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Whole Truth in Herbicide Labelling

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ABSTRACT

The 1999 National Competition Policy Review of Ag & Vet Chemical legislation recommended, *inter alia*, that registrants no longer be required to prove 'APPROPRIATE' levels of efficacy of their products but only that the claims on product labels be 'TRUE'. 'Appropriate' efficacy standards amount to market regulation, limiting economic competition from formulations with lower efficacies. Cheaper formulations with lower efficacies are excluded from the marketplace by such standards. Unanswered is the question of what 'TRUTH' on a label means in practical terms. Flexibility in dose rates and guidance with usage information is not always well-stated on herbicide labels. There is considerable evidence that efficacy of herbicide varies with dose and with environmental or growth conditions. Under favourable conditions at a given site, a low rate of herbicide will kill most of the target weeds. Under less favourable conditions at the same site, a high rate may be required. Labels could take variations in efficacy into account by indicating observed results for a range of environmental conditions at different dose rates. This is illustrated with examples of herbicide performance and analogies from another industry in which explicit performance information is absolutely required. This paper raises the question of reforms towards providing 'the whole truth' in herbicide labelling, to provide users with guidance on when they might adjust doses to specific environmental and growth conditions.

HERBICIDES: IMPORTANT TOOLS IN INTEGRATED WEED MANAGEMENT

The NFF (1997, p352) cited Avcare members' factory-gate herbicide sales of **\$452M** in **1995**. Avcare (1998) cited the NRA (no date or title) figures on sales of 714 herbicide products totalling **\$626M** in **1996**, from manufacturers sales of \$1,233M in crop protection products in Australia. In addition to herbicides this sum accounted for insecticides (\$252M), fungicides (\$88M), and others (\$266M), such as molluscicides and rodenticides. Avcare (1999) again cited the NRA's latter total figure for agricultural chemical sales for 1996, along with new totals for 1997 and 1998, \$1,356M and \$1,587M, respectively. Thus, we are safe in assuming herbicide sales in 1998 were well above \$700M.

ABARE's (1999) survey of the Australian grains industry, by GRDC agroecological zones in 1997-98, gives production cost estimates and areas of the main grain crops. To estimate herbicide expenditures crop by crop we multiplied the reported herbicide cost per hectare in a zone by the area of crop in the zone, and aggregated across zones. Where area reports did not distinguish among production practices or grain classes, areas were divided equally among them. Where zone descriptors did not match those in the cost tables, the lowest input cost per hectare in the closest zone was assumed to hold. Accepting some aggregation error in our data extraction across so many cost and production summary tables, expenditures for herbicide materials nationwide were about **\$251M for wheat** crops; **\$52M for barley**; **\$46M for lupins**; and **\$21M for oilseed crops**. Therefore, these crops alone used herbicide materials costing some \$370M, or about half the national expenditure on herbicide chemicals in 1997-89. For these crops, herbicides accounted for about 96% of the total spent on insecticides, fungicides and herbicides. Costs of applying the herbicides are in addition to chemical expenditures, with **spraying operations** adding over **\$84M** to the costs of these crops.

Referring again to ABARE's (1999) report, we found the average amounts spent on crop and pasture chemicals on grain farms varied from one agroecological zone to another (Table 1). The lowest was \$4.6K on mixed farms in the Victorian high-rainfall and Tasmanian grain areas. The highest annual average expenditures on chemicals was \$79.6K on crop-specialist farms in the central zone of Western Australia. Across 12 GRDC agroecological zones, some **31,400** grain farms spent, on average, **\$19.8K** each on chemicals in 1997-98. Obviously these crop and pasture chemicals are important tools.

Are these tools used as efficiently and effectively as possible? There is evidence that room for improvement exists for better targeting of herbicides to specific field conditions, and finer tuning of dose rates according to factors such as temperature, soil water and photo-period / latitude. Flexibility in dose rates and guidance with usage information is not always well stated on herbicide labels. Manufacturers, or chemical registrants, have had to prove their products are highly effective under all but excluded conditions, at recommended rates determined by them and below those that would exceed 'minimum residue limits' for health considerations. The questions on how much is spent for chemicals sets the stage for asking whether chemical users are provided sufficient information to adjust dose rates downwards on those occasions when local weather and growth conditions allow good weed control with lower doses. Careful, well-informed and efficient herbicide use, integrated with other means of weed control, is an ideal for the future. Many farmers spend enough on crop and pasture chemicals each year, or in a few years, to purchase an airplane. This raises the question of why performance information for herbicides is not accessible by farmers the way essential performance information is required and readily available in aircraft operator's manuals. A short diversion to this analogy will help make the contrast clear.

