SELECTION OF OPTIMUM VARIETIES OF GENUS WHEAT (*TRITICUM* L.) IN ORGANIC FARMING WITH RESPECT TO WEED COMPETITIVENESS

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Regulation of weeds is not easy and smooth thing in the organic farming system, because the methods of the chemical regulation of weeds are limited by the restrictions and legislative regulations. The protection againts weeds is based on the complexe measures. Current methods of the evaluation of the rate of weeds on the fields are not exact. Each variety may be evaluated from the point of view of the morphological, biological and economic features. After that, the competitiveness of variety to weeds may be evaluated too. Competitive varieties must be chosen for the organic farming system. High costs on the removing of weeds may be reduced by the selection of the competitive varieties (mechanical and thermic regulation of weeds) and we may avoid too high rate of weeds in such way. The method of the direct evaluation of certain features in the agroecosystem in the growing season may be also used for the evaluation of the suitability of wheat varieties (Triticum L.). This method is more exact and objective than the subjective method of the rate of weeds. In 2008, the experiments were set up at the location at the Research Institut of the Crop Production in Praque. 59 varieties of wheat were used in the small-plot experiment (eincorn, emmer wheat, spelta wheat, modern varieties of spring wheat, obsolete cultivar, land race). Each feature is evaluated during the growing season (when the crop is growing on the field). These features were evaluted in relation to the weed competitiveness. The data were analysed by STATISTICA programme by Cluster analysis.

***Key words**: weeds, organic farming, wheat, Cluster analysis*

The organic regulation of weeds is limited by the relevant legislative regulations. It is not simple process because of the methods of the chemical regulation of weeds being used there. It is based on the complexe measures, e.g. plant seeds without any weed seeds, regulation of the weed extension (the weeds reproducing through the root system, stolons, tillers) with the mechanization, via the minimalization of the ripening and following extension of the weed seeds. Respect of the suitable cropping is the most efficient method of the weed regulation. However, different methods of the weed regulation from the chemical

regulation with herbicides are used in the organic farming system. The physical (thermic, mechanical and biological weed regulation) methods are permissible there.

The competitive varieties to weeds have to be grown in the organic farming system. The good choice of the varieties may save the costs on the difficult mechanical or thermic regulation of weeds. When evaluating the suitability of the varieties of spring wheat (*Triticum aestivum* L.), we may use the method of the evaluation of particular characteristics in the growing season and directly in the agroecosystem. Such method is more exact and objective than the method of the subjective evaluation of the weed rate.

The optimal rate of plants per area unit is an essential condition for the higher competitiveness of the crop stand. 301 – 400 of the spring wheat plants/m^2 is the optimal rate of plants in the organic farming system. Sparse crop stands are not competitive to weeds; however, if the varieties is able to form a lot of tillers, it is able to increase the competitiveness to weeds. The coverage of the soil is influenced by agronomic factors, e.g. the relation between the row width and grain weight (LEMERLE *et al*., 2004).

Tuft shape in the tillering stage increases the competitiveness of the plant to weeds in the initial growing period – it reaches LAI 1 and it makes the development, growth and extension of the weed plants more difficult. Such characteristic is studied and evaluated from the beginning of the tillering stage (DC 23 – three sprouts have already been formed) to the end of the tillering stage (DC 29 – the end of the tillering stage); the maximum rate of the tillers has been formed there (KONVALINA *et al.*, 2007).

The length of plants in the collumning stage is related to the level of the competitiveness to weeds. It is evaluated in the stage of blossom fall (DC 69) and the length of plants is measured from plant heel to the spike top (without awns) (KONVALINA *et al.*, 2007). Mid-long plants (varieties) are the most suitable ones (MOUDRÝ, 2003). KUNZ, KARUTZ (1991), EISELE, KÖPKE (1997), MÜLLER (1998) and KÖPKE (2005) also emphasize the fact that longer (higher) plants (varieties) are more competitive. The plants which are 81 – 125 cm long (high) are the most suitable ones, seen from the point of view of the competitiveness to weeds. The length of plants is thought to be an important characteristic and condition for the ability to compete to weeds (GOODING *et al*., 1993).

