Instytut Uprawy
Nawożenia i Gleboznawstwa
Państwowy Instytut Badawczy

HR EXCELLENCE IN RESEARCH

AUTOREFERAT

for scientific outputs and achievements

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1. Name and Surname

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2. Diplomas and academic degrees - with the name, place and year of obtaining them and the title of the doctoral dissertation

Master of Science, Agricultural University of Krakow, Faculty of Agriculture, 1987. Diploma thesis "The impact of the use of NPK mineral fertilizers on the occurrence of toxinogenic fungi" made at the Department of Agricultural Microbiology. Work carried out under the direction of Dr. Małgorzata Czachor.
Doktor nauk rolniczych w zakresie agronomii,
Doctor of agricultural sciences in the field of agronomy, Institute of Soil Science and Plant Cultivation in Puławy, Department of Systems and Economics of Crop Production, 1996. Dissertation entitled "Influence of seven agrotechnical factors on the yield of winter wheat : half-replicate experiments".
promoter: Prof. dr hab. Jan Kuś
reviewers: Prof. dr hab. Leszek Malicki
Prof. dr hab. Franciszek Rudnicki

3. Information on previous employment in scientific units

- 1989-1996, Assistant, Department of Crop Rotations, Institute for Soil Science and Plant Cultivation in Puławy;
- 1996 – 2008, Assistant Professor, Department of Systems and Economics of Crop Production, Institute of Soil Science and Plant Cultivation in Puławy;
- 2009-2013, Head of Department of Systems and Economics of Crop Production, Institute of Soil Science and Plant Cultivation in Puławy;
- 2014 – now Assistant Professor, Department of Systems and Economics of Crop Production, Institute of Soil Science and Plant Cultivation – State Research Institute in Puławy.

4. Indication of achievements resulting from art. 16 sec. 2 of the Act of 14 March 2003 on academic degrees and academic title, and on degrees and title in the field of art (Journal of Laws of 2003 No. 65, item 595, as amended)

a) Title of scientific achievement

The achievement that is the basis for applying for the postdoctoral degree is a series of twelve publications under the unified title:

Title of scientific achievement:

"Production and quality of winter wheat under organic farming system conditions"

b) List of original publications constituting a scientific achievement

As a basis for scientific achievement, a cycle of twelve monothematic original scientific publications was selected, whose total Impact Factor according to the year of publication is 2.543, and the number of points according to the list of the Ministry of Science and Higher Education (MNiSW) is 136 (according to the year of publication).

I.2.1. **Jończyk K. (90%)**, Kawalec A. 2001. Wstępna ocena przydatności wybranych odmian pszenicy ozimej do uprawy w różnych systemach produkcji roślinnej. Biul. IHAR, 220: 35-43.

I.2.2**. Jończyk K.** 2002. Reakcja wybranych odmian pszenicy ozimej na uprawę w różnych systemach produkcji roślinnej. Pam. Puł., 130/I: 339-346.

I.2.3. **Jończyk K.(80%),** Stalenga J. 2016: Yielding of new quality varieties of winter wheat cultivated in organic. Journal of Research and Application in Agricultural Engineering, 61(3): 200-205.

I.2.4. Kuś J., **Jończyk K.(30%),** Stalenga J., Feledyn-Szewczyk B., Mróz A. 2010. Plonowanie wybranych odmian pszenicy ozimej w uprawie ekologicznej i konwencjonalnej. Journal of Research and Application in Agricultural Engineering, vol. 55 (3): 219-223.

I.2.5. Feledyn-Szewczyk B., **Jończyk K.(40%),** Stalenga J. 2018: Assessment of the usefulness of new winter wheat varieties (*Triticum aestivum* L.) for cultivation in organic farming. Journal of Research and Application in Agricultural Engineering, vol. 63 (2): 43-49.

I.2.6. **Jończyk K.(80%),** Solarska E. 2004. Zdrowotność pszenicy ozimej uprawianej w ekologicznym i konwencjonalnym systemie produkcji roślinnej. Progress in Plant Protection, Vol.44, Nr 2: 772-775.

I.2.7. Kuś J**., Jończyk K.(40%),** Kawalec A. 2007. Czynniki ograniczające plonowanie pszenicy ozimej w różnych systemach gospodarowania. Acta Agrophysica, 10(2): 407-417.

I.2.8. Kuś J., Mróz A., **Jończyk K.(30%),** 2006. Nasilenie chorób grzybowych wybranych odmian pszenicy ozimej w uprawie ekologicznej. Journal of Research and Applications in Agricultural Engineering, Poznań, Vol.51 (2): 8 – 93.

I.2.9. Feledyn-Szewczyk B., **Jończyk K. (40%),** Berbeć A. 2013.The morphological features and canopy parameters as factors affecting the competition between winter wheat varieties and weeds. J. Plant Protection Research, vol. 53, No 3: 203-209.

I.2.10. Cacak – Pietrzak G., Ceglińska A., **Jończyk K.(40%).** 2014. Wartość wypiekowa mąki z ziarna odmian pszenicy uprawianych w ekologicznym systemie produkcji. Zesz. Prob. Nauk Roln., nr 576: 23-32.

I.2.11. Zuchowski J., **Jonczyk K.(30%),** Pecio L., and Oleszek W. 2011. Phenolic acid concentrations in organically and conventionally cultivated spring and winter wheat. J. Sci. Food Agric., 2011, 91: 1089-1095.

I.2.12. Kowalska I., Jędrejek D., **Jończyk K. (20%),** Stochmal A. UPLC–PDA–ESI–MS analysis and TLC–DPPH activity of wheat varieties. Acta Chromatographica, DOI: 10.1556/1326.2017.00416.

Regardless of the above list, the list and copies of the monothematic series of publications constituting a scientific achievement are included in **Appendix 4**. The co-authors' statements describing the contribution of each of them to the creation of these publications, including my contribution to the creation of these works, are included in **Appendix 5**. The above-mentioned works included in habilitation achievements are discussed below (point 4c) in accordance with the numbering assigned to them **[I.2.1. - I.2.12.]**. The supplementary literature quoted in the text was placed at the end of the scientific achievement.

c) Discussion of the scientific purpose of the articles enlisted above and achieved results with discussion their possible use

Production and quality of winter wheat under organic farming system conditions"

Introduction

Modern agriculture is under intense transformation related to the search for manners / management systems consistent with the idea of sustainable development, guaranteeing the implementation of economic and environmental goals. In modern agriculture, three management systems are most often distinguished (their synonyms in brackets):

without production certification (conventional, intensive, industrialized, etc.);

with production certification

a) organic (ecological, biological, biological - organic, etc.);

b) integrated (harmonious, balanced, sustainable, etc.).

The criterion for distinguishing these systems is the degree of dependence on industrial means of production and the possibility of realizing the assumptions of sustainable development. Each of the distinguished systems is characterized by a different hierarchy of goals and different production process methods. The conventional system of production is most popular farming system. It is based on the use of intensive production technologies. As a result of intense farming, disturbing phenomena began to appear with varying intensity, such as: degradation of the natural environment, overproduction of food, decrease of consumer confidence in food products produced by intensive production methods [7,9,20,41]. Consequently, in recent years more and more attention has been paid to the development of more sustainable farming systems, including organic and integrated farming systems [14,18,26,33,41].

On the 1st of January 2009 Council Regulation EC 834/2007 of 28 June 2007 [5] came into force. It states that: " Organic production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of certain consumers for products produced using natural substances and processes. The organic production method thus plays a dual societal role, where it on the one hand provides for a specific market responding to a consumer demand for organic products, and on the other hand delivers public goods contributing to the protection of the environment and animal welfare, as well as to rural development."

In recent years, dynamic development of organic farming has been observed in Poland and in the world. In 2017, organic arable lands amounted to over 69.8 million ha globally (1.4% of total UAA in the world), and in Europe to 14.6 million ha (2.9% of total UAA in Europe). At present, in Poland, there are over 20,000 of farms with certified organic production. They manage around 495 thousands of hectares of land, which constitutes to 3.4% of the total area of arable land in the Poland and positions Poland (according to this criterion) above the European average [30,31]. The organic market data indicate that polish organic market is one of the fastest growing in the world and Europe. It can be expected that support mechanisms focused on the development of organic farming under the Common Agricultural Policy of the EU, the subsidy system implemented under the Rural Development Plan and the demand for organic farming products will result in a further increase in the number of organic farms and the organic products market in Poland [14]. In order to sustain the development of organic farming, it is necessary to support it by research aimed at both improving the methods and organization of production, as well as shaping the quality of products and processing.

