The Impact of Labeling Herbicides with their Site of Action

Hugh J. Beckie[1], Fa-Yan Chang[2], and F. Craig Stevenson[3]
[1]Saskatoon Research Centre, Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK, S7N 0X2; [2]Alternative Strategies and Regulatory Affairs Division, Pest Management Regulatory Agency, Health Canada, 2250 Riverside Drive, A. L. 6607D, Ottawa, ON, K1A 0K9; and [3]Department of Soil Science, University of Saskatchewan, Saskatoon, SK, S7N 5A8

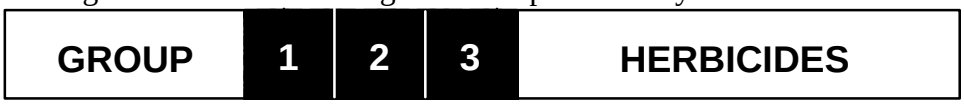
Introduction

The Pest Management Regulatory Agency (PMRA), in cooperation with the crop protection industry, has drafted voluntary guidelines on pesticide resistance management labeling. These guidelines identify the site of action of a pesticide (Retzinger and Mallory-Smith 1997) on the end-use product label (Figure 1) and contain resistance management statements in the use directions.

Originally, the guideline was to be implemented in Canada beginning in 1997. However, the PMRA initiative was expanded in 1997 into a joint project of Canada, the United States (Environmental Protection Agency, EPA), and Mexico (Cicoplafest) under the auspices of the North America Free Trade Agreement (NAFTA). The finalized document is expected in early 1999. The objective of this paper is to predict the impact of labeling herbicides with their site of action on herbicide-use practices of growers, by examining perspectives on this issue from industry (Crop Protection Institute), the public sector agricultural research and extension community, and growers themselves.

Product containing one or more active ingredients of the same site of action:

Product containing two or more active ingredients represented by two or more sites of action:



Outside label for pre-packaged products where each component is in a different container:

Figure 1. Site of action identification symbols.

Perspectives

Crop protection industry (Crop Protection Institute)

The CPI position (as relayed by J. M. Kelly, pers. comm.) is that industry generally supports resistance labeling, but that discussions are continuing on the wording and the identification symbols. With the movement towards harmonization with the EPA, discussions between the agencies were recommended. The initiative is now under the auspices of NAFTA.

Research and extension

All government and university weed researchers and agricultural extension personnel in Alberta, Saskatchewan, and Manitoba were surveyed in the summer of 1998 to determine their perspectives on how labeling herbicides with their site of action would impact herbicide-use practices of growers. Responses were received from all 16 researchers and 124 extension workers who were asked to complete the printed survey. When asked if they felt that including the herbicide group number on the product label would be useful to growers in practicing herbicide-group rotation (i.e., not repeated use of herbicide(s) from the same group in a field over successive years), most respondents (94%) said “yes”, 4% said “no” and 2% were undecided (Table 1). They were then asked if including the herbicide group number on the product label would change the herbicide-use practices of growers who already rotate herbicides from different groups. Of 135 respondents who answered this question, 33% said “yes”, 55% said “no” and 12% were undecided. Whereas researchers were about equally divided on this question, nearly twice as many extension workers replied “no” than those who replied “yes”. Overall, the majority of respondents felt that including the site(s) of action on the herbicide label would not change the frequency of use of herbicides from different groups by growers who currently practice herbicide-group rotation. Of the respondents who answered “yes”, 25 indicated that including the herbicide group number on the label would cause growers to more actively rotate herbicides from different groups by maintaining, reinforcing (i.e., a reminder), or increasing awareness of the group(s) to which a product belongs, and of the importance of practicing herbicide-group rotation for resistance management. Nine respondents indicated that having the site of action on the label would be a quick source of information and make it easier and more convenient for the grower who practiced herbicide-group rotation. Six respondents said that the herbicide group number on the label would prevent some confusion and error by growers during the busy spraying season in properly identifying the site of action of products, particularly those packaged as mixtures. Four respondents suggested that the herbicide group number on the label would help identify alternative herbicide options, particularly new products.

