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WEED COMMUNITIES AND THEIR EFFECT ON PRODUCTIVITY OF BREAD SPRING WHEAT IN DRY STEPPE OF WESTERN KAZAKHSTAN

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Abstract

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In organic farming the spatial distribution, number and present productivity data of weed communities and their effect on the productivity of spring wheat depending on meteorological conditions, tillage system and sowing were determined. The projective cover and density of weeds were taken into account. Thirty seven types of weed communities were identified by dominant and subdominant species and marked out on the plan. Mapping of weed communities was carried out in the heading stage of wheat. Air-dry above-ground phytomass of weeds was determined. The productivity of wheat was calculated in the identified types of communities. In our experiments the weather conditions of the year had more strong impact on the number and composition of weed communities than tillage system and methods of sowing. The number of communities of weeds increased from conventional to minimum tillage. The number of weed communities decrease from the wet and cool to drier years. Herbaceous perennial weeds (*Lactuca tatarica, Euphorbia virgata, Sonchus arvensis, Cirsium setosum*) were the most stable component of weed communities. The spring annual weeds with the dominance of *Setaria pumila* well developed in the years with significant rainfall in March and April. Perennial weeds reduced parameters of spring wheat productivity more than annuals. In communities with a dominance of thistle grain yield was 32-34% lower than in communities with foxtail. Gluten and protein content significantly decreasing in communities of perennial weeds. Understanding spatial pattern of weed communities is necessary for precision weed management, practical application of herbicides.

Key words: perennial weeds; annual weeds; dominant species; tillage; sowing; yield

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important food crops of the world. The major factor affecting the production of wheat is weeds. It has been estimated that global yield losses in wheat due to weeds is 13.1% (Oerke et al., 1994). Most weed ecology studies have focused primarily on the effect of the crop rotation, tillage system, sowing on weed diversity, abundance and community composition on wheat yield (Olsen et al., 2006; Wortman et al., 2010; Feledyn-Szewczyk, 2012; Gawęda and Kwiatkowski, 2012; Wozniak et al., 2015; Armengota et al., 2016). The 15 most important weeds were determined for spring cereals crops in European countries (Schroeder et al., 1993). One hundred and one weed species were observed in conventional farming and 149 species were found in spring cereals in organic farming in the Czech Republic. *Chenopodium album* L., *Fallopia convolvulus* (L.) A. Love., *Cirsium arvense* (L.) Scop. were recorded as the species with the highest constancy in both types of farming. *Fallopia convolvulus* was the most common species in spring cereals (Kolářová et al., 2015). Research on the structure of weed communities on cultivated land has been concentrated in Europe (Holzner and Immonen, 1982; Wozniak and Soroka, 2015), USA (Dale and

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Thomas, 1987) and Canada (Thomas and Dale, 1991). Yield loss due to weeds in spring cereal crops was estimated in Sweden (Milberg and Hallgren, 2004). The worst weed species in spring-sown crops were annuals *Polygonum lapathifolium* L., *P. persica* L. and *Galeopsis* spp. Effect of weeds on tillering, shoot and root dry weight, 100-grains weight, grain yield, yield losses of wheat was investigated in Pakistan (Siddiqui et al., 2010). The average yield losses caused by weed competition in Manitoba (Canada) grain fields are 15.2% (Friesen and Shebeski, 1960).

The study was conducted during the 2003, 2004 cropping seasons in Terektinsky district of West Kazakhstan region in a zone of dry fescue steppe. The objective of this study was to determine the number and present productivity data of weed communities in spring wheat crops and their effect on the productivity of wheat depending on meteorological conditions, tillage system and sowing.