Numerous reports and meta-analyzes regarding the comparison of organic and conventional production systems indicate crop yield achieved in organic farming is lower than in conventional farming system. The authors emphasize at the same time that the differences in yields depend to a large extent on organizational factors (optimal crop rotation, plant selection), the use of innovative agro-technical methods and habitat conditions. Smaller differences, up to 5%, are obtained when comparing species with lower agrotechnical requirements and production in poorer habitat conditions. Yields lower by 15% are recorded in the conditions of using best practices in organic farming, and the biggest differences up to 34% occur when compared production systems are similarly managed [29,31]

Cereals are main crops of farms, regardless of the region of cultivation and the way of farming. It is because of its versatile use on the farm and ease of cultivation, Common wheat (*Triticum aestivum ssp.vulgare*) is one of the most important cereal species grown on organic farms in Poland and in the world. The importance of wheat in crop production is determined by such features as: the possibility of cultivation in different climatic zones, high yielding potential, chemical composition of the grain and technological properties enabling extensive use as food, feed and industrial crop. [6,16].

The analysis of the market for organic products also indicates that organic cereal are leading in the structure of food consumption and processing [30]. Cereals are of great importance also in organic farms as they have high share in the crop structure (about 40%) and they can be used in many ways in production and processing of organic products.

Research on the quality of organic products and their evaluation and importance in human nutrition (content of allergenic, antioxidant compounds) is of great importance for organic farms.[1,2,3,10]. In conventional agriculture the use of various forms of fertilizers, divided nitrogen doses adapted to the state of the field and the needs of the plant, there is a wide spectrum of possible impact to direct the quality of yield to meet the needs of specific industrial use of grains (eg production of bread, pastries and pasta, making feed etc). In organic production, the impact on the qualitative characteristics of grain is limited. The quality of grains is made mostly by selection of the appropriate variety of cereals, forecrops, agrotechnics aimed at reducing the pests risk (use of high quality seed, mechanical care treatments, care for cleanliness and grain storage conditions).

Research on organic farming are complicated, as there are many methodological issues. In classical agricultural research, the analytical approach prevails, ie the individual elements and phenomena are analyzed separately and then a synthesis is created which creates a comprehensive solution (eg production technology). In ecological farming, however, individual phenomena cannot be analyzed separately, because the organic farm work as a “whole organism” and observed phenomena cannot be divided and analyzed in the form of individual components. In this situation, there are two ways of solving this problem. In the first one, groups of farms conducted in accordance with the assumptions of the compared farming systems are subjected to analysis. The factors hindering the analysis of the results are: varied soil culture, greater variability of habitat conditions, farmer's personality, etc. Therefore, this methodology is most often used for comparative economic and organizational analyzes, in which a larger number of farms are included. IUNG conducted such research in 1992-1995, comparing groups of organic and traditional farms in the Podlasie province [19].

Detailed environmental research is most often carried out on special experiments of the area of several or even more hectares. The experimental fields are divided into parts, each of which is run according to the rules of the given system. It is assumed that each of the separated parts of the field creates a kind of experimental farm. The most known experimental facilities run in this way are: Nagele (Holland), Lautenbach, Reinshof and Marienstein (Germany), Long Ashton (England), Foulum

(Denmark), Logarden (Sweden) and Burgrain (Switzerland). A similar experimental object was established in 1994 at the IUNG-PIB Experimental Station in Osiny.

Description of the research task

The research issue which is described in the selected work cycle, concerns the issues of productivity and quality of winter wheat cultivated in an organic farming system. The inspiration for undertaking this field of research was the growing interest on the organic production as well as a number of scientific challenges related to this farming system, including:

- long-term assessment of the productivity of winter wheat in the organic farming system and its comparison with other farming systems;
- identification of yield limiting factors;
- elaboration of criteria for the varieties selection and methods for improving wheat agrotechnology as crop of high agrotechnical requirements and of great importance in the commodity production of organic farms.

An important element of research is the quality assessment of winter wheat grain that go beyond the standard qualitative analysis of cereal grain (protein content, gluten, falling number, sedimentation index). An additional element influencing the research was the possibility of using a research facility, which enables comprehensive assessment of the organic farming system, but also conducting comparative analyzes with other management methods used in other farming systems.

Research hypotheses, which were formulated in the studies described in the cycle of discussed works, say that in the ecological management system wheat yields are smaller and are characterized by greater variability in years than in in all variants of conventional faring system (intense, integrated and monoculture). By selecting varieties, yield losses in organic production can be reduced and s grain quality can be modified.

The main objective of the research was to assess the yield of winter wheat cultivated in the organic farming (production) system and compare its efficiency and quality to that obtained in other farming (production) systems (conventional, integrated, monoculture). Assessment of the occurrence and severity of factors that determine its productivity to the greatest extent was also assessed.

Main research issues (specific objectives):

- **Evaluation of winter wheat yield in the organic production system with consideration / division into research issues::**
    - **winter wheat yield and the varieties suitability for cultivation in organic production conditions;;**
    - **ocurrence and intensity of factors limiting the yield of winter wheat in the organic production system (occurrence and severity of fungal diseases, weed infestation, nutritional status of plants)**

- **Quality assessment of flour and the content of secondary metabolites in the grain and vegetative parts of wheat grown in the organic farming system.**

Research on the yielding of winter wheat in the organic farming system was carried out over a dozen years. In the discussed studies, the latest wheat varieties belonging to the group of qualitative varieties (E - elite, A - qualitative, B - bread) were used. The cultivars selected for the tests were morphological differentiated, characterized by high productivity in the Post-registration Variety Experimentation system and additionally showed greater resistance to fungal pathogens and higher frost resistance.

In organic production the yielding level of crops is determined by other factors than in conventional farming system, and the importance of particular elements of agrotechnics requires different valuation. Organic production, in which synthetic fertilizers and plant protection products are forbidden, crop rotation and selection of the varieties are the key yielding factors.

Average yields of cereals in organic farms in Poland are very low, depending on the species, they range from 1.5 to 3 t / ha. This indicates a completely extensive way of growing this group of plants and not utilizing the production potential of cereals. The results presented in the discussed cycle indicate the possibility of obtaining higher yields. One of the basic elements of cereal agrotechnology insufficiently used in the practice of organic farms is the selection of the right variety. [8,13,21]. Another important reason for carryind presented research on the selection of varieties for cultivation in organic farms is limited access to seed material in organic quality. So far, mainly due to the small area of cultivation, there is no special plant breeding for organic farming. The commercial offer for organic seeds is negligible and does not guarantee the selection of the appropriate variety (list of available seed material, web page of the Main Inspectorate of Plant Health and Seed Inspection, www.piorin.gov.pl). In this situation, organic farms use common seeds of selected varieties that are in the general offer of breeding companies and enlisted in the national register. It should also be emphasized that the current research conducted by COBORU and recommendations of breeding companies **did not take into account the assessment of varieties in the conditions of organic production**, which hinders the proper selection and increases the risk of cultivation.

Research conditions and research infrastructure

The research described in the selected cycle of publications relate to long-test studies conducted mainly in the experimental facility located in the experimental station of the Institute of Soil Science and Plant Cultivation - PIB in Osiny, lubelskie province (geographical position - latitude 51^{O} 28', longitude 22^{O} 04', height – 155 m above sea level). According to the physiographic characteristics, it was located in the mesoregion - Wysoczyzna Lubartowska, a macroregion - Nizina Południowopodlaska by. J. Kondracki is a wasted-up undulating moraine plain [17].

Part of the research on organic farming impact on varieties was conducted on organic farms located in different regions of the country: Chwałowice, mazowieckie province- CDR

Brwinów-Radom farm, Chomentowo, podlaskie province - individual organic farm (publications **I.2.3; I.2.5; I.2.9**).

The IUNG - PIB Osiny experimental facility has a total area of 16 ha. It is divided into parts representing various production systems. The location of experimental fields allows to conduct observations and tests in the same habitat conditions, limiting the impact of variability associated with soil and meteorological conditions. An important element of the research is durability of experimental facility which has been established in 1984. This fact means that apart from the location's value in comparable habitat conditions, the research was conducted in conditions with constant mathematical assumptions concerning the functioning of various production systems. This element is particularly important in experiments conducted in accordance with the principles of organic farming. The layout and assumptions concerning the experimental facility are unique on a national scale and refer to the assumptions and methodology of research on production systems in other scientific centers. [11, 25, 29]. Experimental fields are located on podzolic soil with a mechanical composition of strong loamy sand. The size of each field (with single crop) is 1 ha, which allows the use of agrotechnics similar to production fields. The experiment is carried out with all crops of crop rotation cultivated annually, which makes it possible to obtain full information from individual field and crops. The factors differentiating the compared systems are: crop rotations and associated intercrops and soil tillage techniques, organic fertilization, mineral fertilization, plant protection against weeds, diseases and pests mechanical harrowing, etc. Winter wheat is “the center” of the experiment, its cultivated in each variant of the production system as it is the main test plant enabling comparative analyzes. The general description of winter wheat production and agriculture systems is given below:

I. Organic system (EKO) *crop rotation:*

- **potato[xx] - spring barley (since 2005 spring wheat) + undersown intercrop - papilionaceous (red and white clover with grass 1st year - red and white clover with grass 2nd year - winter wheat + intercrop**.