When research and extension personnel were asked if including the herbicide group number on the product label would change the herbicide-use practices of growers who currently do not rotate herbicides from different groups, 75% of respondents said “yes”, 9% said “no”, and 16% were undecided. Most respondents (91%) who answered “yes” indicated that having the herbicide group number on the product label would increase awareness or knowledge of herbicide groups (particularly products with more than one active ingredient and site of action) and would be a reminder or would help convey to the grower the importance of rotating herbicides from different groups to prevent or delay the development of resistance in weeds on their farm. Eight respondents who answered “yes” replied that having the site of action on the label would make it easier for the grower to start rotating herbicides from among different groups because the

herbicide group classification would be readily visible. The 12 respondents who answered “no” were extension personnel in Manitoba and Saskatchewan.

The herbicide group number has been listed for each product in the crop protection guide of Alberta since 1997, and in the guides of Saskatchewan and Manitoba (Anonymous 1998) since 1993. These guides are updated and published each year and are readily available to growers about four months prior to the growing season. Researchers and extension workers were asked in the final question if they felt that it was useful to growers to include the herbicide group number both in the guide and on the product label. Ninety-six percent of the 140 respondents answered “yes”, whereas only 6% said “no”. One researcher and five extension workers from Saskatchewan and Manitoba preferred that the information be listed in the guide only, because they felt that most growers carefully read the information in the guide prior to the spraying season and decide what product(s) to use before, or instead of, examining the label of the product at the retail outlet (dealer). These same people felt that including the herbicide group number on the label would not be useful to growers in practicing herbicide-group rotation (first question) for the same reason.

In summary comments by a few of the respondents, the importance of dealer education to achieving the goal of greater herbicide rotation by growers was stressed, since these people interact directly with the grower at the time of product purchase. A brief statement on the label indicating to the grower why the site of action and herbicide-group rotation were important for resistance management was also recommended. The proposed resistance management labeling statements should address this recommendation. Additional comments included the importance of record keeping by growers in planning herbicide rotations and how the simplicity of the herbicide-group numbering system would facilitate record keeping. Overall, the results of this survey indicate that most researchers and extension workers believe that labeling herbicides with their site of action will facilitate herbicide-group rotation by growers who use herbicide(s) from the same group year after year, and that the information on the label should duplicate the herbicide group information already contained in provincial crop protection guides.

Growers

Growers in Saskatchewan participated in a telephone survey conducted in October of 1998. One hundred and twenty-six growers were picked at random from the database of the Saskatchewan Wheat Pool. They were asked a number of questions for us to better understand how proposed labeling of herbicides with their site of action would impact their herbicide-use practices. Analysis of the data was based on specific questions pertaining to growers’ perceptions and herbicide-use practices as they relate to herbicide-group rotation and resistance management labeling. These questions were answered using results from a generalized linear model with the GENMOD procedure of SAS (Stokes et al. 1996). A binomial distribution and logit link function was specified for the model because the response variables of primary interest were binary. Covariables thought to be associated with the response variables of interest were included in an attempt to understand why growers responded in a certain way. The covariables included a mixture of binary, ordinal, and nominal variables. A principal components analysis (PCA) was conducted to explore relationships among the grower responses to the importance of herbicide groups. Because of the categorical nature of the data - a mixture of binary, ordinal, and nominal variables - the PROC PRINQUAL procedure, with a monotonic transformation, in series with PROC

FACTOR procedure, was used to perform nonmetric PCA (SAS 1995, 1996). Standardized scoring coefficients from the final stage of the analyses (factor analysis) were used to determine the magnitude and direction of the relationships among the variables.