Materials and Methods

Field experiments were carried out at «Zhanar» in two experimental farmer`s fields using a five crop rotation: bare fallow – winter wheat – spring wheat – spring wheat – barley. The total area of one experimental field was 0.72–1.08 ha in 2003 and 1.08 ha in 2004. The soil of the experimental fields is chestnut, medium, heavy loam, with 2.3–3.3% humus in the arable layer; the topography is flat. Rainfall in May–June and the average monthly temperature in June have the greatest impact on the development of wheat in the dry steppe zone. According to these indicators, 2003 was wet and cool, favorable for development of wheat and 2004 was relatively dry. In May–June 2003 76.3, 2004 – 31.0 mm of precipitation fell and the average monthly temperature in June was, respectively, 15.7° and of 21.0°C. However, significant rainfall in March and April 2004 (41 and 32 mm, respectively) created favorable conditions for the germination and development of the annual weed *Setaria pumila* (Poir.) Schult.

The three-factor experiment (tillage system, methods of sowing, weeds) was established using randomized sub-blocks design in three replications (Dospekhov et al., 1987). There were two main tillage systems: conventional tillage and minimum tillage. The conventional tillage included autumn ploughing (P-4-35) (20–22 cm). The minimum tillage included field cultivation (KPG-250) (20–22 cm) after the harvest of the previous crop. Preplant tillage included spring harrowing. Wheat was seeded on May 1–10th. There were two methods of sowing: disk seeding with a seeder SZP-3.6, with approximately 2.8 million viable seeds per ha with rows 15 cm apart; stubble seeding with about 2.5 million viable seeds. Sowing depth was 4–5 cm. Each year was six experimental plots. Size of plots were of 2400–3600 m^2 (40–60 × 60 m). The single cultivar of bread spring wheat tested (Saratovskaya 42, variety *albidum*) was selected by the Institute of Agriculture of the South-East. Fertilizers, pesticides and irrigation were not applied. Weeds were counted in the spring wheat growth stages of tillering, heading and ripening by counting the projective foliage cover (%) and the number of individuals within a quadrat (0.1–1 m^2). Spatial mapping of weed communities was carried out in the heading stage (Kaplin, 2004). Weed communities were identified by dominant and subdominant weeds and the condition of the wheat and marked out on the plan scale 1: 100. The projective cover of dominant species accounted for more than 36% of the total projective cover of weeds in the community, of subdominant species 16–36% (Lubarsky, 1974). The projective cover (%) and density (plants m^2) of weeds were taken into account in each of communities in a 3–4-fold replication. Similar communities were united in their types. Air-dry above-ground phytomass of weeds was determined in communities which occupied the largest area. The productivity of wheat was calculated by the trial sheaves, taken diagonally in each of the identified types of communities. The following measurements were made in the laboratory: number of productive tillers per plant, number of productive tillers per m^2, spike length (cm), grain number per spike, grain weight per spike (g), thousand grain weight (g), grain yield (c ha^{-1}), grain gluten and protein concentration (%). Yield data were adjusted to 15% moisture content. The data were processed using Microsoft Excel software, and least significant difference (LSD 0.5) was used to compare the mean ± standard deviation (SD) of productivity data of weed communities. For comparing the similarity of weed communities in two experiments (A and B) were used Sorensen's similarity coefficient (S_S): $S_S = 2\,c/(a + b)$, where a – the number of weed communities in experiment A, b – the number of weed communities in experiment B, c – the number of weed communities common to experiments A and B (Sorensen, 1948).

Results

Weed species diversity

Fifteen dominant and subdominant species of weed plants were identified in spring wheat crops. Herbaceous perennial weed forming plants: *Euphorbia virgata* Waldst. et Kit., *Lactuca tatarica* (L.) C. A. Mey, *Sonchus arvensis* L., *Cirsium setosum* (Willd.) Bess., *Convolvulus arvensis* L., *Linaria vulgaris* (L.) Mill. dominated among them. The quarantine weed *Acroptilon repens* (L.) DC. was rarely encountered. The abundance of early spring weeds *Fallopia convolvulus* (L.) A. Löve, wild oat *Avena fatua* L., *Salsola australis* R.

Br. was low. *Fallopia convolvulus* was among the dominant weeds only in 2003. Late spring weeds were represented by foxtails *Setaria pumila, Setaria viridis* (L.) Beauv., redroot pigweed *Amaranthus retroflexus* L. and prostrate pigweed *Amaranthus blitoides* S. Wats. Foxtails mainly dominated in 2004. Sunflower broomrape *Orobanche cumana* Wallr. parasitized on the roots of *Lactuca tatarica*.