The use of synthetic mineral fertilizers, pesticides or growth regulators is forbidden in this system. Organic fertilization includes the use of compost once in rotation (for potatoes) of 25-30 t / ha and catch crop plowed into soil (a mixture of legumes and grass). Weed control consists of intensive mechanical harrowing and additional hand weeding in potatoes.

II. integrated system (INT) – extensive conventional, crop rotation:

- **potato[xx] - spring barley (since 2005 spring wheat) + intercrop - horse bean - winter wheat + intercrop**

In this system, industrial means of production are used in moderate amounts. Nitrogen fertilization is 30-40% lower than in the conventional system, nitrogen doses are adjusted based on the determination of mineral N in the soil during spring vegetation. The protection treatments are performed depending on the severity of the pests. Organic fertilization includes: 25-30 t / ha compost for potatoes, horse bean straw plowed into soil and intercrops (catch crops) plowed into soil.

III. Conventional intensive system in two variants:

Intensive (KON) – crop rotation:

- **oilseed rape - winter wheat - spring barley (from 2005, spring wheat).**

Management in this system is based on intensive managemet technologies recommended by IUNG, they are characterized by high consumption of industrial means of production. Organic fertilization is limited to plowing oilseed rape straw and winter wheat straw into the soil.

- **Monoculture of winter wheat (MONO).**

An object that is an extreme example of simplification in the way of management. Intensive production technology is applied, aimed at limiting the adverse impact of continuous wheat cultivation. Organic fertilization is limited to plowing straw into the soil (annually).

A detailed description of the applied research methodology and agrotechnical procedures used in individual production systems in the field of winter wheat is included in the attached publications.

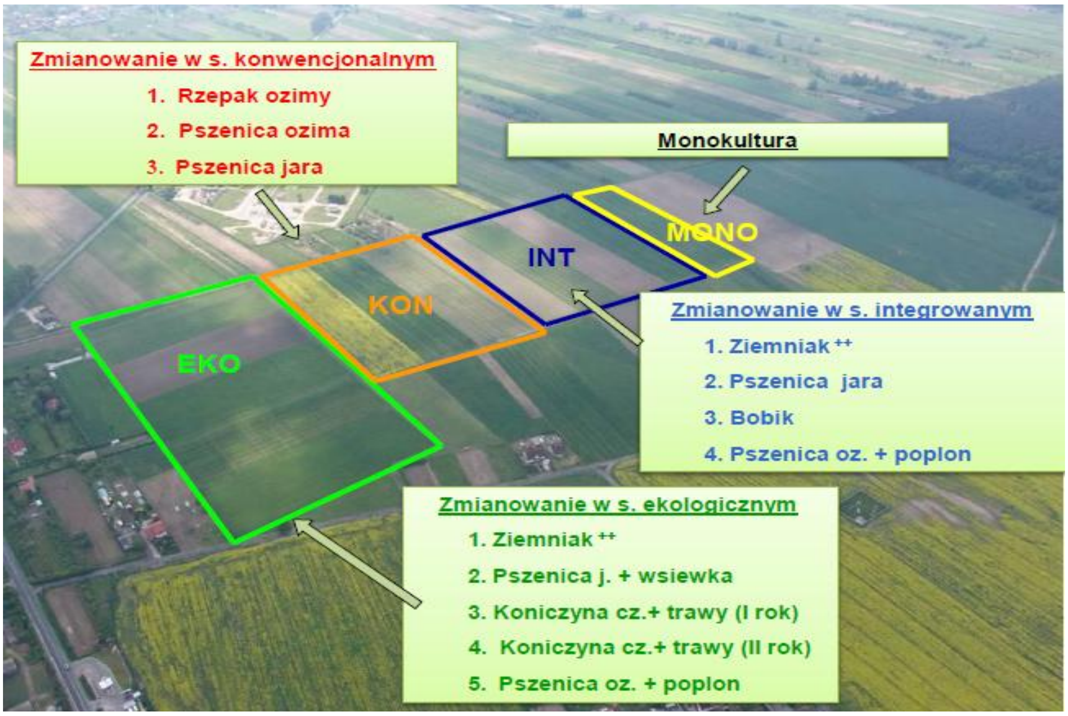

Fig. 2. Osiny Experimental facility with fields of different production systems

Table 1. Selected elements of agricultural practice of winter wheat in different crop production systems

Specification	Crop production system			
	integrated	conventional	monoculture	**organic**
Crop rotation	Z^{++}- J.j./Pj - B - **P.o.** *	Rz. - **P.o.** - J.j. /Pj *	**P.o.**	Z^{++}- J.j. /Pj - K.c. - K.c .- **P.o.** *
Seed dressing	+	+	+	-
Fertilization NPK kg/ha	105+25+60	150+32+75	160+32+75	-
Herbicides	1x	1 lub 2 x	2 lub 3 x	-
Fungicides	1 lub 2 x	2 x	2 x	-
The growth regulator	+/-	+	+	-
Harrowing	1 x	1 x	1x	**2 lub 3x**

*/ Z –potato, J.j. –spring barley, B –faba bean, P.o.- winter wheat, Rz. –winter rape, K.c. –red clover with grass

Yields of winter wheat varieties and their suitability for cultivation in organic farming system conditions.

Publications: I.2.1, I.2.2, I.2.3, I.2.4, I.2.5.

In the first period (1998-2000), the research was conducted with 4 winter wheat varieties: Kobra, Roma, Juma, Elena. The aim of the research was to assess yielding potential of selected varieties in different farming system conditions and to indicate the characteristics that determine their productivity. The varieties for research were selected on a basis of differentiation of morphological features of disease susceptibility, quality traits and previous results obtained in COBORU studies. Winter wheat yields in the organic farming system, regardless of the variety, amounted to 3.93 t * ha-1 and they were lower by 39% than in the integrated system, by 35% than in the conventional system and by 16% than in the monoculture. Additionally, it was found that the yields obtained under the conditions of organic production were characterized by the highest variability in years (V = 24%) and this value was comparable to that obtained for wheat cultivated in monoculture. The high variability of wheat crops cultivated in an organic system resulted from large fluctuations of spike density and grain weight, in the monoculture the variability resulted mostly from variable grain. Intensive wheat cultivation in the conventional system in a simplified 3-crop rotation and integrated in the Norfolki-type rotation resulted in limited variability of yields in the years - 16% and 14% respectively. The assessment of the yields of varieties showed that under the conditions of organic farming system Kobra and Roma varieties had the largest and the most stable yields - on average 4.16 t * ha-1 (from 3 years). The feature that determined their greater productivity was the ability to produce, compared to the other tested varieties, grains with a higher weight of 1000 grains (Cobra 38.6 g, Roma 42.2 g).

Wheat cultivated under organic farming conditions had lower value of the leaf cover ratio (LAI), which was lower by about 1-1.5 than in the other systems, additionally, a more erectile setting of leaves was noted. This resulted from better penetration of light due to a lower density of both shoots and spikes, and a higher intensity of pathogens that infested the leaves. Among the tested varieties, Roma had the highest LAI index, this was due to the density and height of the varieties' canopy and greater resistance of the Roma variety to brown rust infection. Also other authors underlined these characteristics of varieties as the most useful in organic production[8, 21, 22].

The analysis of the canopy was also carried out to assess the suitability of varieties to organic farming system conditions. It was found that organic winter wheat was heigher by about 10-12 cm when compared to the integrated and monoculture systems. Tested varieties also had narrower grain to straw ratio and a higher proportion of mid and low shoots. Kobra and Roma had relatively high yields in all grades of shoots (low, mid and top). Cobra had the highest share of high shoots (34%) with the lowest share of low shoots (24%). At the same time, plants of integrated system, in which the highest yields and the least variability of yields were observed, had different morphological features. A detailed analysis indicated a different morphological reaction of varieties to cultivation in different production systems. In the conditions of optimal supply of plants with nutrients and the use of plant protection treatments, the highest yielding variety was Elena, which was characterized by the lowest canopy (plant height) and the dominance of the shoots of the top level. The lower resistance of this variety to fungal pathogens infecting the leaves under conditions of effective plant protection was of less importance. Study showed that in the organic system the criteria for selection of varieties should be different than in the conventional system. The height of plants, the ability to create a grain with a high weight of 1000 grains, greater tillering ability and the crop structure that ensure high productivity of spikes from all levels (lower dominance of the main shoot) should be preferred in selection of varieties for cultivation in organic farms. The obtained results also indicate the importance of the stability of yields in the years.