ANALOGY

In planning the various phases of a flight, a pilot has several things to think about. Standard performance information will be available from the aircraft manufacturer to help in these tasks. To illustrate the kind of detailed information one expects to find clearly detailed in tables and graphs in an operator's manual, I have drawn a couple examples. Performance values for two long-popular, single-engine, four-seat light aircraft (Cessna, 1972; Mooney, 1966) provide a basis for discussion. The Cessna is a high-wing aircraft with fixed landing gear, and a constant-pitch propeller. The Mooney has retractable landing gear, a low-wing, a constant-speed (variable pitch) propeller, and a more powerful engine. Different as they are, these two aircraft exhibit similar directions of performance change with changes in conditions.

Minimum take-off and landing distances are functions of weight (loading and fuel **decisions**), field altitude, air temperature and presence of obstacles. The minimum distances increase with increases in any of these four variables. The presence of a headwind will shorten the minimum distances, and tailwinds will lengthen them.

Maximum flight range (distance) and **endurance** (flight time) are functions of weight (loading **decisions** including fuel carried), as well as **decisions** on cruising speed and altitude. Maximum range and endurance will be greatest with the highest cruise altitudes and the greatest fuel quantities on board, with lower gross weights and lower airspeeds.

Given these explicit trade-offs and accounting for weather on the day, the pilot may choose a fuel quantity, take-off runway, flight-path, cruising altitude, cruising speed and landing runway to achieve the purpose of the flight at hand with the best safety margins.

- For example, if the purpose is to urgently carry three passengers with baggage from a rural airfield to an international airport only 200km away, the choice is likely to be a middle altitude at the highest

cruise speed. The choice may also involve carrying less than full fuel to allow greater weight in baggage or a faster climb.

- If the purpose, instead, is to carry two passengers to a place 300km distant and return without re-fuelling, the choice is likely to be for full fuel, the highest comfortable cruise altitude and slightly reduced cruise speed to conserve fuel.
- Or, if the purpose is to conduct observations, such as power- or pipe-line inspections, or loitering on fire watch or coastal patrol, the choice may well be to maximise endurance time aloft with full fuel and the lowest airspeeds.

Information describing the multi-dimensional ‘envelope’ of choice in aircraft operations is usually required in the manuals prepared by manufacturers. The manual does not tell the pilot when or where or how to fly their aircraft, only what limits to performance are expected under various environmental conditions. Responsibility for safe operation remains with the pilot.

HERBICIDE PERFORMANCE (EFFICACY)

(The following sections of this paper are drawn chiefly from Nordblom and Medd. (1999a))

There is considerable evidence that efficacy of herbicide varies with environmental and growth conditions. Under favourable conditions a low rate of herbicide will kill most of the target weeds. Under less favourable conditions, a high rate will be required. With unfavourable conditions, even high rates of herbicide may have little or no effect on weeds.

Minkey and Moore (1998), citing recent international literature, listed several factors important in determining the performance of foliar applied herbicides:

1. **moisture stress** (Boydston 1990, Dastgheib *et al.* 1990, Dickson *et al.* 1990, Lemerle and Verbeek 1995);
2. **nitrogen deficiency** (Dickson *et al.* 1990);
3. **temperature** (Coupland 1984, McMullan 1994);
4. **light** (Coupland 1983);
5. **humidity** (Coupland 1983);
6. **rainfall** (Wicks *et al.* 1993);
7. **wind** (Muzik 1975);
8. **plant development stage** (Rioux *et al.* 1974);
9. **plant density and plant species targeted** (Lemerle and Verbeek 1995).

Minkey and Moore (1998) (Western Australia) describe a three-season experiment of their own in which, for some crop and herbicide combinations, 90% weed kill was achieved with doses differing by more than an order of magnitude depending on growth conditions. They further described a decision model, HERBIRATE, based on response relations observed in their experiment. The model allows a farmer to base herbicide dose rates on environmental and growth factors he/she monitors in his/her own field.