Composition of weed communities

Weed communities in spring wheat crops belonged to seven dominants: *Euphorbia virgata, Lactuca tatarica, Cirsium setosum, Sonchus arvensis, Linaria vulgaris, Fallopia convolvulus* and *Setaria pumila*. Twenty-five types of communities were identified in the wet and cool 2003, and 13 in the drier 2004. The total number of weed communities for two years was 37 types. In 2003 and 2004, the largest areas were occupied by communities of *Lactuca tatarica* (71–76%) and *Setaria pumila* (11–22%). In 2003 there were 13 and in 2004 four types of communities of *L. tatarica*, and respectively one and seven types of communities of *S. pumila* (Table 1). The most favorable conditions for the development of *L. tatarica* were found in experiments with conventional tillage and stubble sowing. The highest number, projective cover and biomass of *L. tatarica* and *S. pumila* were observed in 2004 (Tables 2, 3). The most favorable conditions for the development of *S. pumila* were found in the experiments with minimum tillage, with a slight influence from the method of sowing.

Broomrape sunflower *Orobanche cumana* was common in seven (43.7%) types communities of *L. tatarica*. Soil excavations showed that *O. cumana* develops on the roots of *L. tatarica*. In 2003 this root parasite occupied 47–49% of the total area of spring wheat crops and in 2004 up to 10%. The most favorable conditions for the development of *O. cumana* were in a wet and cool year. In experiments with conventional tillage the method of sowing had insignificant impact on its development. *L. tatarica* is an important reservoir of *O. cumana* in the dry steppe of West Kazakhstan region.

The bindweed *Convolvulus arvensis* was part of subdominants in five types of communities of *L. tatarica* and in two types of communities of *S. pumila*. The most favorable conditions for the development of the *C. arvensis* was in the wet and cool 2003, with little influence due to the method of sowing in experiments with conventional tillage. *Lactuca tatarica* communities formed with *C. arvensis* occupied 35% total area in the experiments with disk seeding and 44% with

Table 1
Number of weed communities in spring wheat crop

Parameters	Year, tillage system, sowing		Dominant weed species							Total
			Euphorbia virgata	*Lactuca tatarica*	*Cirsium setosum*	*Sonchus arvensis*	*Linaria vulgaris*	*Setaria pumila*	*Fallopia convolvulus*	
Number of communities	2003, conventional tillage	disk seeding	4	11	2	2	0	1	0	20
		stubble seeding	2	12	0	1	1	1	1	18
	Total:		4	13	2	3	1	1	1	25
	2004, stubble seeding	conventional tillage	0	4	1	0	3	0	0	8
		minimum tillage	0	4	1	1	6	0	0	12
	Total:		0	4	1	1	0	7	0	13
	Sum:		4	16	3	4	1	8	1	37
Occupied area, %	2003, conventional tillage	disk seeding	9.9	67.3	7.1	2.9	0	12.8	0	100
		stubble seeding	1.0	84.5	0	3.9	0.6	9.7	0.3	100
	Average:		5.4	75.9	3.6	3.4	0.3	11.2	0.2	100
	2004, stubble seeding	conventional tillage	0	88.5	6.2	0	0	5.3	0	100
		minimum tillage	0	54.0	5.0	1.9	0	39.1	0	100
	Average:		0	71.2	5.6	1.0	0	22.2	0	100