Longer (higher) plants (varieties) may, nevertheless, cause particular problems, as lodging (KRUEPL *et al*., 2006). It may influence the total yield and yield quality in a very negative way. It poses significant problems with the harvest. It increases the possibility of the occurrence of diseases and damage of grains caused by the sprouting. The lodging in the early growing stages may lead to the extension of the weed plants in the crop stand. Degree of the lodging is represented by the combination of the intensity and range of the lodging. DC 59 (the whole spike is swept up) and DC 87 (yellow ripeness) should be measured and evaluated twice a growing period (KONVALINA *et al*., 2007).

Fast growth of plants is very important in the initial growing stages; it leads to high LAI values (LAMMERTS van BUEREN, 2002). It is related to the increasing competitiveness to weeds (REBETZKE & RICHARDS, 1999, PESTER *et al.*, 1999, LEMERLE *et al.*, 2001, ACCIARESI *et al.*, 2001, BERTHOLDSSON, 2005). There are the measured and evaluated aspects: number of days needed for the total development of plants – from the emergence of the crop stand (DC 10) to the total sweeping of the spikes up (DC 59) (KONVALINA *et al.*, 2007). Wide flag leaf also contributes to the higher competitivenes to weeds, as it provides more shade to lower parts of the crop stand. It is measured and evaluated during DC 77 (late milk ripeness) (KONVALINA *et al.*, 2007). Middle wide (1,6 – 2,1 cm), wide (2,2-2,7 cm) and very wide (>2,7 cm) flag leaves are the most suitable ones.

MATERIAL AND METHOD

In 2008, small-parcel trial has been established on the organic certified parcel of the RI Praha-Ruzyně. The trial parcel of the RI Praha-Ruzyně is situated in the beet area, having the altitude of 340 metres above the sea level. T2 climatic region (warm and middle dry climate), soil type – degraded black soil and clay-loamy soil, mean annual temperature of 7,8 °C, mean annual rate of the precipitation of 472 mm. Soil analysis: pH/KCl 7,63, pH/H2O 8,42, P 87,1 $mg.kg^{-1}$; K 270 $mg.kg^{-1}$; Mg 129 $mg.kg^{-1}$; Ca 4679 $mg.kg^{-1}$.

59 varieties - 18 varieties of eincorn (*Triticum monococum* L.), 8 varieties of emmer wheat (*Triticum dicoccum* SCHUEBL), 22 intermediate forms of soft wheat (*Triticum aestivum* L.), 11 varieties of spelta wheat (*Triticum spelta* L.) have been included in the trial. The list of the varieties included in the trial is given in *Tab. 1.*

Table 1

The list of the varieties

Eincorn (*Triticum monococum* L.)	
T. monococcum (Gatersleben)	Spanisches Einkorn
T. monococcum (Leningrad)	Schwedisches Einkorn
Escana	*T. monococcum*
T. monococcum (Ingu.ASSR)	*T. monococcum*
T. monococcum	*T. monococcum*
T. monococcum	*T. monococcum* No. 8910
T. monococcum	*T. monococcum*
T. monococcum	*T. monococcum*
T. monococcum .(Klein Asien)	Einkorn

Emmer wheat (*Triticum dicoccum* SCHUEBL)	
Rudico	Weisser Sommer
T. dicoccon (Palestine)	*T. dicoccon* (Dagestan. ASSR)
T. dicoccon (Tapioszele)	*T. dicoccon* (Brno)
May-Emmer	*T. dicoccum* (Tabor)
Soft wheat (*Triticum aestivum* L.)	
Česká přesívka	Kastická přesívka 202
Postoloprtská přesívka	Kastická přesívka 203
Dobrovická přesívka P 2	Postoloprtská přesívka 6
Kastická přesívka km. 12	Postoloprtská přesívka XV/1
Přesívka Červený Oujezd	Postoloprtská přesívka II/4
Červená perla	Přesívka Červený Oujezd
Postoloprtská přesívka 15	Rosamova česká červená přesívka
Postoloprtská přesívka 19	Perla přesívka
Postoloprtská přesívka 102	Kastická přesívka 202
Průhonicka jubilejni přesívka	Dregerova přesívka
Selecty přesívka S 205	Červená perla
Spelta wheat (*Triticum spelta* L.)	
Špalda bílá jarni	*T. spelta* No.8930
T. spelta (Ruzyne)	CDC Bavaria
T. spelta (Kew)	*T. spelta* (VIR St.Petersberg)
T. spelta (Ruzyne)	*T. spelta* (Tabor)
129/73 (Radzikow)	*T. spelta* No.8056
T. spelta (Tabor)	

