Uwe Schleuß, Kiel

Tillage and Weed Control in Ecological Farming

Report from a KTBL-, SÖL-, BTQ-Conference in Kassel

Tillage and weed control belong to the most important measures in ecological farming. Weed control must be properly integrated into plant-cultivation measures. The kind and time of tillage, field hygiene, intermediate crop cultivation, crop rotation, and crop management as indirect measures are particularly important. New developments in the area of weed control can contribute to significant progress in production. Given these considerations, the following goals must be met: appropriate control success, high efficiency, soil protection, ecological compatibility, low energy consumption, and low general process costs.

Dr. Uwe Schleuß is a scientist working in the Plant Protection Department of the Office of Rural Areas in Kiel (director: Dr. H.-J. Gleser), Westring 383, D-24118 Kiel; e-mail: *uwe.schleuss@pfs.alr-kiel.landsh.de*.

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The acceptance of ecological farming has increased significantly on both the demand and the supply side. Since the production conditions of this kind of land use are considered particularly environmentally compatible, resource-protecting, and sustainable, ecological farming has already been subsidized for quite a long time. However, the considerable growth figures cannot obscure the fact that at the end of 2001 only 3.3% of all farms on a total of 3.7% of the area used for agriculture in Germany had adopted ecological farming with marked concentration in certain regions (mainly Brandenburg, Mecklenburg-Vorpommern, Hessia, Bavaria, and Baden-Württemberg) [1].

In addition to promotional measures, a significant expansion of ecological farming primarily requires the solution of existing production-technical problems, e.g. in plant protection.

Among the production conditions in ecological farming, tillage and weed control are particularly important measures for the promotion of the crops' growth conditions with the goal of achieving yield increases and guaranteeing higher yield security. In November 2002, the Committee for Technology and Structures in Agriculture (KTBL) in cooperation with the Foundation for Ecology and Agriculture (SÖL) and the Society for Soil, Technology, and Quality (BTQ) held a conference about „Tillage and Weed Control in Ecological Farming" in Kassel in order to document the current status of the discussion and to show research deficits.

Soil Life

The basis of production in ecological farming is soil fertility. Soils are characterized by a large abundance of species and provide living space for an uncountable number of organisms. The dry weight of all soil organisms (bacteria, fungi, algae, nematodes, woodlice, springtails, earthworms) is estimated to be 5 t ha^{-1} [2]. The working structure in soils has particular importance in ecological farming: soil organisms provide stable soil aggregates, create coarse pores for water seepage, enlarge root space in symbiosis with higher plants or bind air nitrogen in symbiosis with leguminous plants, decompose organic substances, and degrade organic pollutants. When evaluating measures affecting the soil, one must take into consideration that only a few soil organisms (earthworms) are able to form their living space themselves. Most soil organisms can only adapt to the existing locational conditions.

Tillage

Tillage measures exert a sustainable influence on soil life. With increasing duration of ecological farming, the efficiency of microorganism performance increases significantly [2]. Moreover, tillage also affects the distribution of organic substance as the basis for the nutrition of the microorganisms. Regular plough use in basic tillage leads to a uniform distribution of organic substance in the topsoil, whereas non-turning soil cultivation causes the formation of a depth gradient with a maximum of organic substance in the uppermost centimetres. Tillage is also one of the factors which are responsible for the development of the weed flora.

Weed Control

Weeds not only damage crops through competition, but they are also host plants for pathogens and pests, significantly impair harvest work, and cause considerable additional expenses, e.g. due to higher drying costs. For both ecological (reduction of water- and wind erosion, biodiversity of agricultural landscapes) and economic reasons (economic damage threshold), weed control does not pursue the goal of weed free crop stands. Certain residual weed infestation is tolerated [3]. All in all, ecological soil cultivation causes an increase in the number of weed species. Over the course of time, species may establish themselves which are rarely or no longer present on conventionally cultivated fields.

In this form of land use, perennial species in particular occur as problem weeds. In arable farming, the creeping thistle (*Cirsinum arvense*) and in some cases also the hemp nettle (*Galeopsis tetrahit*) and cleavers (*Galium aparine*) on better soils as well as couch grass (*Agropyron repens*) and white goose foot (*Chenopodium album*) on lighter soils are of great importance. In addition to the mentioned species, field bindweed (*Convolvulus arvensis*), French weed (*Galinsoga parviflora*), rough-haired amaranth (*Amaranthus retroflexus*), and water grass (*Echinochloa crus-galli*) occur to a larger extent in vegetable cultivation.

