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How to select varieties for organic farming: science and practice

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Summary

Selection of cereal varieties suited to organic farming requires a different, but complementary, approach to that used when developing cereals for conventional high input systems. Selection is based on the interaction between a series of desirable plant and crop characteristics, in particular competitive ability against weeds. Certain key characteristics that are generically desirable for organic cereal varieties include: (1) good establishment ability, (2) high tillering ability, (3) increasing plant height, (4) planophile leaf habit, (5) high leaf index and (6) robustnesses in yield performance across sites. Our data strongly suggest that high crop ground cover is the most important feature for creating a highly competitive crop that also has consistency in yield. Individual plant or crop traits in (1) to (5) can be used to define plant growth habits. A scheme for assessing growth habits in new varieties is presented.

Key words: Cereals, wheat, weeds, organic farming, competitiveness

Introduction

In selecting varieties suited to organic farming it is important to consider the robustness in yield performance and competitive ability against weeds; this includes shading ability and efficient early nutrient capture. For various reasons (e.g. lower or more variable soil fertility, later sowing dates and poorer establishment) organic cereals often have much lower shoot populations compared to cereals grown under high inputs of inorganic fertiliser and pesticides. Therefore high and consistent establishment across a range of soil conditions is a particular requirement for organic varieties. Results from our EU funded research (Neuhoff *et al*., 2005) indicated that the interaction between a series of desirable plant and crop characteristics is important in selection for organic cereals. Our results strongly suggest that crop ground cover is the most important crop feature for competing against weeds (Davies *et al*., 2004). Individual plant and crop traits can be used to define plant growth habits that confer a high degree of competitiveness and consistency in crop performance. A summary of our results based on organic wheat trials is presented below.

Materials and Methods

Organic variety trials

The methods are from our EU project on Strategies of Weed Control in Organic Farming

(WECOF) (Neuhoff *et al*., 2005). A variety trial was carried out in each of four years (2000/01 to 2003/04) at an organic farm at Colstoun Mains Farm, Haddington, near Edinburgh. Varieties were supplied from four countries: Germany, Poland, Spain and UK. Each trial comprised of seven reference varieties used in all years (Batis, Isengrain, Malacca, Pegassos, Rialto, Riband and Shamrock) and a selection of between 8 to 18 other varieties (including Maris Widgeon, Marius, Option, Ramiro and Zyta). The trials also included a spring wheat (Chablis) and a winter oat (Gerald). Measurements of crop and weed growth were observed throughout the crop life cycle. The key measurements were based on: (1) early growth habit, including plant number, tillering ability and % ground cover. (2) Canopy expansion and spring/summer growth including mean leaf angle/orientation. Grain yield was also measured. The most important criteria applied to variety selection is summarised below.

Results and Discussion

Early growth habit

An early prostrate habit (at the start of tillering) combined with a moderate to high leaf area index (either through rapid leaf development or good crop establishment) was a good indicator of high crop competitive ability against weeds. Other competitive characteristics such as nutrient and water competition are suspected to play an important part, as may allelopathy, at this early stage (Neuhoff *et al*., 2005). Ground cover at early tillering was strongly correlated with weed suppression throughout the season (e.g. Richards & Davies, 1991). An erectophile habit at early tillering tended to require a high crop establishment to be as equally competitive as an early planophile.

High tillering capacity

Some varieties have a relatively high shoot population because of good establishment, whilst others produce a higher than average number of shoots per plant – some varieties may have both characteristics. High tillering capacity is likely to be most important at low plant populations i.e. 150 plants per square metre or less. The target for an organic cereal variety is to have high and consistent establishment across a range of soil conditions. Therefore selected varieties should be high tillering types to cope with adverse situations leading to delayed or poor emergence.

Rapid early growth to stem extension

Rapid early growth allows the crop to maintain a light interception lead over the rapidly growing weeds, and with the right habit, shade newly emerging weeds. Ground cover by the crop at the end of tillering was strongly correlated with weed suppression up to full canopy cover and up to harvest (Neuhoff *et al*., 2005). Rapid autumn and early spring growth is required to cope with weed emergence with the crop and a further emergence in early spring. In late sown crops a rapid early spring growth is required to shade a largely spring emerging weed flora. In early sown crops rapid autumn tillering is required, as well as rapid early spring growth.

Plant habit

A planophile leaf habit is when the leaf angle from the main stem (and tillers) exceed 30^{o}–45^{o} from the vertical. A leaf may be relatively straight or curved. A highly curved or extended leaf in which the leaf tips exceed an angle of 60^{o} from the stem can also be described as planophile. In general, highly planophile morphologies increase crop light interception and shading of weeds, and this compensates significantly for lack of height. Some varieties change from planophile to erectophile (leaf angle is less than 30^{o} from the vertical, straight or curved) over the season. Fig. 1 illustrates a method for determining growth habit. This five-point scale takes into account whole plant structure; mainly as a function of leaf inclination and a visual assessment of the plant height to width ratio. This type of scale can be used to indicate extremes of plant habit, as well as potentially useful growth habits in between.