The existing methods of the evaluation of the rate of weeds in the crop stands of field crops are not exact. The varieties may be evaluated from the point of view of the morphological, biological and economic characteristics. The competitiveness to weeds of the varieties may be evaluated after such a study of the above-mentioned characteristics. The characteristics are evaluated in the growing season of the crops, being grown on fields. The following characteristics have been chosen for the evaluation and study (see *Table 2*).

Table 2

Proposal of the selected features

Morphological features	
Evaluated feature	*DC period*
Tuft shape	23-39
Length of plant	69
Length of flag leaf	77
Width of flag leaf	77
Length of the upper internode	83
Biological features	
Growing season: initial growth - speed	10 – 59
Index of lodging	59 and 87
Economic features	
Number of plants per area unit	after the emerging

These characteristics were appraised in the growing period, but in different DC growing stages. Tuft shape was the first evaluated morphological characteristic. It was appraised in the period of the initial formation of tillers, in DC 23 stage. The shape of the tuft was classified according to the following figure (*Figure 1*).

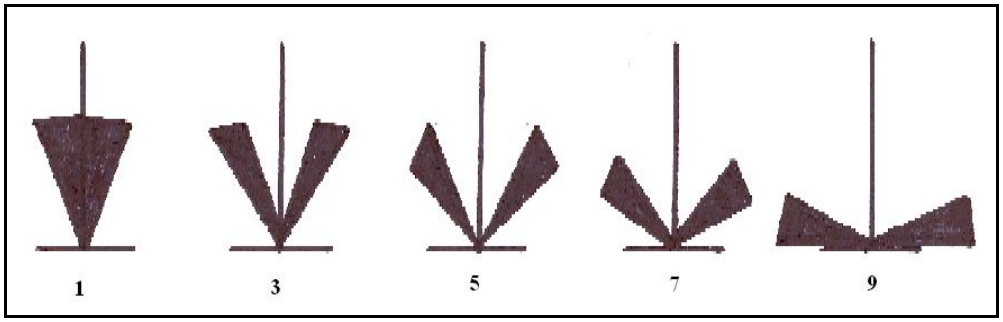

Figure 1 **Evaluation of tuft shape** (KONVALINA *et. al*, 2007)

Length of the plants became the second evaluated morphological characteristic. It was evaluated in the period after the blossom fall, in DC 69 stage. The length of the plants was measured from the plant heel to the top of the spike (awns were not included). In DC 77 stage (late milk ripeness), the length and width of the flag leaf were evaluated. The length of the upper internode was the last evaluated morphological characteristic. It was evaluated in DC 83 stage (early wax ripeness).

Two biological characteristics were appraised in the growing period. Index of lodging was the first one; it was evaluated twice in the growing period. At first, it was appraised in DC 59 stage (the end of earing), and after that, it was evaluated in DC 87 stage (yellow ripeness). The index of lodging is represented by the combination of the intensity and range of the lodging (Figure 2 and Table 3). The initial growth of the development of the plant was the second evaluated characteristic. It is represented by the number of necessary days for the development of the plant, from the emergence of the crop stand to the total earing. One economic characteristic was also appraised in the growing season. Number of the plants was evaluated after the emergence of the crop stand.

