

Soil Tillage System and Precrops Influence on Spring Wheat Flag Leaf Area and Grain Quality Indicators

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Abstract—Spring wheat (*Triticum aestivum* L.) is the most widely grown spring cereal in Latvia. The aim of the research was to determine soil tillage system and precrops influence of spring wheat flag leaf area and grain yield quality indicators. Field trials were carried out at the Research and Study farm “Peterlauki” study site “Poki” (56°30.658’ N and 23°41.580’ E) of the Latvia University of Life Sciences and Technologies (LBTU) at year 2024. Spring wheat ‘Berlock’ was grown with two soil tillage systems (conventional and minimal soil tillage) and three different precrops (winter wheat, winter oilseed and spring oilseed rape). The flag leaf area (cm²) has been analyzed by using scanner STD4800 and specialized computer software WinFOLIA. The determination of the yield components, grain yield (t ha⁻¹) and straw yield (t ha⁻¹) was made by sample sheaf analysis. Grain quality indicators: crude protein content; starch content; gluten content and Zeleny index, thousand grain weight were determined in Grain and seed study and research laboratory at LBTU. Significant differences (p<0.05) between soil tillage systems were found in flag leaf area and length. A strong positive correlation was observed between grain yield and flag leaf area r=0.854 for conventional and r=0.958 for minimal soil tillage system. Sample sheaf analysis showed significant differences in spike mass and grain weight. Among grain quality indicators, gluten content differed significantly and significant differences were associated with the precrops (p<0.05). It

should be noted that in the 2024 growing season, July saw increased precipitations at the trial site.

Keywords—Grain quality, soil tillage, spring wheat, WinFOLIA.

I. INTRODUCTION

Wheat (*Triticum* spp.) belongs to the family of the Gramineae (*Poaceae*) and is the main agricultural commodity produced in Latvia in terms of number of farms, cultivated area [1], [2], [3] and one of the most important cereal crops worldwide [4], [5], [6], [7], [8], [9], [10]. Spring wheat crops in Latvia are harvested on average every year 22% of the total cereal area [11]. The climatic conditions in the Nordic-Baltic region facilitate the cultivation of both types of spring wheat and winter wheat. Notably, most of the harvested area in the Baltic countries is dedicated to winter wheat, with only about 20% of the area allocated to spring wheat cultivation. Given that a significant portion of spring wheat production in the Baltic countries and Norway is earmarked for breadmaking [12]. Wheat-based food products are staple in the diets of a large part of the world population. In 2020, 776 million tons of wheat were produced worldwide. Globally, around 20% of both the total daily energy and protein intake is accounted for by wheat-based products, making wheat rather irreplaceable in the human diet and a major contributor to food security [4], fodder and industrial purposes [8]. Whole-grain wheat is a nutritionally important source of

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dietary fibers, minerals, vitamins and bioactive phytochemicals [4]. It is rich in nutrients such as starch and protein, making it one of the primary sources of food for humans. Given its significance in fulfilling the basic dietary needs of people worldwide, ensuring the quality of wheat products is of paramount importance [5]. Scientific literature [13] mentions that wheat straw majorly remains unutilized and is often burned to clear the farming land, resulting in greenhouse gas emissions and adversely affecting soil fertility. Instead, this renewable and carbohydrate-rich wheat straw can be efficaciously utilized for second-generation bioethanol production. However, scientists have proven that wheat straw is mainly composed of 27–40% cellulose, 22–25% hemicellulose, and 15–25% lignin. A research group from Estonian Crop Research Institute [14] reported that high yields are one of the essential parameters in wheat farming. Farmers aim to increase yields by selecting the most suitable cultivars and soil tillage systems. By a group of researchers from Latvia [15] accepted that different minimum soil tillage practices are becoming more and more popular as the minimum soil tillage has several advantages compared to the traditional soil tillage system: lower costs, time savings, etc. Rotational cropping is an important and effective agricultural management practice that significantly contributes to crop yields, plant health, and soil structure [16]. Scientists [17] have proven in their research that the inclusion of pulses in crop sequences can ameliorate environmental impacts of cereal-based agricultural production systems by increasing soil carbon stocks, increasing N use efficiency and reducing incidence of pests. Additionally, scientists [16] have reported that crop rotation and systematic cultivation of diverse crops in a predetermined sequence within the same field over time, is one of the traditional agricultural practices that offers substantial benefits to the soil ecosystem, greatly contributing to plant growth. According to the research of many scientists [6], [7], [8], [18] weather conditions and temperature during the growing season is one of the main environmental factors affecting the growth, development and yield of plants. In turn grain yield in cereal crops is due to complex physiological and biochemical processes but is essentially associated with the carbohydrate accumulation process of grain filling, which in turn is attributed to leaf functionalities [10]. In turn an interesting conclusion has been discovered by researchers [19] that flag leaves, as the ‘functional leaves’ in wheat production, are the primary photosynthetic organ contributing 45–58% of photosynthetic performance during the grain-filling stage. Morphological traits related to flag leaves are determinant traits influencing plant architecture and yield potential in wheat [10]. Additionally, scientists [7], [9] have reported the flag leaf is the main component of the canopy in the middle and late growth stages of wheat and is an important organ that determines the grain-filling rate and the final yield. Thus, the leaf morphological traits variation can play an essential role for plants coping with environmental changes, and is strongly correlated with changes in temperature, precipitation, radiation, and soil nutrients [20]. The aim of the research was to determine soil tillage