Tillage, crop rotation, fertilizing, and plant protection are closely interconnected. In ecological farming, tillage and crop rotation are particularly important. Dr. Hampl reported on a tillage trial in the Rheno-Hessian town of Rommersheim (conditions: annual precipitation: 500 to 600 mm, annual mean temperature: 10° C, loess pararendzina, crop rotation: green fallow – winter wheat (intermediate crop) – peas – winter rye (intermediate crop) – summer barley), where different tillage techniques have been applied since 1994. In this trial, the plough (turning of the topsoil up to a depth of 30 cm, intensive), the two-layer plough (superficial turning up to a depth of 15 cm, deep loosening up to a depth of 30 cm, reduced), and the cultivator (no turning, loosening up to a depth of 30 cm, conserving) are being compared as variants. After eight years, the trials have yielded the following initial provisional results:

- Reduced and conservation basic tillage not only lead to humus enrichment in the topsoil, but also to increased humus and microbial biomass contents in the entire topsoil area
- Reduced and conservation tillage provide higher infiltration rates and, hence, higher water absorption ability
- Reduced and conservation tillage show a tendency towards lower yields in particular due to higher weed infestation[1].

According to different speakers at the workshop, decreasing tillage intensity generally entails the following agronomical consequences:

- slower soil warming in the spring with a resulting lower N-release in a frequently N-limited system
- reduced leaf surface index with the consequence of lower yield
- reduced root length density with the consequence of reduced nutrient intake
- higher aggregate stability combined with lower susceptibility to silting and erosion
- a higher degree of soil coverage by weeds combined with smaller damage caused by water and wind erosion
- reduced nitrate content in the soil
- greater phytosanitary problems
- lower natural yields.

In ecological farming, indirect measures of weed control (seed cleaning, crop rotation, choice of varieties, crop density, row distance) are of great importance in order to prevent an increase in problem weeds.

Results from the Workshops

According to the experts and farmers at the workshop, heavier weed problems must be expected in particular under the following conditions:

- high grain percentage in the crop sequence
- low grass-clover percentage in the crop sequence
- small differences between winter- and summer crops
- late position of grain in the crop sequence
- less frequent plough use
- reduction of comb- or hoe use.

At the moment, the turning plough is by far the most frequently used basic tillage implement[1]. For mechanical weed control, particularly the comb, the chain harrow, the hoe, or the hoeing comb along with flaming in some special cultures play an important role as direct measures. As compared with chemical control measures in conventional farming, the efficiency of direct mechanical weed control measures is considerably lower. Since the possible use of manual labour causes very high expenses, indirect measures (see above) must be given priority.

The contributions of some farmers showed the enormous importance of crop rotation. In addition, it was emphasized that on better soils especially *Cirsium arvense* caused greater problems so that the relevant workshop discussed measures for the control of this weed species in particular. For good control success, intensive mechanical weed control shortly after the harvest and in the cultures is an indispensable prerequisite[2].

The participants saw a need for further research in particular with regard to the further development of superficially clearing tillage implements, whose efficiency for weed control on heavy soils[3] was proven impressively. Additionally, available knowledge about the optimal time for the control of the creeping thistle leaves room for improvement.

In row cultures (e.g. maize), the space between the rows causes virtually no problems. Here, the efficiency of weed control is generally good. However, this does not apply to weed infestation in the row. To what extent encouraging results of experiments with newer technologies (pneumat, Weihenstephan separating hoe, sensor-based cross hoe) can be confirmed under practical conditions is a question which has not been able to be answered based on the little experience which has thus far been available.

Of course, the control effect of all techniques is strongly dependent upon the appropriate time of use, the kind and size of the weeds, the kind and moisture of the soil, the driving speed, and the weather immediately after the application of the measures. Mechanical weed control must meet the following target requirements: secure control success, high efficiency, reduction of manual labour, soil protection, ecological compatibility, low energy consumption, and low general process costs. In addition to ecological farming, progress in mechanical weed control can also be of great interest for cultivation in water protection areas or at other sensitive locations (transitional areas to biotopes).

The results of the conference and the workshops are currently being prepared for publication in the proceedings, which should be available in the middle of 2003.

[1] Lecture by professor Köpke (Institute for Organic Farming, University of Bonn) at the KTBL workshop
[2] Lecture by Dr. Marold (Mittelsömmern) and Mr. Palme (Wilmersdorf estate) at the KTBL workshop
[3] Lecture by professor Kahnt (Hohenheim University) at the KTBL workshop

Literature to the subject:

KTBL-Kalkulationsdaten

Ökologischer Landbau

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