Kudsk (1988) (Denmark) first introduced the concept of ‘**factor-adjusted doses**’ to accommodate the environmental influences and prevailing environmental conditions, with the observation that dose-response curves for percent weed kill make parallel shifts according to environmental factors.

An example of a herbicide decision dependent on environmental factors starts with the idea that economic response to herbicide is measured by crop yield per hectare at harvest, times the crop price, the vertical axis of Figure 1. The variables affecting this outcome include the weed biomass and general growing conditions as well as herbicide dose, the horizontal axis. Figure 1 is based on a function borrowed from Brain *et al.* (1999) in which crop yield, given a set of environmental conditions, is influenced by weed biomass and herbicide dose.

$$Y = Y_0 / (1 + u * (W_0 / (1 + (Dose / (e^{LD_{50}}))^B))^T)$$

Where: Y is estimated crop yield; Y_0 is the potential weed-free crop yield;

W_0 is weed biomass; $Dose$ is herbicide dose (g ai/m²); LD_{50}

is the dose to kill 50% of the weeds under the prevailing conditions; u ,

B , and T are parameters specifying those conditions, along with Y_0 and W_0 ;

e is the natural logarithm; and $^{\wedge}$, $*$ and $/$ indicate exponentiation, multiplication and division respectively. All values assumed in the present example were set to illustrate the points.

Crop yield times crop price gives a gross crop value for each herbicide level. Subtracting a constant spray-rig cost and the cost of herbicide material according to amounts used, results in a gross margin curve for each level of weed infestation. The upper curve in Figure 1 represents the lowest initial weed biomass while the middle and bottom curves represent orders of magnitude greater weed biomass, respectively. Notice the three gross margin curves in Figure 1 are maximised at higher herbicide rates as weed biomass increases: at about 16, 26 and 42 g ai/ha for the low, medium and heavy weed biomass situations respectively. While these rates may represent the immediate opportunity to do something about weed damage in a growing crop, there is an obvious advantage in being on the top curve rather than a lower one due to a failure to manage weed seeds in previous seasons. Other means of weed control than standard herbicide must come into consideration; effective crop rotations, pasture phases, timely grazing, cultivation tactics, selective spray-topping, etc., in an integrated plan suited to the particular farm conditions.

Figure 1. about here, please

In Denmark, a computerised advisory system has been developed which is based on the hypothesis of parallel dose response curves and the derived factor-adjusted doses (see Christensen 1998). In Australia, there is often no specification of variable rates; and there is a lack of information on when best to use the lower rate or higher rate when a range of rates is given on a herbicide label. Top farmers may sort this out for their own farms and seasonally changing conditions. The vast majority of users are left without guidance from manufacturers.

Economic and social considerations

Pannell (1989) argued “that while there are good reasons for imposing maximum limits on usage of many...(agricultural)... chemicals, there are a number of very good reasons why, in many circumstances, use of sub-label rates should be facilitated”.

Pannell (1989) expanded on the economic and social reasons for allowing downward flexibility in chemical use. Since his points are still valid, we quote several of his passages on the topic:

“Upper limits on chemical rates reduce the probability of high levels of chemical residues accumulating in agricultural produce and, in the case of herbicides, limit the risk of crop damage. Preventing use of sub-label rates does not serve this purpose. Low rates result in even less risk of chemical residues so if this is the prime concern in legislation, low rates should be encouraged.”

The main reason users are attracted to using sub-label dose rates of herbicides is to maximize profits. If, as we have argued above (4.1), equivalent weed control can be achieved with a lower dose under favorable environmental conditions, it makes economic sense to use a lower rate. Likewise, if equivalent or better weed control can be achieved by integrating non-chemical control methods with lower doses of herbicides, this can also lead to increased economic benefits, as shown for wild oats by Jones and Medd (1997). Consequently, the concept of using economically optimum dose rates is now accepted as best practice. As Pannell (1989) further pointed out:

“... variables outside the biological system, such as chemical costs and output price, can influence the optimal dose, with lower rates favored by high chemical costs or low output prices (Talpez *et al.* 1978; Rawat *et al.* 1987).” (also see Pannell 1990)

“Optimal treatment rates can also be influenced by the type of rotation practiced. For example, Abadi Ghadim and Pannell (1989) showed that reductions in herbicide rates in the crop phase of crop-pasture rotations may be beneficial. The loss of crop yield can be more than offset by the gain from higher subsequent pasture production and lower herbicide costs.”