When growers were asked if they were familiar with the 'herbicide group' concept, 81 (64%) replied "yes" and 45 (36%) replied "no" (Table 2). An analysis was conducted to determine if the overall mean was greater than zero in an ANOVA with a normally distributed continuous response variable (SAS 1996); P was equal to 0.002, indicating there was a significantly different number of respondents among the different levels, i.e., "yes/no". Covariance analysis indicated that age and status of the grower influenced this response. The respondents aged 60 years and over (20% of respondents), and part-time growers (20% of respondents), had a proportionally poorer understanding of herbicide groups. A similar conclusion was drawn from results of the modified PCA. The source of their herbicide-group information was: the Crop Protection Guide (Anonymous 1998) -25%; 'everywhere' -25%; pamphlets (extension or herbicide manufacturer/distributor sources)-14%; print media-14%; dealers-12%; provincial extension personnel-5%; herbicide manufacturer/distributor reps-3%; other growers and elevator agents-1% each (total of 92 responses; some respondents indicated more than one source).

For respondents who were *unfamiliar* with herbicide groups, 15 of them (33%) indicated that they tended to use the same herbicide(s) in a field year after year, whereas 30 (67%) indicated that they tended to use different products in a field over a number of years (P = 0.028) (data not shown). The main reason given for using the same product(s) repeatedly was that the herbicide gave good control of their weed populations. Conversely, the main reasons given for using different products were crop rotation considerations and weed species present. Forty-two respondents (93%) had read or heard that repeated use of the same herbicide in a field over time can cause the development of herbicide-resistant weeds, versus only three respondents (7%) who had not (P = 0.001). Sixteen respondents (37%) keep records of the crops grown and herbicides used, whereas 27 respondents (63%) do not (P = 0.097). The number of years that records were kept ranged widely from two to 30 years, as indicated by only eight respondents. Four respondents (9%) have suspected or confirmed herbicide-resistant weeds on their farm, 27 respondents (60%) do not, and 14 (31%) do not know. Reading or hearing that repeated use of the same herbicide in a field can create a resistance problem (P = 0.044), and keeping records (P = 0.013), explained the tendency to use a different herbicide(s) in their fields. There was not a clear association between having suspected or confirmed herbicide-resistant weeds on their farm and their tendency to use similar or dissimilar products in a field over time. However, it is unknown to what group(s) these products belonged.

Of the respondents who were *familiar* with herbicide groups, 60 (74%) did not know the basis on which herbicides are classified into different groups, i.e., the criterion used to group herbicides, 14 (17%) knew and responded with the answer, whereas seven (9%) replied that they knew, but did not indicate the answer (P = 0.002). However, the majority of respondents (65%) knew the purpose in grouping herbicides and stated so. An additional 17 respondents (21%) indicated that they knew, but did not state the answer (P = 0.001). Almost all respondents (99%) had read or heard the statement that repeated use of products within a group in a field over time can lead to herbicide resistance in weeds. Similarly, most

respondents (95%) had read or heard the statement that resistance to one product within a group could lead to resistance to other products in that group. Moreover, 98% of respondents were able to match herbicides with their group number using printed extension material. Covariance analyses did not indicate a significant association between a grower's understanding of the basis for herbicide grouping or the purpose of herbicide grouping and whether they practiced herbicide-group rotation, i.e., the herbicide group number is taken into account when deciding which product to apply to a field in a given year. Forty-seven respondents (58%) who were familiar with herbicide groups, practiced herbicide-group rotation, whereas 42% did not. PCA analysis of the untransformed data indicated an association between growers who did not practice herbicide-group rotation and lack of understanding of the basis of herbicide classification, and lack of understanding of why herbicides are classified. Modified PCA gave unreliable results because '0.00' coefficients occurred for most of the variables. Most respondents (65%) did not give a reason why they did not practice herbicide-group rotation; 24% of respondents indicated that the products they were using gave acceptable control of their weed populations up to the present time (P = 0.001) (data not shown). Including the herbicide group number on the product label would influence 29% of these respondents to practice herbicide-group rotation, but would not influence 44% to do so (27% undecided) (P = 0.001).