system and precrops influence of spring wheat flag leaf area and grain yield quality indicators.

II. MATERIALS AND METHODS

Field investigation were carried out at the Study and Research farm ‘Peterlauki’ study site ‘Poki’ (56°30.658’ N and 23°41.580’ E) of Latvia University of Life Sciences and Technologies during season 2024. The two-factorial trial with three precrops (winter wheat (W-W), winter oilseed (WB-N) and spring oilseed rape (SB-N)) and two tillage systems: conventional soil tillage system (CT) with ploughing at a depth to 25 cm and minimal soil tillage system (MT) with soil disc harrowing at a depth to 10 cm. The spring wheat ‘Berlock’ sowing at 16 May with Horsch Pronto 4DC a rate of 550 germinable seeds per m².

Plant material. Spring wheat (*Triticum aestivum* L.) variety ‘Berlock’ (Sweden) was used in this experiment. The variety is medium-early, characterized by a very high yield potential, with high and good grain quality. Baltic trials, the yield can reach up to 9 t ha⁻¹[21].

The spring wheat flag leaves were taken in each field places at 10 replications according to the principle of randomization (BBCH 44). Spring wheat basic indicators of flag leaf length, width (cm) and area (cm²) were analyzed by using scanner STD4800 and specialized computer software WinFOLIA (Fig. 1. A).

Sample sheaf’s for spring wheat were taken at 3 locations randomly selected in each replication from a 0.125 m² area. The grain yield (t ha⁻¹) for spring wheat was calculated by an indirect method: calculation from sample sheaf analysis. Yield was recalculated in t ha⁻¹ at 14% moisture and 100% purity. Straw yield and wheat structural elements were calculated from a sample sheaf too (Fig. 1. B).

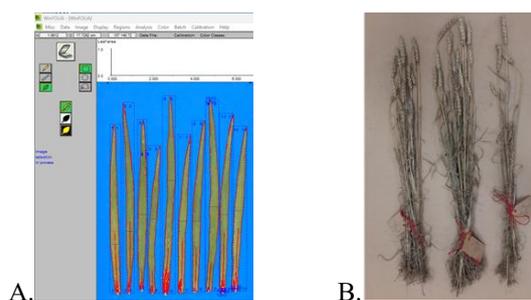


Fig. 1. Spring wheat flags leaves placed in the scanner (A) and sample sheaf (B).

Grain quality indicators: crude protein content (CP, %); starch content (SC, %); gluten content (GC, %) and Zeleny index (ZI, %) was measured using Near Infrared Spectroscopy (NIRS) method (analyzer InfracTM NOVA (FOSS, Hillerød Denmark)) at the Latvia University of Life Sciences and Technologies in Grain and Seeds research laboratory. It is a whole grain analyser for testing multiple parameters by use of near-infrared transmittance technology. The thousand grain weight (TGW, g) was determined following the ISO 520:2010 standard.

Meteorological conditions were variable in the research year. Average day and night temperature from May till August was 17.1 °C in 2024 (Table 1 shows period from May 1 till August 31). The sum of precipitation in the research year was 68.2 mm, which is a total of 0.1 mm less (long-term observations).

TABLE 1. WEATHER CONDITIONS DURING THE FIELD INVESTIGATION

Month	Temperature, °C		Precipitation, mm	
	2024	Long-term observations	2024	Long-term observations
May	14.4	11.4	28.5	50.4
June	17.0	15.2	54.2	70.1
July	19.0	17.8	131.4	75.7
August	18.1	16.9	58.6	76.8
On average	17.1	15.3	68.2	68.3

Meteorological conditions according to Latvian Environment, Geology and Meteorology data.

Although the total precipitation seemed sufficient, spring wheat experienced drought stress in May (Table 1). The lack of rainfall and soil drought prevented the crop from fully benefiting from favourable temperature conditions, leading to a decrease in yield. Conversely, in July, excessive precipitation (131.4 mm) caused noticeable stress on the plants.