“Many farmers are concerned not just with profits but also with avoiding risk and uncertainty (Anderson *et al.* 1977). The degree of risk aversion varies widely between individual farmers (Bond and Wonder 1980). If, as is often claimed, lower treatment rates increase uncertainty about the level of final profits (Feder 1979; Robison and Barry 1987) different farmers will be more or less inclined to take the risk of cutting rates. It is illogical that farmers who are less averse to risk are forced to adopt very risk averse control strategies by being restricted to label rates.”

“The state with the most restrictive laws is New South Wales where legislation prohibits all rates other than the label rate. ...the law is widely known to exist and.... It affects the

thinking and behavior of farmers, advisers and administrators. While many farmers might be willing to break the law to make profits and avoid resistance, others will not. Even farmers who don't feel constrained by the law may believe that it is based on impartial scientific evidence and choose to follow it on this basis. Others may see the law is an indicator of what is and is not socially acceptable behavior.”

“Another impact of the law is the constraints it places on the activities of researchers. It is bound to discourage research into use of alternative chemical dosages. Indeed it has been argued that because of the law, research into the determination of economically optimal herbicide rates is not relevant to New South Wales.”

“At least as important as allowing producers to cut rates is allowing their consultants and advisors to advise on rate cutting. Without this, there is no point conducting field experiments or economic analyses to provide the managerial information farmers need to make decisions on optimal chemical rates. In New South Wales off-label advice cannot be given by government or private sector advisors.”

“Finally it is noted that lower chemical usage may benefit society as a whole by reducing the risks of high chemical residues in food and/or environmental contamination.”

“For all these reasons, legislation which restricts farmers to using only label rates for all chemicals is irrational. It not only results in unnecessarily high usage of agricultural chemicals; it can also make farmers worse off.”

A footnote is appropriate here regarding Pannell's statement about NSW legislation blocking sub-label rates. As of last month, with the passage of *NSW Pesticides Bill 1999*, this problem was resolved. NSW is now in line with most other Australian states, Canada and the USA in allowing sub-label doses, except in cases where explicitly prohibited.

Policy considerations

In considering an application for registration of a herbicide, the NRA is bound by Section 14(3)f of the Agvet Code (1994) to satisfy itself that a **product's claimed efficacy is both true and appropriate** (PwC/FAL 1999, p.41). Since determination of 'appropriateness' involves regulation of product standards, the NCP considered it a restriction on economic competition in a free market. The NCP, therefore, recommended “the Agvet Code be amended to specify that efficacy review extends only to ensuring that the chemical product meets the claimed level of efficacy on the label” (PwC/FAL 1999). In other words, the NCP judges it is better for the market to decide what levels of efficacy are appropriate, leaving the NRA to ensure that manufactures' claims regarding efficacy are **true**.

It is important to note that efficacy review is always in addition to NRA's provisions for assessing health, OH&S, environment and trade effects. There is no argument intended here for exceeding maximum label rates as we respect the necessary bounds to meet maximum residue levels (Baker 1991; Pannell 1991). The biological, economic and free market driven arguments for flexibility in using herbicides are constrained, of course, by public health and safety considerations. Market failure in fully costing and compensating health and environmental externalities make such measures necessary (Brush and Clemes 1995).

A key to success of integrated pest management is a farmer's close monitoring of conditions in the field and the deliberate creation of diversified conditions over time in each field to avoid maintaining niches in

which pests (weeds, insects and diseases) can thrive. There is controversy over the belief that low herbicide doses lead to development of herbicide resistance, with most specialists convinced that there are neither experiments nor compelling theory that higher rates slow resistance (Preston and Roush 1999). An alternative view ascribes the cause of resistance to a lack of diversity in growing conditions with herbicide constantly present. This is supported in Denmark, where use of herbicides has been cut back by government environmental policy, with no appearance of resistance due to wide use of diverse crop and herbicide rotations (Per Kudsk, personal communication 1999).

Unification of 'control of use' legislation

National unification of 'control of use' has been highlighted as an issue by the National Competition Policy (NCP) legislation review of ag. & vet. Chemicals legislation (PwC/FAL 1999).

