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EFFECTS OF DIFFERENT GROUND SURFACE ON RYE HABIT AND YIELD

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A b s t r a c t. Rye was sown in pots embedded into the ground, in non-competitive conditions. Plots differed only with kinds of ground surfaces (grass, bare soil) which affected the spectral composition of reflected sunlight. Plants growing on the ground covered with grass received more radiation in the range of far red (reflected by green tissues) than plants growing on bare soil. The plants from both plots reacted differently to the environmental conditions by creating different habits.

During most of the experiment, main shoots of rye growing in the neighbourhood of grass had been much taller than those of rye growing on the bare soil; its internodes were longer and its heads heavier, and heads had more grains. The plants from the neighbourhood of bare soil had greater mass of 1000 grains, heavier mass of straw, and a higher amount of culms and heads.

Also, varied development of the plants was observed in the compared plots. The plants growing in grass grew faster. The course of tillering also varied. After the emergence, more shoots appeared in the plot neighbouring with grass. In spring, more shoots appeared on the bare soil.

K e y w o r d s: rye, bare soil, grass, plants' habit

INTRODUCTION

The architecture of a canopy is shaped by the environmental conditions modified by agrotechnical factors. Competing for water, soil nutrients, and solar radiation results in a varied habit of plants of the same species and makes it dependant upon the conditions in which the plants grow.

One of the factors differentiating plants' appearance is the spectral composition of sunlight. Living plants are capable of transmission [2,3] and reflection of radiation [2] which is characterized with predominant far red (approximately 730 nm) over red (approx. 660 nm) absorbed by chlorophyll [11].

In natural solar radiation, the value of the ratio of far red to red is close to one. In a canopy, the ratio may be increased up to 10:1 [5,18] because green leaves absorb far red on a small scale, and also significant amounts of this range of spectrum, received by plants, are reflected by the neighbouring plants [8]. Spectral compositions of radiation reflected by bare soil and by grass vary. The essential difference is shown in the ratio of far red to red (725 nm to 660 nm). The ratio of radiation reflected by grass is several times higher than the ratio of radiation reflected by bare soil [8].

Phytochrome is a photoreceptor receiving information about a spectral composition of radiation reaching the plants. Photoreversible phytochrome mechanism controls many life processes of plants, from germination to shedding [14].

Photomorphogenic effects of far red on plants were first noticed in the course of elongation growth [10,14-16], and then with reference to tillering [4,6,13]. Photomorphogenic effects of neighbouring plants on the habit and growth of plants have been shown for many plants [1,7,8,12,13,17].

The aim of the experiments conducted on rye was to present differences in the growth and habit of rye growing under non-competitive conditions and on two different grounds: grass and bare soil.

METHODS

Rye (cultivar Motto) was sown on September 13, 1993. Six grains were sown in each plastic tube (later called 'pots') with a 20 cm inside diameter and 40 cm long, filled with soil of good fertility (heavy loamy silty sand, pH=7.0). The pots were embedded into the ground, 9 pots on each of two sites: bare soil and grass. After the emergence, 3 plants were left in each pot. Two plants 'dropped off' on the bare soil in winter. Rates of appearance of succeeding leaves were measured in a pot by means of a mean value in Haun's scale [9].

The soil was watered according to needs, and it was prevented from drying up. The lawn was mown systematically. The grass was kept not higher than 5-8 cm.

Differences between objects were determined by means of t-test and non-parametric tests (of signs, ranks). The differences were regarded as significant if they were confirmed by all tests.

RESULTS

Growth. The beginning of emergence and occurrence of the second leaf were observed simultaneously on both plots. Differences were observed in the course of appearance of the third till the sixth leaves. Statistically significant differences were noticed beginning on the 20th day from the emergence, namely in the third-leaf phase. They were still present in the course of appearance of the succeeding leaves. Differences occurred earlier by one day in the pots situated on the lawn. The leaves stopped appearing earlier by 16 days on the plot neighbouring the grass (Table 1, Fig. 1).