For data mathematical processing dispersion and correlation analysis were used. The significance of difference in results has been assessed at level of 95% using p-value which determined with Anova: Single factor.

III. RESULTS AND DISCUSSION

Morphological traits related to flag leaves are determinant traits influencing plant architecture and yield potential in wheat [10]. WinFOLIA specialised computer software provides precise measurements of various leaf morphological parameters [22]. The results of our studies (Table 2) demonstrated that the area ($p=0.48$), length ($p=0.45$) and width ($p=0.35$) of the flag leaf of the studied spring wheat were not significantly ($p>0.05$) depending on precrops. In turn our research results showed that the soil tillage system (MT and CT) had a significant ($p<0.05$) impact on wheat flag leaf area and flag leaf length ($p=0.04$). Still, flag leaf width was not significantly different between the soil tillage systems ($p=0.10$) (see Table 2). The results confirm, that the flag leaf area in the conventional soil tillage system was, on average 5.1 cm² larger than in the minimal soil tillage system. Additionally, the flag leaf length in the conventional soil tillage system was on average 4.5 cm longer than in the minimal soil tillage system. Our data indicate that there was no significant difference ($p>0.05$) between yield and straw yield of spring wheat between the tillage systems and precrops (Table 2). Furthermore, researchers from the Institute of Plant Physiology and Genetics, National Academy of Sciences of Ukraine [7], reported that estimated yield losses in major wheat-producing countries due to drought stress range from

10 to 50%. In turn an interesting conclusion has been discovered by researchers from Latvia [11], their study concluded that the yield of spring wheat depends on the interaction of several factors: soil fertility, meteorological conditions, as well as the agricultural machinery used. If any of the factors change, crop yield changes. A study by Latvian scientists [11] observed significant differences in yields in different regions, which is similar to our study. Nowadays, not only yield amount but also yield quality is important. Latvian researcher's studies [23] suggest that the cultivar is the first criterion determining specific grain quality parameters, as well as environmental and management conditions. High yields are one of the essential parameters in wheat farming. Farmers aim to increase yields by selecting the most suitable cultivar or adjusting various agricultural techniques [14].

TABLE 2. SPRING WHEAT PARAMETERS OF FLAG LEAF, YIELD AND STRAW YIELD

Factors	Flag leaf area, cm ² $p=0.48$	Flag leaf length, cm $p=0.45$	Flag leaf width, cm $p=0.35$	Yield, t ha ⁻¹ $p=0.06$	Straw yield, t ha ⁻¹ $p=0.10$
Precrops/Soil tillage system					
SB-N	13.5	20.0	0.7	2.95	4.28
W-W	9.2	16.3	0.6	1.60	1.83
SB-N	12.2	18.8	0.7	3.16	4.17
W-W	6.4	13.7	0.5	1.04	1.46
MT	10.3*	17.2*	0.6	2.19	2.94
Precrops/Soil tillage system					
WB-N	17.2	22.8	0.8	2.32	3.72
W-W	13.7	20.3	0.7	2.10	2.93
WB-N	17.1	24.1	0.7	2.74	3.61
W-W	13.4	19.5	0.7	1.76	2.82
CT	15.4*	21.7*	0.7	2.23	3.27
MT/CT	$p=0.04*$	$p=0.04*$	$p=0.10$	$p=0.94$	$p=0.69$

SB-N spring oilseed rape, W-W winter wheat, WB-N winter oilseed rape, MT – minimal soil tillage system; CT – conventional soil tillage system; *significant at $p<0.05$.

In the trial year was a strong positive correlation between spring wheat grain yield and flag leaf area ($r=0.854$) for conventional soil tillage and ($r=0.958$) for minimal soil tillage system. Similar results have been obtained in other studies conducted in Latvian conditions in winter wheat trials, where it was determined that the larger the flag leaf area, the higher the grain yield [24], [25].

Cereal grain yield is mainly determined by spike (ear) number, grains per m² or grain weight, while changes in grains m² are primarily associated with spike number [26]. Data statistical analysis confirmed that soil tillage system was no significant difference between grain quality indicators: spikes, pcs.; spikes mass, kg; grain weight, kg;

straw mass, kg; GC, %; SC, %; ZI, %; CP, % and TGW, g. In turn, in the trial year, a significant influence of the precrops were observed on spike mass ($p=0.02$), grain weight ($p=0.03$), and GC ($p=0.04$) (Table 3). On average, significantly higher spikes mass and grain weight was if precrops SB-N at MT system and WB-N at CT system, but GC, % content if precrops W-W in both soil tillage systems. Gluten plays an important role in dough formation and affects dough stability and bread loaf volume [27]. In the present study results show that the content of starch content was 56.3–57.0%, soil tillage did not significantly affect ($p>0.05$) the SC in grain. Our data indicate that there was no significant difference

($p>0.05$) in the ZI (57.0–57.6%) (Table 3) of spring wheat between the tillage system. Protein content shows grain suitability for processing. Researchers [11], reported spring wheat ZI ranging from 62.4 to 79.3%, respectively, which are higher than the results of our study. Protein content from 12–13% is suitable for bread making, but grain with higher protein content is used for lower quality grain improver [28]. CP content was 15.1% significant differences were observed based on soil tillage system ($p=0.94$) and precrops ($p=0.33$) (Table 3).