Table 2
Area occupied by weed communities in spring wheat crops, %

Subdominant weed species	Year, tillage system, sowing		Dominant weed species							Total
			Euphorbia virgata	*Lactuca tatarica*	*Cirsium setosum*	*Sonchus arvensis*	*Linaria vulgaris*	*Setaria glauca*	*Fallopia convolvulus*	
1	2	3	4	5	6	7	8	9	10	11
Euphorbia virgata	2003, conventional tillage	disk seeding	9.9	11.7	0	1.0	0	0	0	22.6
		stubble seeding	1.0	17.9	0	3.9	0	0	0	22.8
	2004, stubble seeding	conventional tillage	0	12.1	0	0	0	0	0	12.1
		minimum tillage	0	0	0	4.5	0	0	0	4.5
Lactuca tatarica	2003, conventional tillage	disk seeding	5.8	67.3	3.2	1.0	0	0	0	77.6
		stubble seeding	1.0	84.5	0	3.9	0	0	0.3	89.2
	2004, stubble seeding	conventional tillage	0	88.5	6.2	0	0	1.1	0	95.8
		minimum tillage	0	54.0	5.0	0	0	1.1	0	60.1
Cirsium setosum	2003, conventional tillage	disk seeding	2.9	8.7	7.1	0	0	0	0	18.7
		stubble seeding	0	8.2	0	0	0	0	0	8.2
	2004, stubble seeding	conventional tillage	0	0	6.2	0	0	0	0	6.2
		minimum tillage	0	0	5.0	0	0	0	0	5.0
Sonchus arvensis	2003, conventional tillage	disk seeding	0	0	0	2.9	0	0	0	2.9
		stubble seeding	0	2.4	0	3.9	0.6	0	0	6.9
	2004, stubble seeding	conventional tillage	0	9,5	0	0	0	0.4	0	9.9
		minimum tillage	0	0.7	0	1.9	0	0.8	0	3.4
Linaria vulgaris	2003, conventional tillage	disk seeding	2.9	2.1	3.2	0	0	0	0	8.2
		stubble seeding	0	0.6	0	0	0	0	0	0.6
	2004, stubble seeding	conventional tillage	0	0	0	0	0	0	0	0
		minimum tillage	0	0	0	0	0	0	0	0
Convolvulus arvensis	2003, conventional tillage	disk seeding	1.5	34.9	0	0	0	12.7	0	49.1
		stubble seeding	0.6	43.5	0	0	0.6	9.7	0	54.4
	2004, stubble seeding	conventional tillage	0	0	0	0	0	0	0	0
		minimum tillage	0	0	0	0	0	1.4	0	1.4
Fallopia convolvulus	2003, conventional tillage	disk seeding	0	0	0	0	0	0	0	0
		stubble seeding	0	0	0	0	0	0	0.3	0.3
	2004, stubble seeding	conventional tillage	0	74.3	6.2	0	0	4.9	0	85.4
		minimum tillage	0	48.1	5.0	1.9	0	37.0	0	92.0
Avena fatua	2003, conventional tillage	disk seeding	0	0	0	0	0	0	0	0
		stubble seeding	0	0	0	0	0	0	0	0
	2004, stubble seeding	conventional tillage	0	0	0	0	0	0.4	0	0.4
		minimum tillage	0	0	0	0	0	0.8	0	0.8
Salsola australis	2003, conventional tillage	disk seeding	0	0	0	0	0	0	0	0
		stubble seeding	0	0	0	0	0	0	0	0
	2004, stubble seeding	conventional tillage	0	0	0	0	0	0	0	0
		minimum tillage	0	0	0	0	0	0.1	0	0.1

Table 2
(Continued)

1	2	3	4	5	6	7	8	9	10	11
Setaria pumila	2003, conventional tillage	disk seeding	0	7.2	0	0	0	12.7	0	19.9
		stubble seeding	0	3.2	0	0	0	9.7	0	12.9
	2004, stubble seeding	conventional tillage	0	88.5	6.2	0	0	5.3	0	100
		minimum tillage	0	54.0	5.0	1.9	0	39.1	0	100
Setaria viridis	2003, conventional tillage	disk seeding	0	0	0	0	0	0	0	0
		stubble seeding	0	0	0	0	0	0	0	0
	2004, stubble seeding	conventional tillage	0	0	0	0	0	0.7	0	0.7
		minimum tillage	0	0	0	0	0	7.9	0	7.9
Orobanche cumana	2003, conventional tillage	disk seeding	0	46.8	0	1.0	0	0	0	47.8
		stubble seeding	0	49.4	0	0	0	0	0	49.4
	2004, stubble seeding	conventional tillage	0	9.5	0	0	0	0	0	9.5
		minimum tillage	0	0.7	0	0	0	0	0	0.7