Differences in the occurrence rate of the following phases were up to 3 days: tillering, shooting, and heading. In the case of blooming, the

Table 1. Development stage of plant rye cv. Motto

No.	Phases	Bare soil	Grass
1	Beginning of emergence	Sept. 18	Sept. 18
2	Beginning of second leaf	Sept. 23	Sept. 23
3	Beginning of third leaf	Sept. 28	Sept. 27
4	Beginning of fourth leaf	Oct. 6	Oct. 6
5	Beginning of fifth leaf	Oct. 12	Oct. 11
6	Beginning of sixth leaf	Oct. 19	Oct. 18
	abundance	Oct. 26	Oct. 21
	finish	Nov. 10	Oct. 25
7	Beginning of tillering	Oct. 2	Sept. 29
	abundance	Oct. 7	Oct. 5
	finish (autumn 1993)	Oct. 8	Oct. 6
	finish (summer 1994)	July 27	June 27
8	Beginning of shooting	April 28	April 25
9	Beginning of heading	May 14	May 11
	abundance	May 16	May 12
	finish	May 17	May 13
10	Beginning of flowering	May 30	May 26
	abundance	May 31	May 27
	finish	June 4	May 29

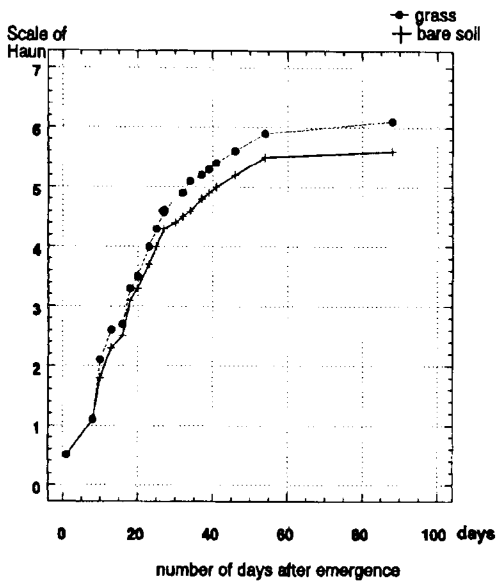

Fig. 1. Rate of rye growth (cultivar Motto) occ. to Haun's scale.

differences were even up to 4 days. The mentioned phases occurred sooner in the case of the plants surrounded with grass (Table 1).

Tillering. From the beginning of the tillering phase, i.e., for the whole autumn (about 100 days from the beginning of the emergences), the plants growing in the neighbourhood

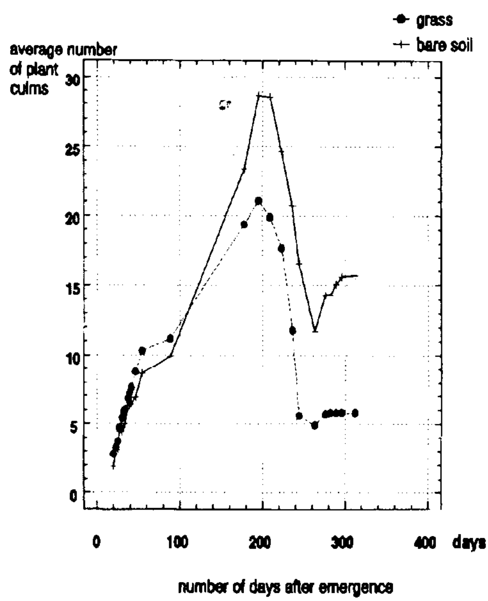

Fig. 2. Course of rye tillering.

of grass had more shoots (Fig. 2). In spring (March 15th), a high number of shoots on the plants growing on bare soil was noticed for the first time; from April 1st (on the 195th day after the emergences) to the end of the experiment, differences in numbers of shoots between both objects were statistically significant. Tendencies to the appearance of shoots were similar in both objects. The number of culms was increasing to April 1st, then it started decreasing because of drying to June 8th. Finally the number of culms increased again, particularly in the plot neighbouring with bare soil. However, the phase ended as much as in varied times. In the neighbourhood of grass, the phase ended one month earlier (Table 2).

Heading. A distinct increase of the number of heads occurred between the 16th and the 20th of May, i.e., between the 5th and the 9th days of the phase (Fig. 3). At first, there were more heads in the plot with grass, but after 9 days there were twice as many heads on the plants growing on bare soil (Table 2). The number of heads in the plot with grass did not change in the course of the experiment, whereas the number of heads in the plot with bare soil slowly increased up to the 55th day of the phase.

Flowering. The process of flowering had lasted for four days in the plot with grass and it ended on May 29th. The plants growing on bare soil had not started this phase at that time yet (Fig.4). The first flowering plant on bare soil appeared on May 30th, and the phase in this object lasted 5 days longer than on the object with grass.