In the period of 2005-2007, the research included a wider list of varieties: 6 top quality varieties from the national variety list (Roma, Zyta, Kobra, Korweta Success, Mewa), "Old varieties" whose seeds were obtained from the IHAR collection (Ostka Kazimierska, Kujawianka Więcławicka, Wysokolitewka Sztywnosłoma), spelt (*Triticum spelta*)- Swabiankorn and a mixture of varieties (Kobra + Mewa + Roma). The mixture of varieties and spelt in the study was included in the research to search for agrotechnical solutions that increase the competitiveness of wheat in relation to weeds, reduce the development and severity of fungal diseases. The incorporation of "old varieties" made possible to verify the view that organic farms, in addition to achieving the goal of increasing biodiversity and expanding the market offer, can successfully produce „old varieties" grain for market.

In the analyzed period, wheat yields were (on average for all tested varieties) from 2.41 to 4.36 t * ha^{-1} due to changing weather conditions in the years. Very low yields of "old varieties" were observed. They were lower by 36% than yields of modern varieties. The lower yield in this group of varieties was the result of a greater infestation by fungal pathogens colonizing the base of the stalk and leaves. As a result, "old varieties" formed fields of low integrity susceptible to weed infestation and had in low weight of 1000 grains in years with more severe diseases. Spelt yielded, on average for 3 years, at the level of 3.36 t * ha^{-1} (yield of husked grain), this result was about 30% higher than "old varieties" and 18% lower than modern varieties in the national register. A characteristic features of the spelt were: the highest plants and tillering ratio and high biomass ratio - features that decide about good competitiveness in relation to weeds.

A comparative analysis of the winter wheat yields in the organic and conventional system indicates that, on average, organic wheat yields were lower by 20% than in the conventional system. This also ranged in years, from 0% in very dry 2006 to 20 - 30% in other years. Roma (4.05 t * ha^{-1}) and Zyta (4.36 t * ha^{-1}) were the highest organic yielders, with yields lower by 15% than in conventional farming. In general, lower wheat yields under organic farming conditions were associated with lower spike density of about 100-150 pieces * m^{-2} and greater weight of 1000 grains in the highest yielding varieties (Roma - 43.3 g, Zyta - 43.1g).

The assessment of the occurrence and severity of fungal diseases showed stalk base diseases of modern wheat varieties occurring in the organic farming system are of little importance, whereas the leaf diseases are much more severe.

In the next stage of research (years 2014-2016), the yield of 12 varieties of winter wheat, including the first Polish spelt variety Rososz, was assessed in three organic farms located in different regions of the country. The choice of varieties was made, as in previous years, based on the preliminary criteria, including: resistance to fungal pathogens, frost resistance, qualitative features, morphological diversity. The main objective of the research was to evaluate new qualitative winter wheat varieties, specify the criteria for selecting varieties for organic farming and indicate the varieties best suited to organic production conditions. The research was located in stabilized (long-term) organic farms which which was of great importance in the context of the assumed objective and the representativeness of production conditions. Nitrogen nutritional status and biometric analysis of the tested varieties were new elements of the research. They aimed at assessing the competitiveness of the tested varieties in relation to weeds, which is important for the usefulness of varieties for cultivating in organic farming. The scope of research included: grain yield, elements of the yield structure, occurrence and severity of fungal diseases, as well as evaluation of weed infestation and nitrogen nutritional status of plants assessed using the NNI (Nitrogen Nutrient Index) test. The research results allowed to indicate varieties, which regardless of the habitat conditions, had large and stable yields in years, had greater competitiveness in relation to weeds. These were: Julius, Skagen, Sailor, Jantarka, and Smuga. The grain yield of individual varieties was within 5.5-5.7 t / ha. Their high productivity was mainly determined mass of 1000 grains, which varied from 41 to 43 g. Also the compactness of the wheat stand was greater than the average (numer of shoot and spikes per m^2). Bamberka and KWS Ozon also had higher yields, however the yield of these varieties depended to a greater extent on habitat conditions.

The analysis of the dependence of yields, biometric features and factors limiting productivity (weeds and fungal diseases) indicates that the varieties yielding above-average had higher: stand densities, height and mass of aboveground parts of plants and greater resistance to infection by pathogens damaging the leaves - mainly *Septoria* spp. and *Puccinia striiformis*. Rokosz spelt in all locations yielded at the level of the lowest yielding whaet varieties, with yield of grain of 4.96 t * ha^{-1} on average. Spellt stand was of 418 heads * ha^{-1} with a mass of 1000 grains of 38.6 g. Septoria and yellow rust susceptibility were main factors limiting the yield of spelt.

Occurrence and intensity of factors limiting the yield of winter wheat in the organic farming system;

Publications: I.2.5, I.2.6 I.2.7 I.2.8, I.2.9

Weeds, increased occurrence of fungal diseases and insufficient supply of plants with nutrients, mainly nitrogen are the basic factors limiting crop yields in organic farms [13, 36,37].

In organic farming, protection methods are primarily to prevent damage caused by pests, stimulation of production of protective substances by plants, biotechnical procedures and the development of habitat conditions suitable for beneficial organisms and the use of antagonistic interactions. The basic principle in limiting weed infestation in organic farming is creating and maintaining a balance between weeds and crop. All agrotechnical activities aim at creating the dominance of the crop over the weeds and maintaining weed population at a level below the threshold of harmfulness.

Prevalence and severity of fungal diseases. The studies described in selected publications concern the assessment of the occurrence of a set of root, leaves and spike diseases as well as weed infestation and competitiveness of varieties in relation to weeds. The research was conducted in different periods from 1997 to 2012 in the IUNG - PIB Osiny experimental facility and organic farms in various regions of the country. Long-term observations and methodological assumptions, including research conducted in diversified habitat conditions, varieties and the possibility of conducting comparative analyzes with other production systems, made possible to specify the criteria for selecting wheat varieties and indicate agrotechnical measures to reduce the risk of failure of organic cultivation. Research results were used in numerous training and information materials.

Infestation by fungal pathogens was dependent on weather conditions and the location of experiments. Long term study showed that organic farming system had significantly lower rate of infestation of root and the stem base diseases than conventional and integrated systems. The lack of chemical protection was compensated by the complex, best suited crop rotation. In addition, there was a different structure of the root and base of the stalk diseases in the compared systems. In the conditions of organic farming system, with generally lower intensity of root and base of the stalk diseases, fewer plants had symptoms of *Fusarium spp*. and more had symptoms of *Pseudocercosporella herpotrichoide* infestation.

Rizoctonia spp. symptoms in organic farming system was comparable to monoculture and integrated system, and smaller than in the conventional farming system.

Infestation of leaves by *Puccinia recondita* and *Septoria spp,* as well as worse nitrogen nutrition was the basic yield limiting factor in Organic winter wheat. *Erysiphe graminis* and *Drechslera tritici - repentis* infestation was less significant, occurring more severely only in some years and early phases of wheat development. The average index of infection of wheat leaves in the stage of milk maturity in organic farming, in years with high infectious pressure, was even 4 times higher than on objects protected by fungicides. As the effect of fungal leaf diseases the leaf area index (LAI) was reduced (in the milk-dough maturity phase was by 1 - 1.4 lower than in the conventional system). As a consequence of the greater damage to the leaves by fungal diseases, organic wheat in some years dried up 2 weeks earlier than in other systems. The reduction in the duration of photosynthetic activity of plants was the main factor that reduced grain yields. The results of the research indicate that yield losses can be partially limited by the selection of varieties. In own research, it was also found that the efficacy of certified organic plant protection products was low [15, 35]. It should be emphasized that there were no increased pest incidence (aphids, cocks, etc.) in the cereals throughout the entire study period, which can be associated with more than twice larger population of predatory insects, mostly ground beetles (*Carabidae*), compared to wheat cultivated in other systems [38].