Table 3
Number of weeds per 1 m^2, projective cover and air-dry above-ground phytomass of the dominant weeds in spring wheat crops in the stage of heading

Parameters	Year, tillage system, sowing		Dominant weed species					
			Euphorbia virgata	*Lactuca tatarica*	*Cirsium setosum*	*Sonchus arvensis*	*Linaria vulgaris*	*Setaria pumila*
Number of weeds (shoots m^{-2} for perennial, plants m^{-2} for annual weeds)	2003, conventional tillage	disk seeding	26.3±3.8	40.9±19.6	18.7±4.6	17.0±6.5	–	12.0±3.8
		stubble seeding	42.0±12.0	28.7±4.2	–	27.0±5.1	18.0±3.2	9.0±1,2
	2004, stubble seeding	conventional tillage	–	101.9±5.8	–	–	–	93.9±15,1
		minimum tillage	–	83.6±22.1	134.6±8.9	95.0±15.3	–	39.9±14.1
Projective cover (%)	2003, conventional tillage	disk seeding	41.1±3.8	47.2±7.5	32.5±5.3	20.5±2.6	–	8.8±1.1
		stubble seeding	60.5±8.6	40.6±7.5	–	55.0±4.6	51.7±5.4	4.3±0.5
	2004, stubble seeding	conventional tillage	–	59.7±8.6	–	–	–	49.3±6.3
		minimum tillage	–	41.0±3.5	83.9±7.8	47.9±5.6	–	18.5±2.3
Air-dry aboveground phytomass (g · m^{-2})	2003, conventional tillage	disk seeding	80.5±22.5	94.7±24.2	88.6±15.6	30.0±5.4	–	8.5±1.5
		stubble seeding	84.0±12.3	63.5±18.3	–	127.5±25.6	37.2±9.5	5.8±1.2
	2004, stubble seeding	conventional tillage	–	103.7±9.7	–	–	–	72.1±8.4
		minimum tillage	–	118.6±17.4	213.0±24.3	78.8±12.4	–	31.0±5.2

stubble seeding, Communities with *S. pumila*, occupied 13 and 10% respectively.

One type communities with *Linaria vulgaris* was found, four types with *Euphorbia virgata*, three with *Cirsium setosum*, and four with *Sonchus arvensis*. *Euphorbia virgata*, *S. arvensis* and *L. vulgaris* preferred conventional tillage. *Cirsium setosum* preferred disk sowing, *S. arvensis* and *L. vulgaris* stubble sowing. Twenty-three percent of the total area was occupied by *E. virgata* as dominant, and subdominant in 2003 and 5–12% in 2004; *C. setosum* occupied 8–19 and 5–6% respectively; and *S. arvensis* 3–7 and 3–10%. The highest number, projective cover and phytomass of *C. setosum* and *S. arvensis* were observed in the experiments with minimum tillage and stubble sowing (Tables 2, 3).

In 2003 *Fallopia convolvulus* was part of the dominants in only one type of communities (about 0.3%). In 2004, *F. convolvulus* was represented as subdominant in two types of communities with *L. tatarica*, one type with *C. setosum* and *S. arvensis*, five types with *S. pumila* (Table 2).

In 2004 the early spring annuals *Avena fatua* and *Salsola australis* were part of the subdominants in the communities with *S. pumila*, where they occupied about 0.1–0.8% of the area.

Thus, in spring wheat crops in the wet and cool 2003 the largest area was occupied by the communities: *Lactuca tatarica* + *Convolvulus arvensis* (35–44%), *Lactuca tatarica* + *Euphorbia virgata* (12–18%), *Setaria pumila* + *Convolvulus arvensis* (10–13%). In the drier year 2004, with a damp April *Lactuca tatarica* + *Setaria pumila* + *Fallopia. convolvulus* occupied 47–65%. In 2003, weed communities with predominance of annual weeds were absent, communities with a predominance of perennial and annual weeds occupied 20% of the area in experiments with disk sowing and 13% with stubble sowing. Communities with a predominance of perennial weeds only, occupied 80% and 87% of the area respectively. In 2004, communities with a predominance of perennial weeds were absent. Only annual weeds occupied 4% in experiments with conventional tillage and 37% with minimum tillage. Communities with a predominance of perennial and annual weeds occupied 95% and 61% of the area respectively.