Process of appearing of undergrown shoots. Undergrown shoots appeared sooner on bare soil than in grass. This phase had lasted for about 50 days in the plot with bare soil (Fig. 5). In the grass plot, the process of appearing of undergrown shoots had lasted for about 30 days. Beginning on the 27th day of the phase, statistically significant differences occurred between numbers of undergrown shoots in both plots. By the end of the experiment, seven times higher number of undergrown shoots was observed on bare soil.

Table 2. Character of single shoot of rye, cv. Motto

Character	Main shoots		Stunted stems	
	bare soil	grass	bare soil	grass
Length of first internode (cm)	2.4	4.2	1.6	2.8
Length of second internode (cm)	6.7	10.0	4.7	5.6
Length of third internode (cm)	12.7	15.8	11.1	12.3
Length of fourth internode (cm)	24.0	30.5	18.7	23.5
Length of fifth internode (cm)	40.9	44.6	25.9	30.6
Length of sixth internode (cm)	45.1	41.8	30.3	15.8
Height to base of spike (cm)	116.8	122.4	51.3	59.9
Number of internodes	5.6	5.4	4.6	4.9
Number of shoots	9.3	4.9	6.4	0.9
Number of spikes	9.3	4.9	5.7	0.9
Number of spikelets in spike	35.0	36.3	17.4	16.9
Length of spike (cm)	11.6	9.9	6.4	5.8
Number of grain in spike	44.3	53.9	1.2	13.9
Mass of grain in spike (g)	2.01	2.24	0.02	0.32
Mass 1000 grains (g)	45.5	41.6	4.2	24.0
Mass of culm (without grain)	4.46	4.01	1.07	0.90
Total mass of shoot (g)	6.47	6.26	1.10	1.22

[shaded] statistical differences significant on 0.05 level.

Height of the plants. A statistically significant difference between height of the plants was measured with the length of the tallest culm and it occurred within the first 20 days from shooting. Higher plants grew in the neighbourhood of grass. In the course of the experiment, differences between heights diminished (Fig. 6).

More distinct differences occurred between height of plants when length of single shoots were compared (Table 2). Internodes, from the first one to the fifth one, of the main shoot growing in the grass neighbourhood were longer, whereas the sixth internode was shorter.

Heads. Heads of the plants in both plots significantly differed in lengths. The plants growing on bare soil had longer heads. Heads of the plants surrounded with grass had more grains (Table 2). Taking into consideration a total yield of a plant, it can be noticed that rye growing on bare soil had a higher total number of grains (Table 3).

A mass of a single head of a plant growing in grass was heavier than that of a plant growing on bare soil (Table 2). A mass of grains of whole plants was heavier in the plot with bare soil (Table 3). A mass of 1000 grains was heavier only in the case of single heads of the plants growing on bare soil (Table 2). Such a difference was not noticed in the case of whole plants from both object together with undergrown shoots.

Table 3. Comparison of mass and number of grains of singular plant of rye cv. Motto

No.	Character	Main shoots	
		bare soil	grass
1	Mass of grain (g)	18.62	10.97
2	Number of grains	411.1	263.6
3	Mass of 1000 grains (g)	45.1	41.3

[shaded] significant statistical differences on 0.05 level.

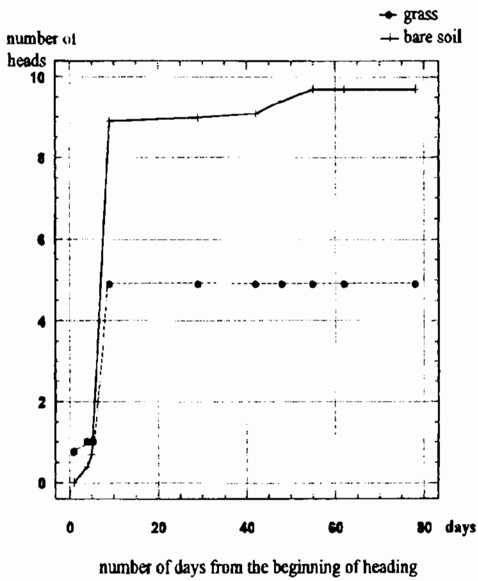

Fig. 3. Rate of rye heads emergence.