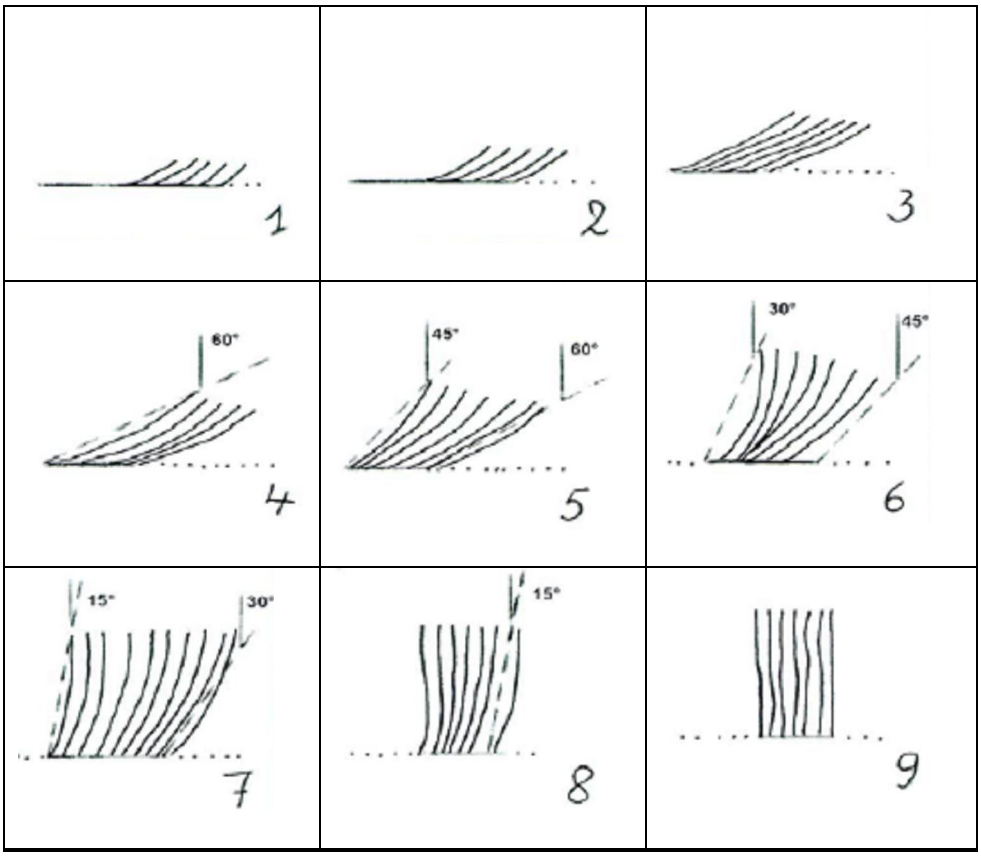

Figure 2 **Evaluation of intensity** (arranged according to Van WAES and De VLIEGHER, 2000)

Table 3

Comments to intensity of lodging (KONVALINA et al., 2007)

1. straw fully down to the ground
2. straw for more than 50 % touching the ground with only the stem ends upright
3. for less than 50 % touching the ground, the rest is upright
4. stems sloping for more than 60° but not touching the ground, expect at the basis
5. stems sloping between 45° and 60°
6. stems sloping between 30° and 45°
7. stems sloping between 15° and 30°
8. stems lightly sloping (<15º)

Table 4

Index of lodging (dle WAES, 2006)

Range of lodging	Intensity of lodging								
	9	8	7	6	5	4	3	2	1
96-100	9,0	8,0	7,0	6,0	5,0	4,0	3,0	2,0	1,0
81-95	9,0	8,1	7,2	6,3	5,4	4,5	3,6	2,7	1,8
76-80	9,0	8,2	7,4	6,6	5,8	5,0	4,2	3,4	2,6
51-75	9,0	8,3	7,6	6,9	6,2	5,5	4,8	4,1	3,4
31-50	9,0	8,4	7,8	7,2	6,6	6,0	5,4	4,8	4,2
21-30	9,0	8,5	8,0	7,5	7,0	6,5	6,0	5,5	5,0
11-20	9,0	8,6	8,2	7,8	7,4	7,0	6,6	6,2	5,8
6-10	9,0	8,7	8,4	8,1	7,8	7,5	7,2	6,9	6,6
1-5	9,0	8,8	8,6	8,4	8,2	8,0	7,8	7,6	7,4
<1	9,0	8,9	8,8	8,7	8,6	8,5	8,4	8,3	8,2
0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0

