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Effect of agronomic practices on wheat protein levels

By Mel Mason, Senior Research Officer, Division of Plant Research

High grain protein levels are preferred for many end-uses of wheat. However, there has been little or no incentive for farmers to use practices which would increase protein levels, because wheat payments are made without a price differential for protein level, except where the wheat could qualify for the Australian Hard grade.

Farmers have used practices purely to increase yields, and when used for this objective these practices result in minimal changes in grain protein levels. If farmers were paid enough money for higher protein in the grain, they could adopt practices which would result in worthwhile increases in protein levels of wheat.

A proposal by the Australian Wheat Board to pay a price for wheat according to protein level is being discussed by the industry. This scheme suggests varying payments on the basis of $3 per tonne per 1 per cent protein between the range of 9.5 and 11.5 per cent protein, and $2 per tonne per 1 per cent protein above and below this range. Premiums would apply at levels above 10.5 per cent protein and discounts at levels below.

Nitrogen fertilizers

The effect of nitrogen fertilizers on grain protein levels depends on the grain yield increase produced as a result of the fertilizer application. The relationship proposed by Toms (1965) and shown in Figure 1, generally holds.

In region A of the figure, grain yields are increasing at a rapid rate with application of nitrogen fertilizer. At the same time grain protein levels can actually fall because the increased grain production that results from the earlier applied nitrogen dilutes the amount of nitrogen available at the time of grain fill. In region B, grain yield responses are diminishing and grain protein levels may remain steady or increase slightly, whilst in region C, because yield increases are slight or there is no increase at all, grain protein levels increase because of the increased uptake of nitrogen without any extra grain to act as a “sink” for the nitrogen. At the upper end of this zone yields begin to decrease and protein levels increase sharply.

Growers will use recommended rates of nitrogen application in region B, so that there is minimal effect on grain protein.

Under the current system of wheat payments the only way farmers can use nitrogen fertilizers to ensure any substantial increase in grain protein levels is to use them uneconomically. Examples of this are:

- Where nitrogen application rates are higher than recommended rates, that is, they are less profitable or there is a high risk that the increased nitrogen applied will not give a profitable return.

Conventional agronomic practices are unlikely to have any great impact on grain protein levels in wheat.
Where no grain yield increases can be expected, such as from crops grown on highly fertile heavy land or on light land which has a high level of soil nitrogen because of many years of good legume pasture.

Where the nitrogen fertilizer is applied late in the season and there is little or no increase in yield as a result of the application.

The $3 extra return proposed for a 1 per cent increase in the grain protein level within the range previously mentioned would buy only 13 kg of the cheapest nitrogen fertilizer available—bulk urea. The chances of this amount applied above the recommended rate, resulting in a 1 per cent increase in grain protein, are small and risky. An increase greater than 1 per cent would be needed to obtain a profit. Therefore, the $3 possible increase in price for wheat is unlikely to provide enough incentive for farmers to increase rates of nitrogen fertilizer application.

Soils

Protein levels are higher in grain grown on highly fertile, heavy soils which do not respond to nitrogen than on the light soils where there is a crop yield response. These heavy soils have more nitrogen available than is necessary for maximum yields and the effect is the same as over-fertilizing light soils. However, heavy soils are already important wheat growing areas in Western Australia. In recent years cropping has become more intensive and many of these heavy soils are being continuously cropped. Consequently, levels of nitrogen in these soils are being lowered so that they may no longer fall into the category of natural high grain protein producers and are beginning to respond to nitrogen fertilizers.

There is, therefore, little scope for increased cropping of these soils to increase overall grain protein levels.

A premium on protein could encourage increased cropping on heavy land in the eastern wheatbelt by buffering the effect of year to year yield variations on these soils. This could result in an increase in higher protein wheat production in the short term, but the increased intensity of cereal cropping would eventually result in lower soil nitrogen levels and lower grain protein levels, unless a legume crop such as field peas was included in the rotation.

Region and season

Seasonal conditions have a marked effect on grain protein levels, so that the levels are generally higher in seasons with a dry finish and in lower rainfall areas.