Effect of agrotechnical methods and weeds on the productivity and on the baking quality of grain of spring wheat

The most important parameters defining the yield of wheat are number of productive tillers per plant and per m^2, grain number and weight per spike, thousand grain weight, which depend primarily on the biological characteristics of cultivars, weather conditions and agrotechnical methods of crop cultivation.

In the wet and cool 2003 the number of productive tillers per plant was 1.3-1.4 times higher compared to more arid 2004. In experiments with stubble sowing this was increased 1.1 times compared to disk sowing. Perennial weeds reduced this parameter significantly more than annuals (Table 4). The number of productive tillers per plant was least in communities of *C. setosum* (1.4-1.5 tillers per plant).

Table 4
Effect of weeds, tillage system and sowing on components of yield, grain gluten and protein concentration in spring wheat crops

Components	Year, tillage system, sowing		Dominant weed species						Mean	LSD (0.05)
			Euphorbia virgata	*Lactuca tatarica*	*Cirsium setosum*	*Sonchus arvensis*	*Linaria vulgaris*	*Setaria glauca*		
1	2	3	4	5	6	7	8	9	10	11
Number of productive tillers per plant	2003, conventional tillage	disk seeding	1.8	1.9	1.5	1.9	–	1.9	1.8	0.1
		stubble seeding	1.9	1.9	–	2.1	1.9	2.3	2.0	0.1
	2004, stubble seeding	conventional tillage	–	1.3	–	–	–	1.5	1.4	0.1
		minimum tillage	–	1.3	1.4	1.4	–	1.5	1.4	0.1
Number of productive tillers per m^2	2003, conventional tillage	disk seeding	339.7	351.7	252.5	280	–	358.0	316.4	48.5
		stubble seeding	321.0	295.6	–	293	255.0	254.0	283.7	26.4
	2004, stubble seeding	conventional tillage	–	164.5	–	–	–	158.5	161.5	4.2
		minimum tillage	–	164.0	129.0	152	–	157.5	150.6	12.4
Spike length (cm)	2003, conventional tillage	disk seeding	5.4	5.0	6.2	5.5	–	5.7	5.6	0.8
		stubble seeding	5.0	5.6	–	5.5	5.8	5.6	5.5	0.4
	2004, stubble seeding	conventional tillage	–	5.8	–	–	–	5.8	5.8	0.05
		minimum tillage	–	5.2	5.1	5.2	–	5.4	5.2	0.1
Grain number per spike	2003, conventional tillage	disk seeding	13.7	12.5	17.2	16.6	–	15.5	15.1	3.4
		stubble seeding	13.9	14.1	–	14.4	14.5	14.7	14.3	0.6
	2004, stubble seeding	conventional tillage	–	15.4	–	–	–	16.6	16.0	0.8
		minimum tillage	–	14.4	13.9	13.9	–	14.4	14.2	0.4
Grain weight per spike (g)	2003, conventional tillage	disk seeding	0.41	0.37	0.52	0.51	–	0.55	0.47	0.11
		stubble seeding	0.51	0.53	–	0.55	0.55	0.54	0.54	0.05
	2004, stubble seeding	conventional tillage	–	0.46	–	–	–	0.50	0.48	0.15
		minimum tillage	–	0.43	0.40	0.38	–	0.43	0.41	0.04
Thousand grain weight (g)	2003, conventional tillage	disk seeding	29.7	30.0	30.1	30.7	–	35.7	31.2	3.2
		stubble seeding	36.7	37.4	–	38.6	38.1	37.3	37.6	1.4
	2004, stubble seeding	conventional tillage	–	29.6	–	–	–	29.9	29.8	0.4
		minimum tillage	–	30.0	29.9	27.4	–	29.8	29.3	1.3

Table 4
(Continued)