RESULTS AND DISCUSSIONS

Spelta wheat

Eleven varieties of the spelta wheat have been included in the trial. The results of the trial are shown in the dendrogram (tree diagram), chosen for the method of the furthest neighbour, in Figure 3. The diagram shows the fact that particular varieties prove to have similar characteristics and they are specialised on the competitiveness to weeds. *T. spelta* 1 varieties (Ruzyně) and *T. spelta* No. 8056 variety make one cluster of the varieties being the closest one to each other (1,4). Therefore, they are the most similar one to each other from the point of view of the studied characteristics, especially the competitiveness to weeds. These two varieties do not have favourable tuft shape, index of lodging in DC 87 stage and the length of the upper internode. Another varieties, as *T. spelta* No. 8930 and *T. spelta* (VIR St. Petersburg) (distance of the relation of 1,6), make the other cluster of the

varieties. In the case of these two varieties, all the appraised characteristics were evaluated there, except the number of plants. Both were indicated as highly competitive to weeds. Another two varieties, *T. spelta* 2 (Ruzyně) and *T. spelta* 1 (Tábor), make the other cluster of the varieties having the distance of the relation of 2. *T. spelta* 1 (Tábor) variety was indicated as the most competitive to weeds in the growing season.

The cluster of the varieties, *T. spelta* (Kew) and *T. spelta* 2 (Tábor), was also established in the distance of the relation of 2,4. These two varieties proved to be more competitive in the trial. On the other hand, they proved to have some less favourable apprasied characteristics, as the index of lodging in DC 87 growing stage. Variety called 129ú73 (Radzikow) was the most different from the varieties of spelta wheat. This variety made an cluster of the varieties in the distance of the relation of 3,8. It especially differs in the length of plant, length of the upper internode and tuft shape.

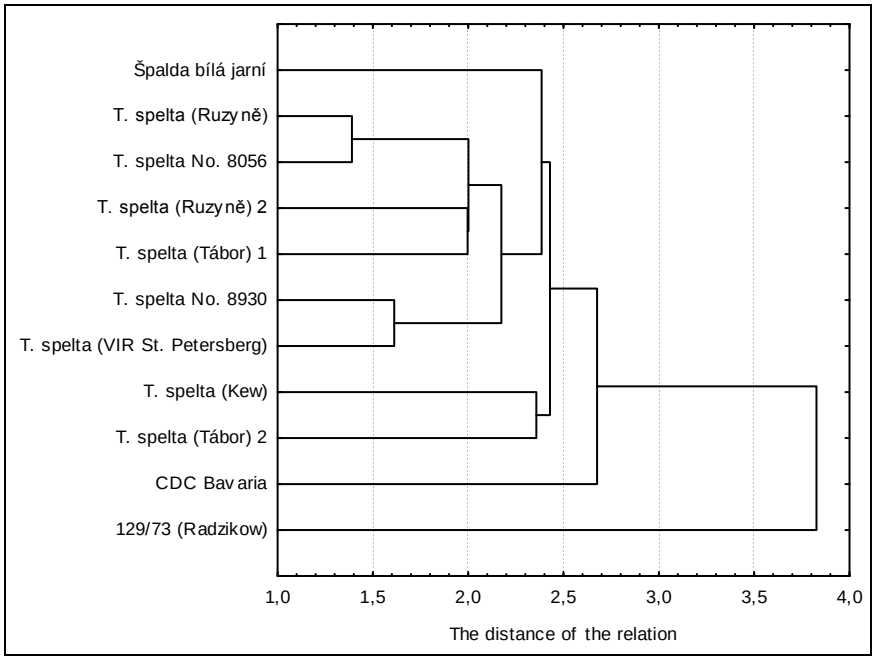

Figure 3 **Dendrogram of spelta wheat (*Triticum spelta* L.*)***

Intermediate varieties

23 intermediate varieties of the soft wheat were included in the trial. The results of the cluster analysis are shown in the dendrogram (*Figure 4*). It shows Perla přesívka and Dregerova přesívka are the most similar one to each other (the distance of the relation of 1,1). Perla přesívka was thought to be the worse evaluated variety. These two varieties had the unfavourable tuft shape, narrow and short flag leaf, high index of lodging in DC 87 stage. Kastická přesívka km. 12 and Postoloprtská přesívka 15 made an cluster having the distance of the relation of