TABLE 3. SPRING WHEAT STRUCTURAL ELEMENTS OF THE SAMPLE SHEAF M^{-2} AND GRAIN QUALITY INDICATORS DEPENDING ON PRECROP AND SOIL TILLAGE SYSTEM

Factors	Spikes, pcs. $p=0.07$	Spikes mass, kg $p=0.02^*$	Grain weight, kg $p=0.03^*$	Straw mass, kg $p=0.06$	GC, % $p=0.04^*$	SC, % $p=0.40$	ZI, % $p=0.05$	CP, % $p=0.33$	TGW, g $p=0.29$
<i>Precrops/Soil tillage system</i>									
SB-N	627	0.50	1.06	0.51	36.3*	57.4	54.9	14.6	23.6
W-W	333	0.26	0.57	0.22	39.1	56.6	59.0	15.7	24.0
SB-N	650	0.59	1.30	0.57	36.6	57.4	55.3	14.6	24.3
W-W	217	0.13*	0.29*	0.14	39.1	56.6	59.0	15.7	24.0
MT	457	0.37	0.80	0.36	37.8	57.0	57.0	15.1	23.9
<i>Precrops/Soil tillage system</i>									
WB-N	547	0.50	1.01	0.54	37.9	56.3	56.6	15.4	21.2
W-W	393	0.46	1.02	0.47	38.6	56.6	57.1	15.2	26.7
WB-N	517	0.62*	1.37*	0.60	37.3	57.1	56.1	14.9	26.5
W-W	403	0.24	0.53	0.28	39.6*	56.5	60.5	15.2	21.9
CT	465	0.46	0.98	0.47	38.3	56.3	57.6	15.1	24.0
MT/CT	$p=0.94$	$p=0.54$	$p=0.56$	$p=0.41$	$p=0.55$	$p=0.24$	$p=0.74$	$p=0.94$	$p=0.95$

Grain quality indicators: gluten content (GC, %), starch content (SC, %), Zeleny index (ZI, %), crude protein content (CP, %), thousand grain weight (TGW, g), *significant at $p<0.05$.

But in another study [11], it was similar data, where the CP content was from 15.5 to 17.3%. On the other hand, scientists from Poland [29] reported that more protein content of wheat grains sown in the plow system (average 13.5%), which are lower than the results of our study. Mathematical processing of the data showed that soil tillage system and precrops did not significantly ($p>0.05$) affect TGW. Data from our trial show that the average TGW depending on the tillage system was 23.9–24.0 g, which was lower than those of [11] in the study 46.7–48.9 and 34.1–34.3 g at researcher years.

IV. CONCLUSIONS

The results of our study demonstrated that the soil tillage system had a significant ($p<0.05$) impact on flag leaf area and length. The flag leaf area was on average 5.1 cm^2 larger and the length was 4.5 cm longer in the conventional soil tillage system compared to the minimal tillage system. In the evaluation of the correlation between spring wheat grain yield and flag leaf area, a statistically significant a strong positive correlation was obtained with ($r=0.854$) under conventional soil tillage and ($r=0.958$) under minimal soil tillage system. In contrast, the area, length, and width of the flag leaf in the studied spring wheat were

not significantly ($p>0.05$) affected by the precrops. Our data indicate that there were not significant differences ($p>0.05$) in the grain yield and straw yield of spring wheat between the different tillage systems and precrops. The significant influence of the precrops were observed on spike mass ($p=0.02$), grain weight ($p=0.03$), and GC ($p=0.04$). The analysis of grain quality indicators revealed that significant differences were observed in the gluten content ($p=0.04$). All significant differences were found between the precrops ($p<0.05$), not between soil tillage systems ($p>0.05$). Overall, spring wheat showed higher flag leaf and grain quality indicators in the traditional tillage system. It should be noted that the indicators obtained during the trial, were also influenced by the meteorological conditions, as the trial site was affected by flooding in the month of July. To adapt to climate change and minimize yield losses, farmers should select crop varieties that can withstand adverse weather, ensuring stable grain yields even under less favourable conditions.

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