1	2	3	4	5	6	7	8	9	10	11
Grain yield (c · ha^{-1}) at 15% moisture	2003, conventional tillage	disk seeding	15.8	13.3	13.1	14.3	–	19.7	15.2	2.8
		stubble seeding	16.4	15.1	–	15.1	14.1	18.5	15.8	1.9
	2004, stubble seeding	conventional tillage	–	7.6	–	–	–	7.9	7.8	0.2
		minimum tillage	–	7.2	5.4	5.8	–	6.8	6.3	1.4
Grain gluten concentration on a dry basis. %	2003, conventional tillage	disk seeding	22.1	22.1	21.2	22.6	–	23.8	22.4	2.1
		stubble seeding	23.7	23.3	–	23.2	23.1	24.9	23.6	1.5
	2004, stubble seeding	conventional tillage	–	28.4	–	–	–	30.3	29.4	1.4
		minimum tillage	–	28.7	27.2	28.3	–	29.6	28.5	1.9
Grain protein concentration on a dry basis. %	2003, conventional tillage	disk seeding	12.9	12.7	12.8	12.3	–	13.9	12.9	1.1
		stubble seeding	12.3	12.7	–	13.2	12.5	13.8	12.9	1.2
	2004, stubble seeding	conventional tillage	–	13.9	–	–	–	14.5	14.2	0.5

The number of productive tillers per m^2 depends on field germination, survival of plants in the seedling stage, productive tillers per plant, their survival to the stages of tillering and heading. In 2003, number of productive tillers per m^2 was on average 1.9 times higher than in 2004, while in experiments with disk seeding it was increased 1.1 times compared to stubble. The number of productive tillers per m^{-2} was least in communities of *C. setosum* (252.5±3.5 in 2003 and 129.0±5.4 in 2004).

The grain number per spike in 2003 and 2004 differed slightly, but grain weight per spike in the wet and cool 2003 was significantly higher than in 2004. Conventional tillage contributed to an increase of these parameters compared to minimum tillage. The lowest level of these parameters was in communities of *E. virgata* and *L. tatarica* in 2003 and in communities of *C. setosum* and *S. arvensis* in 2004.

In 2003 the mean 1000 grain weights were 1.2 times greater than in 2004. Methods of seeding and tillage had a negligible effect on weight of 1000 grains. One thousand grain weight of spring wheat was least in the communities of *E. virgata*.

Grain yield of spring wheat incorporates all other parameters of its productivity. It was the highest in the wet and cool 2003, with conventional tillage and disk seeding. In 2003 the yield was on average 2.2 times higher than in 2004. In experiments with conventional tillage it was 1.2 times more than with minimum tillage. Sowing method had a negligible impact on yield. The highest values of grain yield were observed in weed communities with *S. pumila* (19.7±1.4 c ha^{-1} in 2003 and 8.0±0.6 in 2004) and lowest with *C. setosum* (13.0±0.4 c · ha^{-1} in 2003 and 5.4±0.4 in 2004). In 2003 in the communities of *L. tatarica* grain yield was in experiments with disk seeding 13.3±2.8, stubble sowing 15.1±0.5 c ha^{-1}. In 2004 in experiments with conventional tillage it was 7.6±1.4, minimum tillage 7.2±0.4 c ha^{-1}.

In the drier 2004 the baking quality of grain was better than in the wet and cool 2003, when the gluten content was reduced to 1.2–1.3, and protein was 1.1 times lower. Gluten content slightly increased in experiments with stubble sowing and conventional tillage. Gluten and protein content was highest in communities with *S. pumila*, significantly decreasing in communities of perennial weeds, especially *L. vulgaris* and *C. setosum*.