1,3. These two varieties were thought to be the most competitive to weeds (more competitive than the other intermediate ones). They were characterised by slower speed of the initial growth. Another cluster consists of Postoloprtská přesívka 102 and Postoloprtská přesívka XV/1, having the distance of the relation of 1,7. These varieties were competitive to weeds. Postoloprtská přesívka 6 and Postoloprtská přesívka 61 make the cluster having the distance of the relation of 1,8. Both varieties belong to less competitive varieties to weeds. Their tuft shape, slow speed of the initial growth, long upper internode and high index of lodging in DC 87 stage are the unfavourable characteristics of the varieties. Another cluster consists of Přesívka Červený Oujezd and Kastická přesívka 202, having the distance of the relation of 2,1. Dobrovická přesívka P2 variety was the most different from the rest of the group of the intermediate varieties, included in the trial. It was not thought to be most competitive to weeds, however, particular appraised characteristics were more favourable than these ones of the other intermediate varieties. This variety did not lodge in any of the studied growing stages. However, it had very narrow flag leaf (more narrow than the other varieties).

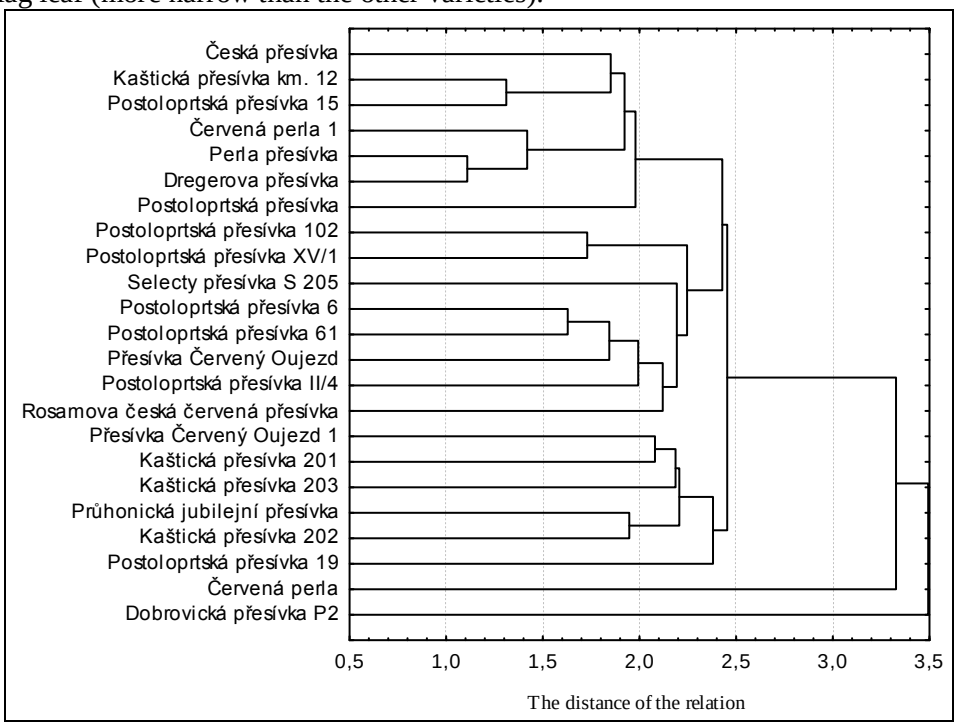

Figure 4 **Dendrogram of intermediate varieties** (*Triticum aestivum* L.*)*

Emmer wheat

Eight varieties of the emmer wheat were included in the trial. Two of them, Rudico and *T. dicoccum* (Tábor), having the distance of the relation of 0,8, made a cluster, the rest of the varieties joined to this one cluster later (*Figure 5*). These varieties have very similar appraised characteristics. The other cultivars joined to

the cluster; the last joined variety, *T. dicoccum* (Dagestan. ASSR), was the most different from the others. This cultivar had the distance of the relation of 4,7. It has high index of lodging in DC 87 stage.