For respondents who practiced herbicide-group rotation, there was insufficient data in the response levels to conduct a covariance or multivariance analysis. This tendency was confirmed by an exploratory analysis conducted to determine if a response tended in a certain direction. Eighty-five percent of respondents practice herbicide-group rotation to prevent resistance, 9% to manage resistance, and 6% to prevent and manage resistance (P = 0.141) (data not shown). The highest number of respondents (23%) indicated that they had practiced herbicide-group rotation for three years. Seventy percent of respondents who practice herbicide-group rotation keep field records (P = 0.001). Coincidentally or not, the highest number of respondents (23%) kept records for three years, similar to the number of years that the highest number of respondents practiced herbicide-group rotation. Proportionally more growers who practice herbicide-group rotation keep field records (70%, P = 0.001) than those who are unfamiliar with herbicide groups (37% of respondents). Most respondents (83%) do not follow a set herbicide-group rotation or sequence (P = 0.005). Sixty percent of respondents feel that herbicide-group rotation is an effective resistance management practice (P = 0.001). Almost one-half of the respondents (49%) feel that herbicide-group rotation is an effective resistance management practice in the short and long term, 21% feel it is effective only in the short term (<10 years), and 30% were undecided (P = 0.001). Eighty-three percent of respondents feel that including the herbicide group number on the pesticide container label will be useful to them in practicing herbicide-group rotation (P = 0.190). However, 89% of respondents said that including the herbicide group number on the product label would not change the way they currently practice herbicide-group rotation (P = 0.001). A majority of respondents (77%) felt that it was useful to include the herbicide group number both in the Crop Protection Guide (Anonymous 1998) and on the product label (P = 0.020). Grower responses to the last three questions were very similar to those responses from the research and extension community when asked a similar series of questions. However, whereas researchers and extension personnel thought that including the herbicide group number on the label would help growers who currently do not practice herbicide-group rotation to do so, only 29% of this group of growers indicated that having the herbicide group on the label

would influence them to start rotating herbicide groups for resistance management.

Conclusion

Most researchers and extension workers believe that labeling herbicides with their site of action will facilitate herbicide-group rotation by growers who frequently use herbicide(s) from the same group, and that the information on the label should duplicate the herbicide group information already contained in provincial crop protection guides that are readily available to growers. Of the two-thirds of the 126 surveyed growers who were familiar with herbicide groupings, 58% practiced herbicide-group rotation. Those growers who did not practice herbicide-group rotation tended to lack understanding of the basis and purpose of herbicide classification. Grower responses to questions related to resistance management labeling on pesticide containers were very similar to those responses from the research and extension community. However, whereas researchers and extension personnel thought that including the herbicide group number on the label would help growers who currently do not practice herbicide-group rotation to do so, only 29% of this group of growers indicated that having the herbicide group on the label would influence them to start rotating herbicide groups for resistance management.

Acknowledgments

We express our appreciation for the cooperation and feedback of: the Crop Protection Institute and in particular Dr. John M. Kelly, Manager, Technical and Regulatory Affairs, Rhone-Poulenc Canada Inc. in representing the views from industry; fellow researchers, extension personnel, the Saskatchewan Wheat Pool, and especially the participating growers. The authors acknowledge Carma Wooff and Debbie Nordstrom, Saskatoon Research Centre, Agriculture and Agri-Food Canada, for the many hours spent on the telephone in conducting the grower survey.

References Cited

Anonymous. 1998. Guide to Crop Protection 1998: weeds, plant diseases, insects. Bi-provincial publication: Saskatchewan Agriculture and Food, Regina, SK and Manitoba Agriculture, Winnipeg, MB. 274 p.

Retzinger, E. J. and C. Mallory-Smith. 1997. Classification of herbicides by site of action for weed resistance management strategies. Weed Technol. 11:384-393.