As pointed out in a survey reported by Pannell (1989), states had different combinations of regulations regarding maximum and minimum herbicide rates and provision for flexibility of private or government advisers in recommending sub-label doses. At that time each state had its own product registration regulations that had to be followed by manufacturers (NRA 1999). Since then, the National Registration Authority (NRA) was established to unify registration requirements nationally, controlling product labelling and sales. Subsequent use in the field remained at state level under a variety of laws peculiar to each state. These have yet to be unified.

State and territory authorities were re-surveyed by the authors in June 1999 posing the same three pairs of questions asked by Pannell (1989):

1. "Is there a maximum legal rate at which each chemical may be applied? If so what are the penalties faced by producers who exceed this rate?"
2. "Is it legal for producers to apply rates of chemicals less than the recommended or label rate? If not what are the penalties faced by producers who do cut rates?"
3. "Are agricultural consultants and advisors (private and government) legally prohibited from advising producers to use chemical rates other than those specified on chemical labels? If so what penalties are faced by advisors?"

All eight state and territory authorities kindly responded to the survey and results of this new survey are presented, in Table 2, in conjunction with those reported ten years earlier by Pannell (1989). In Table 2 the current diversity in 'control of use' legislation across Australia is apparent in the directions regarding over and under label rates, in the flexibilities of advisers and in the wide range of maximum penalties for offenders. SA is the exception on maximum rate; NSW, Tasmania and ACT did not allow use below a minimum rate without a permit and NSW did not allow advisers to provide recommendations on variable dose rates. Changes have occurred over the past decade, most of them being towards allowing greater flexibility in the market place.

It is now the case that users in the majority of Australia are free to apply herbicide at any dose up to the labelled rate, but not more. In Tasmania and ACT, users may legally apply herbicide only at the labelled rate or not at all, except by special permit. This highlights the case for unification of legislation on herbicide use, allowing sub-label rates, and suggests that manufacturers could provide users of herbicides information supporting better decisions in matching doses to specific conditions.

'Truth in labelling' could take variations in efficacy into account by indicating observed results for a range of environmental conditions at different dose rates, guiding rate adjustments rather than keeping them illegal. Such observations could be made by herbicide registrants using strategic field-trial protocols and site selection criteria designed to encounter a representative range of conditions in the product's intended market. Efficacy trials in Australia are required to follow international standards on design (randomisation, replication, measurements), etc. (NRA 1997, EPPO, 1999). Missing is the cross-site and cross-condition analysis and reporting that would allow adjusting herbicide doses to the conditions in a particular paddock at a particular time.

Imagine the analogy of a pilot given only the information on worse-condition aircraft performance based on logic that he/she couldn't handle more information. For example, the pilot would only be informed of take-off and landing distances only for the worse-case: with a combination of obstacles, maximum gross weight, hottest temperature and highest field elevation. This would limit the choice of airports considerably, excluding all but the ones with the longest runways, when many shorter ones would be completely safe under better conditions. And, under the assumption that the only reason for flying is to go places fast, the pilot would be informed only of the minimum range and endurance of the aircraft, given the highest airspeed. This limited information set would be 'conservative' in the sense that operations should be 'safe' as long as no trips to shorter fields, or ones at greater ranges, are planned. It is obvious such 'conservatism', which limits availability of performance information, creates a less flexible and more dangerous setting for operations than would otherwise be the case.

Of course, weeds and the environments in which they grow are far more complex than any machine. They are living things, each with their own survival systems, and they are genetically diverse within each species. Because a system is complex, however, is no reason to neglect the possibilities for better management. The costs faced by registrants in producing full label information for different conditions would be little greater than currently faced in undertaking efficacy trials. The main difference is that environmental conditions would be recorded and taken into account in the analysis to provide improved product information/support in the market place.

CONCLUSIONS

The Weeds CRC promotes integrated pest management as best practice. This means finding strategies for integrating biological controls (i.e., beneficial insects or diseases), crop rotations, more competitive crops, timely grazing, cultivation, fertilisation and other tactics along with finer-tuned and more accurate use of herbicides. For too long, herbicides have been used as the dominant means of weed control, and they are likely to remain essential tools for Australian agriculture. Purchasing these chemicals and applying them costs our farmers nearly \$1b a year today. By using them more accurately and efficiently, and integrating their use with other means of weed control, Australia's environmental and economic interests will be well served. This paper raises the question of reforms towards providing 'the whole truth' in herbicide labelling, to provide users with guidance on when they might adjust doses to specific environmental and growth conditions.

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Table1.xls and Table2.doc should follow