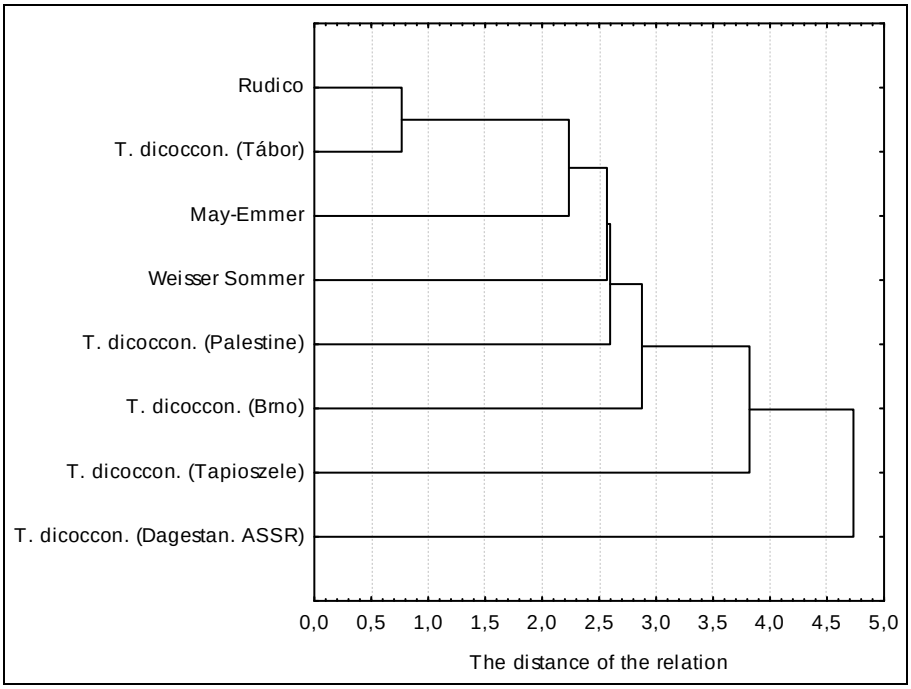

Figure 5 **Dendrogram of emmer wheat (*Triticum dicoccum* SCHUEBL)**

Eincorn

18 cultivars of the eincorn were included in the trial (*Figure 6*). Escana and *T. monococcum* made the shortest distance of the relation in the cluster (1,3). These two varieties were rather more competitive to weeds than the other ones. They had longer internode, less favourable tuft shape, length and width of the flag leaf. *T. monococcum* (Gatersleben) and *T. monococcum* 7 varieties made another cluster; they are rather more competitive to weeds. The distance of the relation in the cluster is 1,5. They had the favourable tuft shape and length of the upper internode. Another two varieties, *T. monococcum* 6 and Einkorn, were thought to be highly competitive to weeds. The cluster of these two varieties was characterised by the distance of the relation of 1,7. *T. monococcum* (Leningrad) and *T. monococcum 3* were assessed as less competitive cultivars to weeds. The distance of the relation was 1,8 in the cluster. *T. monococcum 1* and *T. monococcum* 2 were assessed as the least competitive cultivars to weeds. The cluster was established in the distance of the relation of 2,3. *T. monococcum* 1 was thought to have the favourable length of plant, index of lodging in DC 59 stage and length of the upper internode. The last cluster was established of *T. monococcum* (Cec.-Ingu.ASSR) and Schwedisches

Eincorn in the distance of the relation of 2,4. These two cultivars are mid-competitive to weeds.