Weed infestation. An important factor determining the usefulness of cereal varieties for cultivation in the organic system is their ability to compete with weeds for environmental components: water, nutrients and light. Wheat varieties better suited to organic production conditions should have more horizontal arrangement of leaves, greater tillering ratio, higher leaf surface, fast initial growth rate and higher plants [22,23,39]. Differences between varieties resulting from these traits determine the amount of available photosynthetic active radiation reaching the ground and affecting the development of weeds.

The results obtained in the experimental station in Osiny indicate a greater number and weight of weeds in organic winter wheat in comparison to other management systems. Depending on the period of research, the number of weeds was in organic farming system ranged from 50 to 110 pieces * m^{-2}, and the dry weight of weeds was from 14 to 150 g * m^{-2}. The greater infestation of weeds was also linked with greater biodiversity of segetal flora. The total number of species in organic farming system, depending on the research period, was 38-50% higher than in the systems in which herbicides were used. In experiments located in organic farms, the average level of weed infestation expressed in dry weed mass was comparable. Weed infestation largely depended on the conditions of winter wheat overwintering and the effectiveness of mechanical weed management using the weed harrow. The impact of varieties on weed infestation indicates a significant variation in results. Varieties of different morphological features included in the research in different periods, allowed to analyze the dependence of selected biometric features of single plants and whole plant stands and specify the criteria for selecting varieties best suited for organic farming.

Statistical analysis on weed infestation (number and dry weight of weeds) and cluster analysis (including weed parameters, selected morphological features and canopy parameters) showed that the greatest effect on weed infestation had compactness and height of the plants (canopy) and dry weight of wheat.

Nateja and Legenda were the most competitive varieties in relation to weeds among all 13 varieties included in the research in 2011-2012. These varieties were characterized by greater compactness and height of the plants (canopy), and the dry mass of plants on the surface unit. In the group of tested varieties, the least competitive against weeds were: Alcazar, Boomer and Jenga. The main feature that determined their low competitiveness was the lower height of the canopy .

In 2014-2016, 12 varieties were tested including the first registered polish spelt variety - Rososz. Julius, Sailor, Ostroga, Smuga, Skagen and spelt Rokosz showed the highest competitive ability in relation to weeds, irrespective of the location of the experiments. Distinctive features of this group of varieties, which determined their lower weed infestation, are similar to previous studies: relatively high density of wheat stand, high mass of above-ground parts of plants, height and number of shoots and more horizontal arrangement of leaves.

The results on weed infestation of wheat varieties and their yielding potential indicate that some genotypes of lower plant (canopy) height had lower ratio of yield loss (eg KWS Ozon, Muszelka, Bamberka, Banderola) under high weeds infestation conditions. This observation shows the complex nature of cereal competitiveness and weed infestation. Literature data indicate that the phenomenon of competitiveness depends on a complex features related to plant morphology and habitat conditions, and their interaction, e.g. nutrient uptake capacity, compensation phenomenon and/or allelopathic effects [22,23,40].

Nutritional status of plants. Studies on nitrogen nutrition of wheat in organic farming system indicate a worse supply of plants in N compared to the conventional system and large differentiation between varieties. Analysis of nutritional status, carried out with the NNI test in the stages BBCH 32-35 and BBCH 50-59 showed N deficit for all tested varieties and both dates. These results are convergent with those obtained in other studies in which other methods were used to assess the nutritional status (direct methods - critical interval and NNI test; and indirect methods - SPAD test) [36, 37]. The obtained results indicate that there is no dependence between the yields and the nutritional status of the tested varieties. This indicates the need to develop other critical nitrogen content measures better suited to the specifics of organic farming system conditions and other methods of assessing nitrogen nutrition state of wheat varieties.

IUNG - PIB initiated, as part of the subject of my research, the assessment of the microbiological profile of the rhizosphere of winter wheat varieties cultivated in the organic production system which will also help to solve the above issues (description in the part concerning scientific achievements).

Quality assessment of flour and the content of secondary metabolites in grain and vegetative parts of wheat cultivated in organic production system.

Publications: I.2.10, I.2.11, I.2.12

The goal of the study was to determine the impact of organic farming system on the baking value of flour from the grain of selected winter wheat varieties (**publication I.2.10)** and on the accumulation of antioxidant secondary metabolites in wheat grain and vegetative parts **(publications I.2.11; I.2.12)**. Phenolic compounds are one of the groups of secondary metabolites that are under intensive investigation. They belong to the group of antioxidants found in large quantities in cereal products. From the health-promoting point of view those are important in people's diet as they have significant preventive and healing importance in various disease entities. These compounds also fulfill a protective function in plants by counteracting pathogenic infectious agents [1,3,4,12,27,28].

The quality of wheat grain depends on genetic (varietal), habitat (soil and climate conditions) and agrotechnical (fertilization, plant protection) factors. Fertilization, especially with nitrogen, have a particularly strong influence on the quality of wheat grain. Restrictions in the use of agrotechnical treatments may adversely affect both yield and quality characteristics of the grain [5, 24]. In organic farming the use of synthetic mineral fertilizers and plant protection products is forbidden. This is why farmers have limited number of measures to influence the grain quality – this mostly is limited to choosing the right variety and providing the optimal position (forecrop) in crop rotation and best fields for its cultivation. Bearing in mind the basic function of organic production, i.e. supplying products with high nutritional value to the market, a comprehensive assessment of the suitability of organic wheat varieties for the production of bread flour. The research material included grains of Korweta, Mewa, and Ostka Strzelecka winter wheat varieties; "old varieties" of winter wheat: Kujawianka Więcławicka, Wysokolitewka Sztywnosłoma and (for comparative purposes) varieties of spring wheat: Jasna, Koksa, Zebra and "old variety" Rokicka. The grain came from experiments carried out in the years 2005 - 2007 in the experimental farm in Osiny. Indirect methods of assessment of the baking value were used: the quantity and quality of protein substances, the activity of amylolytic enzymes and rheological characteristics of the dough. The laboratory baking and the evaluation of the quality of the bread was also done.

Flours from the grain of tested winter wheat varieties were characterized by a large, as for organic farming conditions, total protein content (10.3-11.9%) and wet gluten yield (23.4-29.8%). The "old varieties" were had higher content of protein and gluten compared to the varieties being in the national register. The gluten from the flour of the majority of tested wheat varieties, with the exception of the Rokicka and Wysokolitewka Sztywnosłoma "old varieties", showed the optimal quality for baking purposes. According to the quality requirements, the flour intended for baking bread should have a Zeleny sedimentation index of not less than 25 cm^3 [5, 16]. Flours from the grain of the majority of tested wheat varieties, except for the Wysokolitewka Sztywnosłoma variety, had Zeleny sedimentation index higher than 25cm^3. Flour of most varieties had amylolytic activity in the range of 220-280 sec, which is assumed to be optimal for baking bread [16]. The rheological analysis of the dough showed a greater differentition in the examined characteristics. Flour made of Zebra grains had significantly the longest time of development and constancy and the lowest softening of dough. For this variety, the highest value of flour quality was also obtained, which is a synthetic measure of dough rheological properties. The values of the quality number of flours from winter grains were comparable and ranged from 37 to 65. The values of most quality traits of spring wheat flour were higher than winter varieties. During the organoleptic assessment, the highest number of points was awarded to bread made from Korweta winter wheat and Zebra and Koksa spring wheat flours. The lowest number of points were given to bread made from Rokicka and Wysokolitewka Sztywnosłoma"old varieties" flour. The negative evaluators' comments concerned mainly the external appearance and porosity of the bread. On the basis of the point score, Koksa, Korweta and Zebra were qualified to the first class of bread quality. Bread made from flour of other tested varieties, with the exception of the "old variety" Rokicka (III quality class), was qualified to the 2nd quality class.

The study indicates that organic farming is suitable to cultivation of wheat for the bread production, and its quality is similar to bread made of flour from conventional farms.

Other studies covering the same range of flour quality features and a wider range of wheat varieties confirm the suitability of organic grain for processing and bread production. The results showed that negative effects of lower protein content of flour, including gluten proteins, can be minimized by using a direct method in preparing the dough for bread. These results should be associated with exceptionally "strong gluten" (gluten index ≥ 90) from flour made from organic grains [5,6].

The growing interest in organic food and its quality, and the search for qualitative characteristics for this category of food, research on the content of bioactive compounds in winter wheat has also been undertaken **(publication I.2.11)**. The aim of the study was to examine the impact of the organic system of agricultural production on the concentration of phenolic acids in selected winter and spring wheat varieties.

