resistance in Latin America

Bernal E. Valverde*

Twenty-one grass weeds have evolved resistance to herbicides in Latin America, particularly in rice, soybean, wheat, and orchards. Junglerice, the most widespread and economically important rice weed, evolved resistance to propanil, acetyl-coenzyme A carboxylase (ACCase)-inhibitor herbicides, quinclorac, and imazapyr in Central America, Colombia, and Venezuela. Some junglerice populations are resistant to at least three herbicide modes of action. Other herbicide-resistant (HR) rice weeds are barnyardgrass and gulf cockspur to quinclorac in Brazil, and saramollagras to ACCase-inhibitor herbicides in Colombia and bispyribac in Venezuela.
Sourgrass resistant to glyphosate

conyza resistant to glyphosate

Y ahora?

Photo from Fernando Adegas
Glyphosate only based treatment
HPPD resistant crops is certainly an option for a new MoA, with selectivity
Isoxaflutole – controlling Amaranthus
“Key learnings”

“We have to pull out all the tools we can”

Back to the future tools:

✓ Associations of post emergence alternative MoA herbicides – 2,4-D (auxin), glufosinate ammonium (GS), saflufenacil (PPO), etc.

✓ Layer residual herbicides to provide overlapping protection inserting news MoA in the system – ALS inhibitors (imazethapyr, diclosulan, chlorimuron), PPO inhibitors, (sulfentrazone, flumioxazin, saflufenacil), inhibitor of long chain fatty acide – LCFA – (S-metolachlor), inhibitor of carotene biosynthesis – (isoxaflutole, mesotrione, tembotrione, clomazone); phosystem II inhibitors (metribuzin, atrazine).

✓ Don’t let weeds escape and produce seed. Next year’s weed control program starts now.

✓ More research is needed on how to best meet the needs of HR weed management, while at the same time meeting soil conservation compliance goals.
“Key learnings”

“Best management practices x threaten the utility of the new traits”
- multiple resistance -

Ahead to the future:
Resistant crops to non selective alternative herbicides – new MoA in the system

✓ Liberty Link technology – ammonium glufosinate (GS) in association with residual herbicides - ALS inhibitors (imazethapyr, diclosulan, chlorimuron), PPO inhibitors, (sulfentrazone, flumioxazin, saflufenacil), inhibitor of long chain fatty acide – LCFA – (S-metolachlor), inhibitor of carotene biosynthesis – (isoxaflutole, mesotrione, tembotrione, clomazone); phosystem II inhibitors (metribuzin, atrazine).

✓ HPPD technology – association with residuals and non selective post, great option for grass weeds resistant and hard to kill by glyphosate in tropical climates

✓ Auxin like technology – association with post emergence alternative herbicides

✓ Stronger educational programs are needed
Thank you for listening!

Pedro J Christoffoleti
pjchrist@usp.br
+55 19 99727 8314