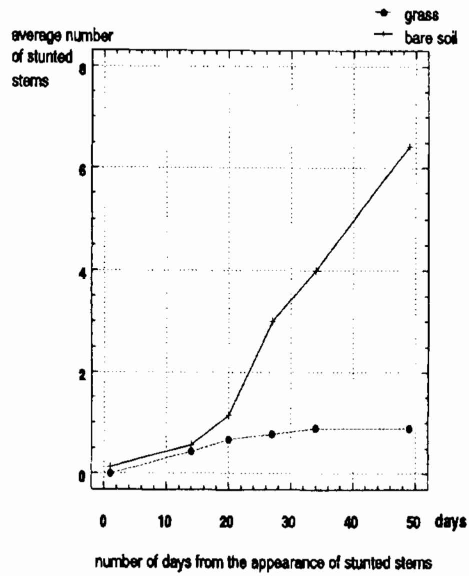

Fig. 5. Rate of appearance of rye undergrown shoots.

Mass. Mass of main shoot of rye (without grains) growing on bare soil were much heavier than shoots of rye surrounded with grass (Table 2). No differences between total masses of shoots (straw + grains) were noticed.

Undergrown shoots. Differences between appearances of undergrown shoots of the plants growing in grass and on bare soil were similar to those of main shoots of rye. Undeveloped shoots of plants growing in grass had longer internodes (except the sixth one) than those of the plants growing on bare soil. In the majority of cases, however, these differences could not be proved at a confidence level of 0.05.

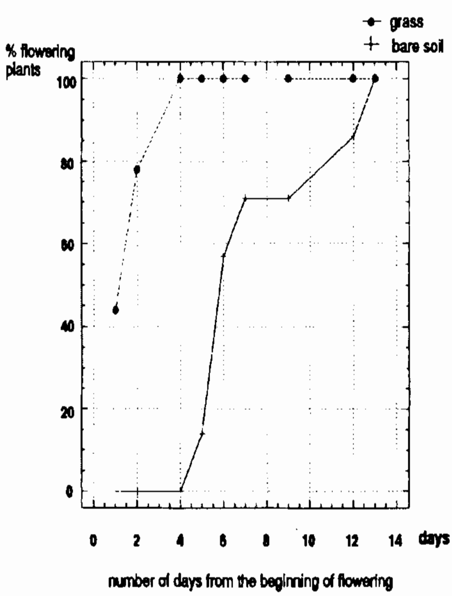

Fig. 4. Course of rye tillering.

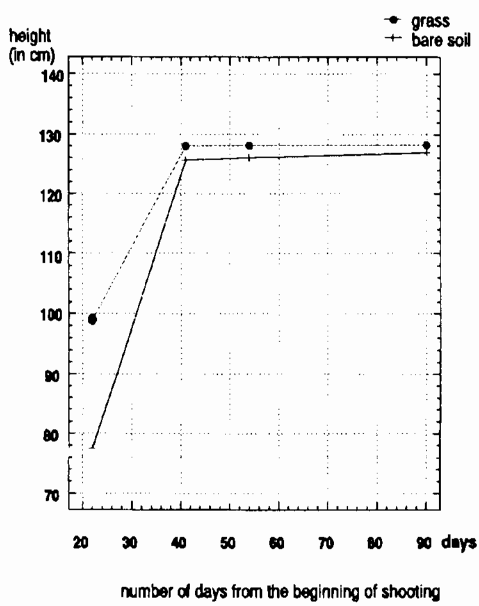

Fig. 6. Mean height of the highest rye caulm (to the spike base).

Significant differences in length of internodes between both objects occurred only in the case of the first internode. The plants growing in grass had longer internodes. The investigated objects significantly differed in numbers of undergrown culms and heads. The plants growing on bare soil had a higher number of culms and heads. Undergrown shoots of the plants growing in grass had more grains of a heavier mass in a head, and a mass of 1000 grains was heavier as well (Table 2).

DISCUSSION

At the beginning of the growth of rye (when the third leaf appeared), the plants growing in the neighbourhood of grass and of bare soil developed at the same rate. Differences appeared in the succeeding phases of growth. In the object with grass (which creates the potential competition), the growth of rye sped up and the succession of the development stages was faster by one to several days. From the appearance of the third leaf, the plants began reacting to the neighbourhood of grass by consistent shortening of the development phases, compared to the plants growing on bare soil. The reason for that process was probably a 'want' to reach a stage of generative development as soon as possible, in other words to fructify sooner than the rival plants. Similar results regarding a faster rate of the growth of the plants surrounded by grass, compared to the plants growing on bare soil, were observed in an experiment with buckwheat [7]. It can be assumed on the basis of the earlier measurements [8] that the spectral composition of the reflected solar radiation was a factor differentiating the plants from both investigated objects.