Five phenolic acids were identified in the grain of all tested wheat varieties: ferulic (FA), sinapic (SA), pkumaric (pCA), vanillin (VA) and p-hydroxybenzoic acid (pHBA). Detailed analysis of the results showed the highest content of ferulic acid of 85.8-89.3% of the total content of phenolic acids in winter wheat grain and 85.3-89.3% in spring wheat varieties. A higher total content of phenolic acids as well as ferulic and p-coumaric acid was found in organic wheat grain than in conventional one. There were also significant differences between varieties in the concentration of individual phenolic acids and their total content. The highest content of all analyzed phenolic acids was found in Tybalt spring wheat and in Kobra winter wheat. The richest source of ferulic and p-coumaric acid was Rywalka variety. The highest content of sinapic, vanillin and p-hydroxybenzoic acid was found in the following varieties: Kobra, Legenda and Bogatka.

Higher concentration of phenolic acids in organic grains was associated with lower 1000 grain mass compared to conventional grains. In addition, the obtained results could have been influenced by a higher rate of fungal infestation and worse nitrogen nutrition status of organic wheat.

Investigations of phenolic compounds in vegetative parts were made in 12 varieties of winter wheat and 13 varieties of spring wheat cultivated in organic farming system **(publication I.2.12)**. The methodological assumptions included a comparison of selected varieties in organic and conventional farming system. The plant material for analysis was collected in the 47-50 BBCH phase. Profiles of phenolic acids and their antioxidant activity in selected winter and spring wheat varieties were examined. Organic plant samples had higher amounts of phenolic acids, and conventional plants samples had higher flavonoid content. At the same time, significant differences in the concentration of phenolic acids and flavonoids depending on the wheat form and variety were found. Average concentrations of tested acids were significantly higher in spring wheat varieties than in winter varieties. The content of all phenolic acids was the highest in the spring varieties: Trappe (1377.96 ± 4.14 µg / g) and Kandela (1004.93 ± 13.24 µg / g). Among the tested flavonoids, isoorientin was detected as the main phenol of all varieties. The spring varieties, Kandela and Ostka Smolicka showed the highest content of flavonoids (13753,7 ± 72,1 and 12484,1 ± 80,7 µg / g respectively).

The results can be usefull in selection of genotypes suitable for cultivation in the conditions of organic farming. The characteristics of phenolic profiles of best wheat varieties is important in the creation of breeding programs aimed at shaping the resistance of new varieties. Higher concentrations of phenolic compounds with antioxidant activity in the vegetative parts of wheat may be important in shaping the resistance of plants and their defense reactions in relation to pathogenic factors and thus reduce the risk of yield loss and deterioration of its quality.

Summary

1. Wheat cultivated in the organic farming system yielded, on average, 4,34t*ha^{-1}. Depending on the year yields varied between 2.9 to 5.7 t * ha^{-1}. Yields of organic wheat were lower than in other systems by: 36-39% in integrated farming system, 20-35% in conventional farming system, and 15% in monoculture. Organic wheat yields were also the most variable in years (V = 24%), Similar variability of yields in years was observed in monoculture. The variability of winter wheat yields in conventional cultivation conditions (in a simplified 3-field and intensive production technology) and in an integrated system (in the Norfolk crop rotation conditions) was at a level of 16% and 14% respectively.

2. The main yield limiting factors of winter in the organic farming (production) system were: fungal diseases of leaves (*Puccinia recondita and Septoria spp*), weed infestation and insufficient supply of plants with nutrients - mainly nitrogen. These factors also had the main impact on high variability of organic wheat yields in years and caused early dying of plants, lower density of wheat stand and formation of grains of lower mass of 1000 grains.

3. Main yield limiting factor – weed infestation – was observed mostly in wheat stands of low density, due to poor overwintering of plants. A significant relation between weeds dry mass and height and density of wheat stand, as well as overground mass of wheat plants was found.

4. Despite the sowing of wheat after legumes (in Osiny and Chomentów - clover, and in Chwałowice, coarse-bean faba), insufficient nitrogen nourishment of plants was found. There was no dependence between the obtained yields and the nitrogen nutritional status of the tested varieties. This indicates the need to develop new critical nitrogen content indices better suited for organic farming system or new methods of assessing nitrogen nutrition of organic wheat varieties.

5. Long-term study on different varieties of winter wheat of various agricultural and morphological features have made possible to specify the criteria for selecting varieties best-suited for cultivation in organic farms. Organic varieties of high and stable yields should be characterized by: higher plants (canopy), the ability to create grains with a high weight of 1000 grains, higher tillering ratio and canopy structure of lower dominance of the main shoot and high productivity of spikes from all levels. In addition, organic wheat varieties should have high resistance to pathogens infecting leaves, greater winter hardiness, greater competitiveness in relation to weeds, high the ability to regenerate after intensive mechanical weed control (harrowing), high tolerance to poor soil quality and good ability to uptake nutrients.

6. 6. The assumption that modern, intensive varieties of winter wheat will be less suitable for organic farming have not been confirmed. "Old varieties" Ostka Kazimierska, Kujawianka Więcławicka, Wysokolitewka Sztywnosłoma had yields lower than varieties from the national list (modern varieties) by 36%. Lower yield in this group of varieties was caused by greater infestation of stem base and leaves fungal diseases.

7. Flours made from the grain of tested organic winter wheat varieties had high (as for organic farming conditions) total protein content (10.3-11.9%) and wet gluten yield (23.4-29.8%). The "old varieties" had higher content of protein and gluten compared to the varieties enlisted in the national register. The gluten from the flour of the majority of tested wheat varieties, with the exception of the "old varieties" of Rokicka and Wysokolitewka Sztywnosłoma, had optimal quality for baking purposes. When cultivated properly, organic wheat grain and flour has the same quality and suitability for the production of bread as wheat grain from conventional farming system.

8. A higher total content of phenolic acids as well as ferulic acid and p-coumaric acid was found in organic wheat grain than in conventional grains. There were also significant differences in the concentration of individual phenolic acids and their total content between varieties.

9. Research on phenols content in vegetative parts showed higher concentration of phenolic acids in organic winter wheat, while flavonoids content was higher in conventional winter wheat. There were significant differences in the concentration of phenolic acids and flavonoids depending on the wheat form and variety. Average concentrations of tested compounds were higher in spring wheat varieties than in winter varieties.

The research and its results are of particular importance in the formulation of opinions on crop efficiency in organic farming system conditions. The information from this research can help to develop the best ways and the amount of support for organic farms. The research issues presented in the selected work cycle gave the basis for cooperation with many interdisciplinary teams at IUNG - PIB and other research centers and universities. An important effect of the research is, among others, the creation and implementation, jointly with COBORU, of the Ecological Experimental Environmental System (EDO), which is the only institutional system for assessing varieties suitability for organic farming. The achievements of the presented and other research were used to develop assumptions and create EDO system (creation of a research base in various regions of the country, development of research methodology). Development of EDO network allows to perform detailed research aimed at solving the issues linked with of organic farming. Experimental farms and fields have also a demonstration function and are basis for information exchange between breeding companies, seed farms and organic producers.
The results can be used in organic cereal breeding programs to develop of seeding material of organic quality.

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5. Discussion of other scientific and research achievements

The indicators of my scientific activity are included in the list of achievements in Annex 3. A description of my scientific achievements, divided into research areas and information on didactic and dissemination activities together with a summary of scientific and research activity, are given below.

My scientific work has begun in the Department of Agricultural Microbiology, Agricultural University in Krakow. I participated in the works headed by prof. dr hab. Bolesław Smyk, related to the effect of fertilization on the microbiological activity of soils, including the occurrence of nitrosamines. In 1987, I obtained a master's degree on the basis of an exam and a master's thesis entitled: "The impact of the use of NPK mineral fertilizers on the occurrence of toxinogenic fungi in mountain grassland ecosystems".