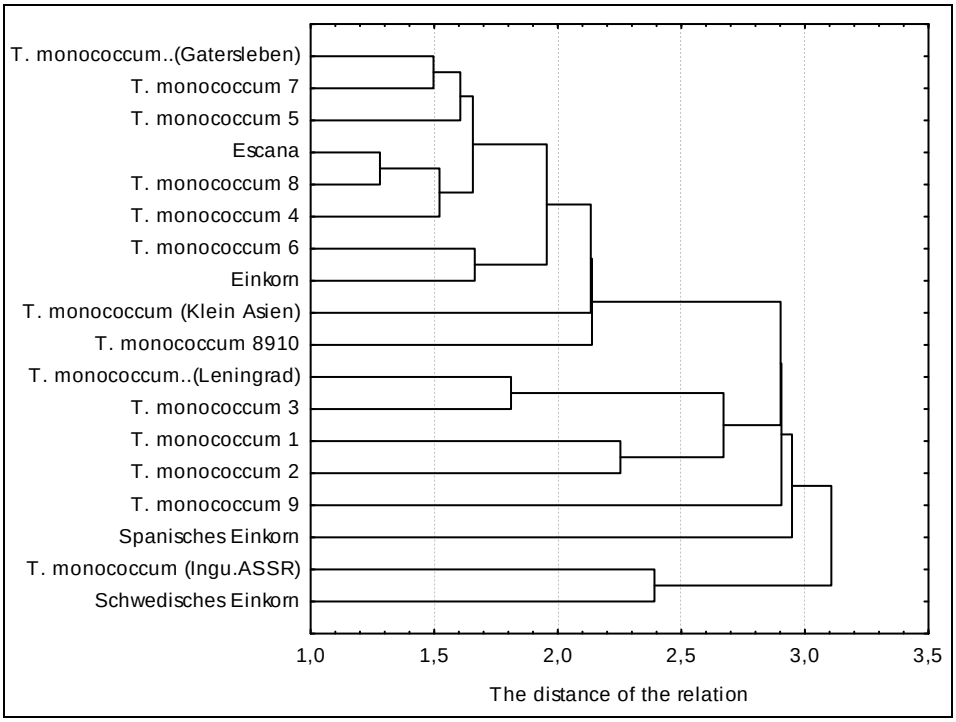

Figure 6 **Dendrogram of eincorn (*Triticum monococcum* L.)**

Tuft shape in the tillering period increases the competitiveness to weeds in the initial growing stages of the cereal plants – it reaches LAI 1 earlier at it makes the development and extension of the weed plants more difficult (KONVALINA *et al.*, 2007). Particular crops made the development and extension of the weed plants impossible through the fast growth.

The length of plants in the collumning period is connected with the competitiveness to weeds. Mid-long cultivars are the most suitable ones (MOUDRÝ, 2003). KUNZ, KARUTZ (1991), EISELE, KÖPKE (1997), MÜLLER (1998) and KÖPKE (2005) also emphasize the fact that the longer varieties are more competitive than the short ones. However, the long varieties more incline to the lodging, especially in bad weather conditions, in the second part of the growing season. Long plants have weak stalks (weaker than mid-long or short ones). The lodging may be followed by the earing of the crop stand and extension of the weed plants, diseases and it can cause worse quality of the production. Long varieties were less competitive to weeds, because of the high index of lodging in later stages of the growth.

Sufficient wide flag leaf contributes to better competitiveness to weeds (KONVALINA *et al.*, 2007). Wide leaves provide more shape to the lower parts of the crop stand, where the weed plants (e.g. *Viola tricolor* L. *subsp. arvensis* , *Stellaria media*, etc.) could spread. Long perennial weed plants are not influenced by length and width of the flag leaf. They have an impact on annual low weed plants.

Eincorn has very narrow flag leaf. It establishes, nevertheless, a compact crop stand thanks to a high ability of tillering. Therefore, it is more competitive to weeds than some other varieties having wide flag leaf.

The competitiveness to weeds depends on the number of plants per area unit and tillering ability of the variety. If the variety produces a lot of tillers, it is able to compete to weeds even in sparse crop stand. Small number of plants is compensated by the high number of the tillers. Eincorn is characterised by such ability. The coverage of the soil is influenced by the agronomic factors, as the width of rows, proportion of the grain weight, etc. (LEMERLE *et al.*, 2004).

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CONCLUSIONS

The particular selected varieties proved to have a different ability to compete to weeds. The studied characteristics of these cultivars were evaluated in different period of the growth. There were significant differences between the cultivars. Some of them were thought to compete well to weeds (they proved to have favourable morphological and biological characteristics). A mid-long variety with fast initial growth, good ability of the tillering, resistant to lodging and a variety with wide flag leaf was thought to be the most suitable one. These characteristics should be taken into account during the breeding process in the organic farming system.

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