Where there is a dry finish to the season, the yield response to nitrogen fertilizers will be limited and grain protein level will be increased more than usual. In these situations the grain often does not "fill out" with carbohydrate, while most of the protein has been set down early. The result is smaller (or even pinched) grain with a higher proportion of protein than usual. Conversely, in situations with good finishing rains and an extended growing season, carbohydrates continue to be laid down in the grain, resulting in plump grains with a lower proportion of protein.

Crop rotation

Crop rotations could be manipulated to increase protein levels in wheat grain but this may be at the cost of reduced overall profitability. Wheat protein level will be increased under a long legume pasture phase of the rotation so that soil nitrogen levels are built up far higher than is required to supply the growth needs of a wheat crop. The excess nitrogen will contribute to increased grain protein.
This practice will be feasible where the pasture enterprises are as profitable, or more profitable than the cropping enterprise. In many high rainfall areas, for example, long rotations are probably already being used. Where the pasture enterprises are not as profitable as the cropping enterprise, it is unlikely that the proposed $3 per tonne per 1 per cent increase in grain protein will make it profitable for farmers to increase the length of the pasture phase enough to make a substantial impact on grain protein.

In the short rotations, legumes usually result in yield increases in the following crop because of increased contributions of nitrogen in the soil and “disease breaks”, resulting in minimal effects on grain protein. Grain protein levels will be higher in wheat grown in a stable old land system where legumes are sown than in wheat grown on new land.

A long rotation on the heavy soils of the eastern wheatbelt could be used to increase grain protein levels of wheat. Sheep grazing medic pastures on these soils can be as profitable as wheat growing (Morrison, pers. comm.—MIDAS model). The length of the legume pasture phase could therefore be increased, thus increasing grain protein to levels which could qualify for Australian Hard grade. Growing field peas on heavy soils could also maintain soil nitrogen levels so that they produce high protein grain.

**Fallow**

The use of fallow on most soils would be unlikely to increase grain protein levels. Any extra inorganic nitrogen produced by the fallow would be available early in the season and would result in a greater crop yield potential than after non-fallow. This increased “sink” for nitrogen, available later in the season, would tend to minimize any effect on protein in the grain. The possible increased soil moisture conserved could result in a better finish after fallow than after non-fallow, and so cause a decrease in grain protein levels.

**Deep ripping**

Deep ripping should have little or no effect on grain protein. The ripping allows wheat roots to penetrate the soil more rapidly, thus giving the plant access to more soil and fertilizer nitrogen. This results in yield increases which minimize the effects on grain protein levels.

In some circumstances, grain protein could be increased by deep ripping, but these are rare cases where the ripping causes a decrease in yield. This has occurred where the deeper rooted and better grown crops produced by deep ripping exhausted the supply of available water in the soil profile, with a dry seasonal finish, whereas the non-ripped comparison crop had a shallow rooting system early, and at the end of the season had access to previously unused moisture deeper in the profile.

**Time of planting**

Agronomic practices, such as time and rate of planting on grain protein, will have an indirect effect on grain yield response. The only increase in grain protein content would be due to a decreased yield as a result of sub-optimal cropping conditions.

**Weeds**

Weeds in crops will compete with the crop for nitrogen supplies early in the season. This will limit the yield potential of the crop and would be unlikely to have a large effect on grain protein, because the weeds will also compete for nitrogen during the period of grain fill. Weeds will also compete for soil moisture at the end of the season and this could result in increased grain protein levels because of the shortening of the grain fill period. By controlling weeds, crop yield potential is increased and therefore the effect on grain protein is minimal.

**Diseases**

If a disease influences early crop growth it will limit the yield potential and tend to increase grain protein as long as late uptake of nitrogen is not impeded. Diseases such as “take-all” interfere with moisture uptake at the end of the season and could result in pinched grain with a higher protein content than usual. The control of diseases in crops, therefore, is more likely to lower grain protein than increase it.

**Little impact**

There seems little chance that conventional agronomic practices would have any great impact on grain protein levels in wheat. The use of nitrogen fertilizers at current economic rates would only be likely to increase grain protein to a small degree. The proposed $3 per tonne per 1 per cent increase in grain protein is unlikely to give farmers sufficient incentive to increase nitrogen fertilizer application rates substantially to increase grain protein. A premium of at least twice that proposed would be needed to have any significant impact.