After completing my studies I began an internship at the Institute of Soil Science and Land Cultivation, IUNG. The Institute's research issues and techniques and methodology of conducting field experiments were presented to me. From 1989, I was an employee of the Institute, initially as an agronomist, and from 1990 as an assistant at the Department of Natural Foundations of Crop Rotation, participating in research work under the direction of prof. dr hab. Jan Kuś. Initially, crop rotation issues, taking into account the role of the habitat and forecrop impact on the productivity of cereals were my main research problems to investigate. Before I obtained the doctoral degree I was working mostly on the influence of selected agrotechnical factors on cereals yields (1990-1996). An interesting and innovative element of this research was the use of a half replication system in the planning and implementation of field experiments of a multifactorial experience model. These studies were carried out in cooperation with the Forschungszentrum für Bodenfruchtbarkeit Müncheberg in Germany. The applied model enabled the assessment of the main effects and interactions of 7 studied factors without the need to create extensive experimental systems. The results of the work obtained during this period were published in publications, which I was the author or co-author [II.D.1, II.D.2, II.D.7, II.D.8, IID.11, II.D13] and conference proceedings [II.D.90, II.D.92, III.I.2.]. Some of the results were presented on conferences and workshops [II.K.1, II.K.2, II.K.12, II.B.2]. The assessment of crop yield characteristics and the possibility of their mutual compensation depending on agrotechnical and environmental factors was also in the scope of my interests. The results on this subject were published in scientific papers [II.D.2, II.D.3. I also participated in dissemination and training activity, related to the research results and research issues of integrated production issues, as workshop organizer. This also included one of the first workshops in Poland of various tillage systems with the use of grubbers, and the Horsch cultivation and sowing system [str.47].In 1996, based on a thesis entitled: “Influence of seven agrotechnical factors on the yield of winter wheat: half – replicate experiments.”, I obtained a PhD degree in agricultural sciences, in the field of agronomy. After this point, my main scientific activities were linked with following issues:

1. **Impact of selected agrotechnical factors on cereals yields;**
2. **Organizational simplifications of plant production and their production and environmental effects;**
3. **Production and environmental consequences of various agricultural production systems**, including:
    - productivity and efficiency of crop rotations;
    - presence of crop productivity limiting factors;
    - assessment of soil fertility, nutrient balance and nitrogen losses indicators;
4. **Organic agriculture**, including:
    - assessment of organic farming in the organizational context and possibilities for its development;
    - assessment of productivity and yield limiting factors of crops;
    - agrotechnology improvements;
    - quality of organic products.

1. Impact of selected agrotechnical factors on cereals yields

The research topic was the continuation and summary of the scientific studies I was dealing with before my PhD. This concerned mostly the assessment of selected agrotechnical factors in various habitat conditions. The research used a multi-factorial model in half replication. The use of this model in the experiments made possible to test 7 factors, each of which occurred on two levels. The tested factors, depending on the period of research and the type of cereals (winter wheat, rye), were: forecrop, variety selection, sowing date, nitrogen fertilization level, application of fungicides, way of nitrogen application, use of multi-ingredient fertilizers, use of anti-lodgings, use of biostimulans. Three series of experiments were carried out with winter wheat in 4 locations (the first series in 1987-1989, the second series in 1990-1993, the third in 1994-1997). The experiments were based on soils of 2nd quality complex and 4th quality complex. Forecrop, control of fungal diseases, use of anti-lodgings, sowing date and selection of varieties had significant effect on the yield of winter wheat among the studied agrotechnical factors. The analysis of the results of crops with the highest yields allowed to separate a combination of factors (technology variants), which in each year resulted in high yields (7.0 - 7.3 t * ha^{-1} on soils of 4nd quality complex and 8.3 - 9 , 3 t * ha^{-1} on soils of 2nd quality complex). Factors determining such efficiency were: full chemical protection, use of the anti-lodgings and optimal sowing date. At the same time the yield decreases caused by the cultivation of winter wheat after the poor forecrop (spring barley) or sowing in the delayed time were not effectively compensated by other agrotechnical measures (increased nitrogen fertilization, higher sowing density, use of fungicides and anti-lodgings, or interaction of these treatments). The use of fuller protection against fungal diseases (including the base of the stalks, leaves and spikes infections) compared to the variant without protection or with limited protection (1 treatment in the stage of heading) in each year of research resulted in a significant increase in yields. The effect of full protection applied in the first series was 14% yield increase when compared to no-fungicides object. In the second series, the yield increase on objects with full protection

(3 treatments) was 10-11% compared to the combination with limited protection (1 treatment in the stage of heading).

Studies on rye were carried out in 1990-1994. Two locations were used, both at 5th soil quality compex. In experiments, a multi-factorial system of half replication was used, taking into account 7 factors at 2 levels (sowing date - early and late, nitrogen dose - 60 and 90 kg N / ha, nitrogen application method - soil and soil + foliar application, use of INSOL 3 fertilizer - without and in the GS 30- 50 phase, the use of fungicides - without and 2 treatments, the use of anti-lodgings - without and Flordimex T, seed dressing - without and Baytan 19.5 DS). The results showed that rye can yield up to 5.0-6.8 t * ha^{-1} on soils of 5th quality complex. The analysis showed that protection against fungal diseases, fertilization at a dose of 90 kg N / ha, use of anti-lodgings on better soils should be implement as necessary elements of high-efficiency rye cultivation technologies. The results also showed that both in the case of winter wheat and rye, chemical protection against fungal diseases was very effective. In addition, protection against fungal diseases allows effective use of other elements of agrotechnics, such as fertilization and its improving the quality of the crop.
With reference to the results and a review of the literature on the issue, I decided to present the integration of methods used in the cultivation of winter wheat as a concept of technology complexity. The publication on this problem points out that agricultural production cannot be implemented unilaterally without understanding the interaction of individual elements of technology and their impact on possible threats to the natural environment [.Jonczyk pam puł 2000].

The research results on this issues were published in scientific journals from category B [II.D.1 – II.D.8, II.D.10, II.D.11, II.D.13, II.D.16, II.D.17, II.D.18] and presented in the form of a paper and conference materials, posters [II.K.1, II.K.14].] Results were also used as workshop and training materials [II.K.1, II.K.14].Detailed results of the above studies were also presented in the final report on the implementation of research topics [II.D.66].

2. Organizational simplifications of plant production and their production and environmental effects

Nowadays, simplifications in crop rotation and soil tillage are more and more common. Excessive weed infestation, increased occurrence of specific diseases and pests, and, as a result, a decrease in the performance of particular crops and entire crop rotations is observed. In order to counteract these adverse phenomena farmers can introduce agricultural measures to mitigate risks associated with simplifications. Intercrops can be one of those measures. The special role of intercrops, escpecially catch crops results from their multilateral impact on the biological and physico-chemical properties of the soil. In modern agriculture catch crops are more a pro-ecological element of crop rotation than the feed source. Their significance increases as a factor improving the sanitary condition of the soil and enriching it with an organic substance, as well as limiting the loss (leaching) of nitrogen. Intercrops can also reduce the intensity of erosion processes. I have participated in studies on the assessment of the effect of intercrops and the method of plowing them into the soil on crop yields and the content of mineral nitrogen forms in the soil.

In the years 1994-1997 I participated as a contractor in the project aimed at assessment of the intercrop and its cultivation methods impact on yielding of spring barley. The experimental methodology included: varied habitat conditions (experiments carried out on the soils of complex 2nd and 4th soil quality complex), different forecrops (root crops, spring barley, spring barley + intercrop), various aftercrops (mustard, spring rape) and various dates of intercrops incorporation to the soil (autumn for pre-winter plowing and winter mulching of soil). The obtained results indicate that under favorable conditions for the growth of catch crops and mineralization of its residues, barley field sown after catch crops yielded about 0.5 $t * ha^{-1}$ higher compared to barley field sown after spring barley. However, it was found that in no case the inclusion of catch crops for crop rotation was able to fully compensate for yield decreases due to the cultivation of cereals after themselves. The cultivation of catch crops definitely limits the danger of leaching nitrogen compounds (mainly nitrates) from the soil in autumn and winter. In the autumn after the vegetation ended, the number of $N\text{-}NO_3$ was lower on the fields with intercrops than on the control, while in the spring more nitrates were found in the soil after plowing in catch crops.

In 1995-1998 I have continued the discussed research issues with involvement in another research study. The aim of the study was to assess the effect of catch crops and soil cultivation method on the yield of spring barley and maize as well as the content of mineral nitrogen in the soil. The studies included the method of cultivation for catch crop (plowing and grubber), the intercrop date of incorporation to the soil (pre-winter plowing and mulching for winter), the species of crops grown as the intercrop (white mustard and spring rape). Results showed that intercrops increased yield of barley grain by about 3-5%, and had no influence on the yield of maize. The late date of grubber use caused a decrease in the yield of intercrops, compared to the plow tillage. In addition, use of grubber caused a higher share of weeds and pre-crop self-emerging plants biomass in total intercrop biomass. The mulching of the soil surface with intercrops for winter increased weed infestation and decreased yields of following crop, compared to the pre-winter plowing in intercrop residues. Fields with intercrops had lower content of nitrates in soil by 40-50% in autumn, while in spring it was higher by 10-20% compared to the control. The obtained results showed that cultivation of catch crops significantly limited the risk of nitrates leaching from the soil in autumn and winter

The results of above research have been published in publications [II.D.9, IID.14, II.D.19, II.D.20,], conference materials [II.D.91, II.D.92] and training materials. [III.I.1.,III.I.12, III.I.14]. The conducted research was also used as a knowledge source for opinions on the implementation of agro-environmental packages and its impact as well as for recommendations for agrotechnical management measure that meet the assumptions of the conservation agriculture.