Apart from the consequences connected with the growth, also different spectral conditions of the radiation reflected by bare soil and grass resulted in a differentiated habit of plants in the particular objects. In the phase of shooting, the plants neighbouring grass were taller and had longer internodes (except the sixth one) than the plants growing on bare soil. Also, the plants surrounded with grass looked like etiolated plants growing in a canopy.

A higher contribution of far red in the radiation reflected by the grass surface also resulted in a decreased tillering. A possibility of unpropitious conditions resulted in a tillering limited to four - five shoots. Accordingly, the plants surrounded with grass became similar to plants growing in a thick canopy. The plants growing on bare soil were able to form twice as many shoots because their tillering was not limited and they had no competitors. It should be stressed that the observed changes in the plants' habits were not results of a competition but of a prior preparation for it. This phenomenon ought to be explained in terms of the existence of a stimulus being a higher contribution of far red which signals the possibility of competition. Accordingly, 'seeing' the neighbouring plants as possible rivals for photosynthetically active radiation, the plants aimed to overgrow their neighbours. The pieces of information received about the environment are transmitted through a phytochrome which regulates many metabolic processes [14,19]. The metabolic processes affect a proper plant's habit and help the plant to deal with the rival. Results achieved for spring wheat [8] and for rye growing in similar environmental conditions indicate significant consistences in tillering, numbers of heads, and in lengths of shoots. However, photomorphogenic reactions of rye are more distinct than these of wheat.

The plants growing in grass formed fewer shoots and their heads had grains of light masses, however, they had more grains than plants on bare soil. Self-sowing of grains of the plants surrounded with grass was easier. This increased a probability of bearing and survival of seedlings. The plants growing in grass made up for a lower number of shoots with a higher number of grains. Accordingly, they still had high possibilities of preserving the species. The described differences in the achieved generative yield also indicate that the plants growing in grass increased their yield to a maximum according to expected conditions which limited their full growth.

CONCLUSIONS

1. Rye surrounded with grass had a higher rate of development. The phases of the third-to-sixth-leaf, beginning with tillering, shooting, heading and with flowering succeeded faster by 1-4 days in the plot with grass than on bare soil.

2. The rye shoots neighbouring grass were at the stage of shooting higher. They had longer internodes (except the sixth one) and longer heads. Their heads were heavier and had a higher number of grains than heads of rye growing on bare soil. However, the heads of rye growing on bare soil had a heavier mass of 1000 grains.

3. The plants growing on bare soil had more shoots and a higher number of heads. The mass of straw was heavier as well.

4. A varied composition of radiation reflected by grass and bare soil resulted in differences between the rye's habits.

5. The changes observed in a habit of rye growing in the neighbourhood of grass had not occurred as a result of a competition, but they were caused by prior preparation to it.

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WPŁYW RODZAJU POWIERZCHNI GRUNTU NA POKRÓJ I PLONOWANIE ŻYTA

Żyto wysiewano w wazonach wkopanych w grunt, w warunkach niekonkurencyjnych, w których obiekty różniły się tylko rodzajem powierzchni gruntu (trawa, ugór), co miało wpływ na skład spektralny napromienienia odbitego. Rośliny rosnące na powierzchni pokrytej trawą otrzymywały znacznie więcej promieniowania w zakresie dalekiej czerwieni (z odbicia od zielonych tkanek) niż rośliny rosnące na czarnym ugorze, zatem rośliny w obu obiektach zareagowały niejednakowo na otaczające warunki, tworzą odmienny pokrój.

Pędy główne żyta rosnącego w sąsiedztwie trawy były przez większy czas trwania doświadczenia znacznie

wyższe, miały dłuższe międzywęźla i cięższe kłosy, te zaś miały większą liczbę ziarn niż pędy żyta rosnącego na ugorze. Natomiast większą masę 1000 ziarn posiadały kłosy żyta rosnącego na ugorze. Rośliny te posiadały także większą masę słomy, większą ilość źdźbeł i kłosów.

W porównywanych obiektach obserwowano również zróżnicowany przebieg rozwoju roślin. Znacznie szbysze tempo rozwoju wykazywały rośliny rosnące w trawie. Odmienny byl również przebieg krzewienia. Po wschodach więcej pędów przybywalo w obiekcie z sąsiedztwem trawy, na wiosnę więcej wystąpiło ich w obiekcie z ugorem.

Słowa kluczowe: żyto, ugór, trawa, pokrój roślin.