[SAS] Statistical Analysis Systems. 1995. Algorithms for the PRINQUAL and TRANSREG procedures. SAS Technical Report R-108. Cary, NC: Statistical Analysis Systems Institute.

[SAS] Statistical Analysis Systems. 1996. SAS/STAT User's Guide. Cary, NC: Statistical Analysis Systems Institute.

Stokes, M. E., C. S. Davis, and G. G. Koch. 1995. Categorical Data Analysis using the SAS System. Cary, NC: Statistical Analysis Systems Institute.

Table 1. Research and extension: survey findings

Will including the herbicide group number on the label be useful to growers in practicing herbicide-group rotation?

	Yes	No	Undecided	Total
Research	15	1	0	16
Extension	117	5	2	124
Total	132	6	2	140

If the herbicide group number is included on the label, will it change the herbicide-use practices of growers who already rotate herbicides from different groups?

	Yes	No	Undecided	Total
Research	7	5	4	16
Extension	37	70	12	119
Total	44	75	16	135

Will it be useful to growers to include the herbicide group number both in the Crop Protection Guide and on the label?

	Yes	No	Undecided	Total
Research	15	1	0	16
Extension	119	5	0	124
Total	134	6	0	140

If the herbicide group number is included on the label, will it change the herbicide-use practices of growers who do <u>not</u> rotate herbicides from different groups?

	Yes	No	Undecided	Total
Research	8	0	8	16
Extension	95	12	15	122
Total	103	12	23	138

Table 2. Growers: survey findings

•*Are you familiar with the 'herbicide group' concept?* **64% yes 36% no** n=125 (*P*=0.002)

Growers aged 60 and over (*P*=0.007) and part-time growers (*P*=0.034) were less familiar than other growers.

The following questions were asked of growers who were familiar with herbicide groups:

•*Do you know the basis on which herbicides are classified into different groups?* **26% yes 74% no** n=81 (*P*=0.002)

•*Do you understand the purpose in grouping herbicides?* **86% yes 14% no** n=80 (*P*=0.001)

•*Have you read or heard that repeated use of products within a group in a field over time can lead to herbicide resistance in weeds?* **99% yes 1% no** n=81 (*P*<0.001)

•*Have you read or heard that resistance to one product within a group could result in resistance to other products in that group?* **95% yes 5% no** n=81 (*P*<0.001)

•*Are you able to match herbicides with their group number (GN) using extension material?* **98% yes 2% no** n=80 (*P*<0.001)

•*Do you practice herbicide-group rotation (HGR)?* **58% yes 42% no** n=81 (*P*=0.001)

Growers who do not tended to lack understanding of the basis and purpose of herbicide classification (preceding two questions).

If no*: If the GN was on the label, would that influence you to practice HGR?* **29% yes 44% no 27% undecided** n=81(*P*=0.001)

If yes (and subsequent questions):

•*How many years have you practiced HGR?* **The highest number (23%) indicated 3 years.**

•*Do you keep field records of herbicide use?* **70% yes 30% no** n=46 (*P*=0.001)

How many years? **The highest number of respondents (23%) indicated 3 years.**

•*Do you follow a particular HGR in your fields?* **17% yes 83% no** n=47 (*P*=0.005)

•*Do you feel that HRG is an effective resistance management practive***? 60% yes 0% no 40% undecided** n=47 (*P*=0.001)

Effective in both the short (<10 yrs) and long term? **49%** *Effective in the short term only?* **21% (30% undecided)** n=47(*P*=0.001)

•*Will including the GN on the label be useful to you in practicing HGR?* **83% yes 15% no 2% undecided** n=47 (*P*=0.190)

•*If the GN is on the label, will it change the way you practice HGR?* **7% yes 89% no 4% undecided** n=47 (*P*=0.001)

•*Is it useful to include the GN in the Crop Protection Guide and on the label?* **77% yes 13% no 11% undecided** n=47 (*P*=0.020)