Discussion

Spatial heterogeneity of natural conditions is typical in the most agricultural fields (Cook and Bramley, 1998; Robert, 2002). First of all, this heterogeneity is manifested in the spatial distribution of weed communities (Auld and Tisdell, 1988; Cardina et al., 1997; Rew and Cousens, 2001). The spatial pattern of weeds in conventional systems is widely accepted. Understanding spatial pattern of weed communities is necessary for precision weed management. Weed communities are good indicators of soil properties (pH, soil bulk density, macroporosity, microporosity, total porosity, aeration capacity of soil matrix, soil water content, field capacity, content of clay, P, K, Mg, Mn (Andreasen et al., 1991; Walter et al., 2002; Schaffrath et al., 2015). Significant reduction in the amount of herbicide can be achieved when the spatial variability of weeds is taken into account (Garibay et al., 2001). The spatial variability of weed distribution can affect crop yield at the field scale (Colvin et al., 1997; Taylor et al., 2003).

In our experiments the meteorological conditions of the year had more strong impact on the number and composition of weed communities than tillage system and methods of sowing. In the wet and cool 2003 there were 25 and in the drier 2004 thirteen types of weed communities. The total number of weed communities for two years was 37 types. In 2003 there were 20 types of weed communities in experiments with disk seeding and 18 with stubble sowing. In 2004 eight types of weed communities were in experiments with conventional tillage and 12 with minimum tillage. In 2003 Sorensen's similarity coefficient for the weed communities in experiments with disk and stubble sowing was 0.68 and in 2004 in experiments with conventional and minimum tillage 0.70. Sorensen's similarity coefficient for the weed communities in 2003 and 2004 was 0.05, where only one weed community was presented in all experiments in 2003 and 2004 (*Lactuca tatarica* + *Setaria pumila*). In 2003 the number of weed communities with one dominant was in experiments with disk sowing 20.0, stubble 5.6%, with two dominants and subdominants 25.0 and 38.9%, three 50.0 and 50.0%, four 5.0 and 5.5% respectively. In 2004 weed communities with one dominant were absent. The number of weed communities with two dominants and subdominants was in experiments with conventional tillage 25.0, minimum tillage 16.7%, three 25.0 and 50.0, four 50.0 and 33.3% respectively. The number of dominant and subdominants in weed communities was an average of 2.2–2.4 in 2003 and 3.2–3.3 in 2004.

In dry steppe of Western Kazakhstan herbaceous perennial weeds having vegetative propagules with well-developed horizontal roots bearing overwintering adventitious buds and forming extensive clonal colonies are the most stable component of weed communities in spring wheat crops. Among them communities with *Lactuca tatarica* were dominated in 2003 and 2004. The number of weed communities with dominance of *L. tatarica* was 55–67% in 2003 and 35–50% in 2004. The area occupied by the communities *L. tatarica* in crops of spring wheat was 67–84 and 54–88% respectively.

In spring wheat crops, depending on weather conditions, primarily rainfall in March and April are also developing the spring annual weeds. Among them communities with *Setaria pumila* were dominated in 2004. The number of weed communities with dominance of *S. pumila* was 5–17% in 2003 and 37–50% in 2004. They occupied 5–10 and up to 39% of the crops area respectively.

The highest of air-dry aboveground phytomass was in *C. setosum* and *L. tatarica* in 2004 in experiment with minimum tillage and stubble sowing (213.0±24.3 and 118.6±17.4 g m^{-2} respectively), *S. arvensis* in 2003 in experiments with conventional tillage and stubble sowing (127.5±25.6 g m^{-2}) and *S. pumila* in 2004 in experiments with conventional tillage and stubble sowing (72.1±8.4 g m^{-2}).

Perennial weeds reduced parameters of spring wheat productivity more than annuals. In communities with a dominance of thistle grain yield was 32–34% lower than in communities with foxtail. Main parameter reduction of grain yield was the reduction in the number of productive tillers (per m^2).

Gluten and protein content significantly decreasing in communities of perennial weeds, especially *L. vulgaris* and *C. setosum,* was highest in communities with annual *S. pumila*.

Thus, weed communities are an important factor in the production of spring wheat and need to be managed by the application of its spatial mapping.

Conclusions

In organic farming one of the major factors affecting the production of spring wheat is weeds. There is the need for studies the spatial distribution, number and present productivity data of weed communities and their effect on the productivity of spring wheat depending on meteorological conditions, tillage system and sowing. Mapping of weed communities is recommended to carry out in the heading stage of wheat.

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