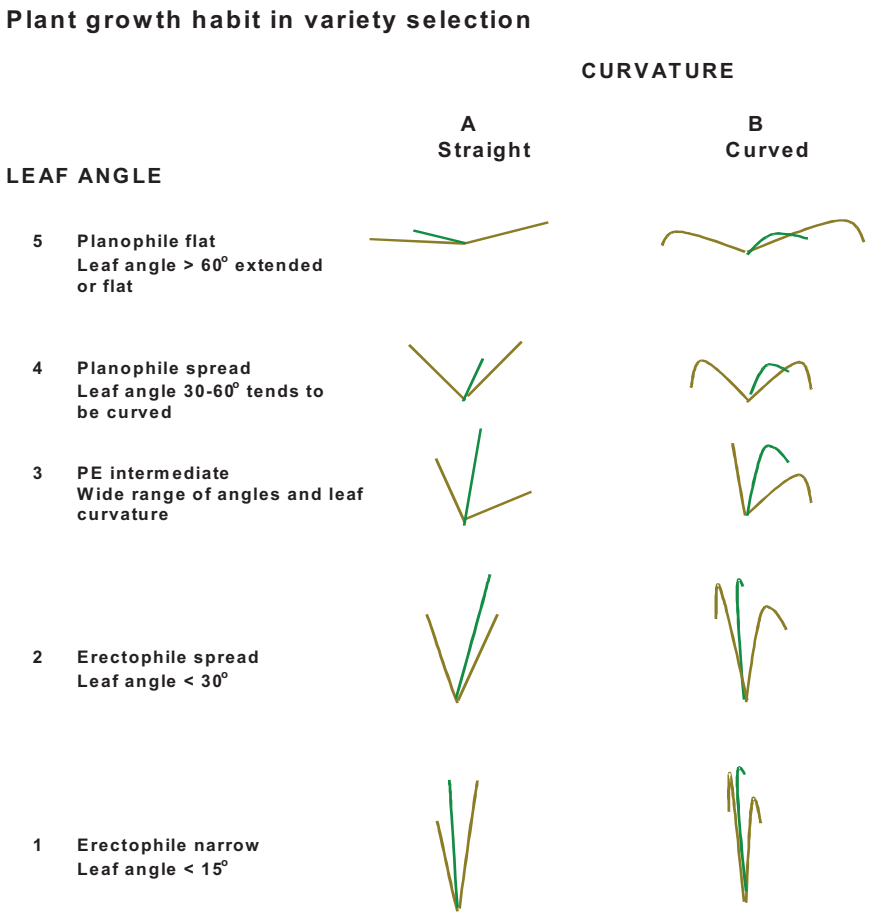

Fig. 1. A five-point scale for describing plant growth habit in variety selection for organic farming and/or weed suppression characteristics. Columns A and B are used to refine the growth habit score by indicating the presence of predominantly straight or curved leaves.

Plant height

Although there was no clear indication of height alone being useful in competition against weeds, very tall varieties would appear to be competitive at moderate to good plant population densities. Height can compensate for an erectophile leaf habit, but a relatively short planophile can give the same shading ability and weed suppression of shorter weeds. Tall varieties may have an advantage over some very tall grasses and scrambling weeds.

Crop ground cover

Crop ground cover integrates several plant and crop characteristics. Crop cover measured from directly above the crop was a good indicator of shading characteristics (R2 = 0.51, data not shown) and can be used as a guide in selection of competitive varieties. However, total leaf area index (LAI) or green area index (GAI) are also good correlants with shading and weed suppression. Leaf size is an important factor in shading, with larger leaves of particular assistance in erectophile varieties. The varieties that have the poorest weed suppression are short, erectophile varieties or planophile varieties with small or narrow leaves.

Selection for yield

Our data indicated that the best weed suppressors were amongst the better yielding varieties. There was a significant correlation between yield and weed cover immediately post-harvest (R^2 = 0.46, data not shown). It is clear that yield benefits are not lost in selecting for weed suppression in winter wheat. This has implications for plant breeding programmes, because the development of competitiveness against weeds does not exclude high yielding varieties.

Practicalities

The information we have leads us to conclude that new varieties for organic agriculture need to be more robust in both their percentage establishment under contrasting conditions and in their ability to produce as high as possible number of shoots per plant: either through tiller production or tiller retention. Seasonal variations in plant establishment and individual variety responses in tiller production and/or tiller retention can make it difficult to group varieties in field trials into consistently good or poor ideotypes. However, it is possible to describe general growth habits in a way that will benefit development of weed suppression ability in new varieties. For plant breeders, targets for plant and crop characteristics should be considered in relation to general growth habits that are of value under different circumstances or location in organic farming. Examples of current varieties that provide a basis for developing future ideotypes are: Chablis: a spring wheat with planophile leaf habit, Rialto: a winter wheat with high tillering under Scottish conditions and Maris Widgeon: a tall winter wheat with a late season planophile leaf habit.

The balance between different characteristics for weed suppression will determine the value of the variety for early, late and season-long weed control. A continuous planophile leaf habit has a clear advantage for weed suppression over the erectophile type at a given plant or shoot population density, but there are also benefits of early and late planophile habits depending on the relative establishment of crop or weeds during the season It is clear that selection for variety types should be considered in relation to climatic factors that affect both crop and weed growth. Where breeding lines are exclusively of erectophile types, then it should be possible to improve weed suppression through shading by increasing LAI with increased height and leaf size.

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