3. Production and environmental consequences of various agricultural production systems

Research on those issues are vary important to my scientific interests. They were also a source of results obtained in a large part of research topics and projects carried out alone or in interdisciplinary teams [II.I.1, II.I.2, II.I.31–35, II.I.40]. The specificity of agricultural research, especially in the field of analysis of various management systems and their impact on the environment requires conducting long-term observations and creating a research base that will provide a comprehensive source of information. In 1994 such base was established in IUNG - PIB in the farm of Osiny near Puławy. I participated in its establishment and I am currently conducting constant supervision over its functioning. (The description of the experimental object and the main methodological assumptions related to it are enlisted in part concerning scientific achievement…….). A long-term field research are an indispensable source of knowledge enabling monitoring of changes in the soil environment its fertility and biology. It allows to understand the source of these changes and linking them with the long-term use of agrotechnical procedures. Long-term field facilities are an ideal testing ground for many disciplines in the field of agricultural sciences, and an irreplaceable source of results serving, among others, validation of various models linked with growth and development of plants, occurrence of fungal pathogens, circulation of nutrients, changes in soil fertility, etc. The results discussed in this part of the paper are at the same time a valuable database used in the preparation of opinions and expertise in the field of production and environmental effects of various management systems, estimation of balances and losses of nutrients, implementation of selected agrotechnical solutions for practice.

The results obtained in the discussed research area concerns long-term studies, the value of which is based on a multithreaded assessment of various plant production systems. The analysis of the results made possible to observe and identify phenomena whose assessment and formulation of generalizations requires a longer time perspective (this applies, for example, to productivity trends, changes in the organic matter content and other soil fertility indicators). The synthetic description of achievements and results is reported by referring to the above-mentioned more specific issues:

Productivity and efficiency of crop rotations

Research on this thematic scope at the experimental facility in Osiny were done in 1996 – 2016. I conducted the research under the following statutory research projects: IUNG - PIB, subsidies of the Ministry of Agriculture and Rural Development for research in organic farming, individual research projects, and projects under international cooperation. In these projects I was the manager or the main contractor, the full list of projects is included in Annex 3 p.

The results on cereals yields indicate integrated and conventional system has the greatest yields of cereals. However, in the conventional system with a simplified crop rotation, and organic fertilization limited to straw plough into the soil, it is necessary to use higher doses of nitrogen fertilizers by about 35 kg N / ha and for winter wheat additionally one herbicide and fungicide treatment more than in integrated cultivation.

Winter wheat. The integrated system had the highest yield of winter wheat grain of 6.68 $t.ha^{-1}$, on average for 20 years. Wheat in this system was cultivated after legumes. Similar yield was observed in a conventional system, where wheat was sown in a 3-field rotation after oil-seed rape using intensive production technology. In monoculture, despite the use of intensive production technology, average 20-year yields were at a level of 5.09 $t.ha^{-1}$ and was 1.59 $t.ha^{-1}$ (24%) lower than in the integrated system. In the organic farming system the yield of winter wheat sown after clover with grass used for two years, on average in 20 years, was 4.41 $t.ha^{-1}$and was lower by 2.27 $t.ha^{-1}$ (34%) than in the integrated system and 0.68 $t.ha^{-1}$ (13%) than in monoculture.

Yields of spring cereals (barley and wheat). The diversity of yields of spring barley cultivated in the compared systems was relatively small.

Barley sown in the years 1996-2004 in the integrated system (after potatoes fertilized with compost), yielded only 3% higher than in the conventional system, in which intensive production technology was applied. In the organic farming system, spring barley with undersown clover grass was grown after potatoes fertilized with compost. The yield of barley grain in this system was, on average, 15% lower than in the integrated system, and in individual years the differences ranged from 0% to 40%. Over-excessive growth of undersown clover and grass, which over-grew the barley, was the main factor that reduced the yield in organic object. This was also the main factor of yield variability in the years, which caused losses during harvesting. Spring wheat reacted with a much greater variation in crop yields in the assessed systems compared to spring barley. The largest yield of 5.4 $t.ha^{-1}$, was observed in an integrated system. In a conventional system, where spring wheat was sown after winter wheat, its yields were lower by an average of 10%. Spring wheat in the organic system was very pool yielder, with average yield for the period of 11 years of 3.7 $t.ha^{-1}$, which was 40% less than in the integrated system. The lower yield of spring wheat in the organic farming system was a consequence of crop density lower by about 25% compared to the integrated system, despite the same density of sowing on all objects. The weight of 1000 grains was also lower by about 25% in organic spring wheat. It should be assumed that the basic factor decreasing the yields of both spring cereals species in the organic system was the nitrogen deficit. In addition, the undersown clover and grasses, which was very successful in all the years of research, could also compete with cereals for nutrients.

Potato. The average yield of potato for 20 years, on average for several varieties, in the integrated system was 37.3 $t.ha^{-1}$ and was about 32% higher than in organic farming system. In both systems large fluctuations in yields were found in years, the coefficient of variation in case of organic farming was 35%, and in the integrated - 29%. The potato yield reduction in organic farming in the years depended mainly on the date of occurrence of potato blight (*Phytophthora infestans*) and the rate of its development (dependent mostly on weather conditions). The effectiveness of copper based plant protection products, allowed to be used in organic farming system, was limited in conditions of high pressure of this disease. The share of large potato bulbs (main market yield) was also significantly lower in the organic system.

Efficiency in cereal units (CU). The highest productivity of 62 cereal units from 1 ha AL, on average for 15 years, was observed in organic and integrated system. In the conventional system, average productivity was lower by 10%, and winter wheat monocultures by 24%. A very important element of the organic farming system were legumes (clover with grass), whose yield on average in 15 year, was 108 CU in the first year of use, and 59 U in the second year of use from 1 ha. In the same system, the potato yield was 62 CU, and cereals about 40 CU from 1 ha. The results shows the importance of legume plants in the organic production system both in the context of productivity, but also in: shaping nitrogen resources, improving the soil balance of organic matter, increasing soil biological activity and limiting the development of annual and biennial weeds. In the integrated system, the highest productivity was observed for the potato, while the lowest value of CU had leguminous (white and narrow-leaved lupine and horse bean). The variability of their yields in the years was very high, and the main factor influencing their productivity was the distribution of rainfall during the period of pod formation. In the conventional system, the yields of winter oilseed rape and winter wheat were similar, while yields of spring cereals were visibly lower. The efficiency of wheat monoculture was by far the lowest of all other systems (rotations).

Crop productivity limiting factors

The research results indicates that the highest number of yield limiting factors occurred in the organic farming system. In the case of cereals, the most important was the infection of leaves by fungal diseases and worse nutrition of plants with nitrogen. The average index of infection of wheat leaves in the phase of milk maturity in organic farming was even 4 times higher than on objects protected with fungicides. As a consequence, a lower number of spikes and lower mass of 1000 grains were observed. The results of the conducted research indicate that these reductions can be partially limited by the selection of varieties, while the use of biological preparations (EM, UG max) had limited effectiveness. No significant increase in the occurrence of pests (aphids, cocks, etc.) has been observed in organic farming system. This effect can be associated with more than twice as large a population of predatory insects, mainly of the beetles, compared to wheat cultivated in other systems. In the winter wheat monoculture, the basic factor limiting the yields was stalk base diseases. The use of plant protection products partially limited the severity of these diseases, partially limiting the yield losses.

During the entire study, weeds were significantly reducing the yield of winter wheat grain only in 5 years (the dry weed mass in the field before harvest exceeded 100 g / m^2). These were the years in which the wheat stand had lower density due to weaker emergence or poorer wintering of plants. However, in the remaining years, with good density of wheat stand, the weed mass generally did not exceed 40-60 g / m^2 and had no significant effect on yielding.

Time of occurrence and intensity of potato blight is of fundamental importance in potato cultivation. The effectiveness of the copper based chemical plant protection products certified to be used in organic farming system is relatively low. Also, no satisfactory effects were obtained by planting sprouted seed potatoes. Therefore, the only method of limiting yield losses due to potato blight is the cultivation of varieties more resistant to this disease.

Environmental effects of the impact of different production systems

One of the basic criteria for the assessment of production systems are environmental effects. Those are combined effects of organizational and agrotechnical factors associated with agricultural production. Those can affect and change physical, chemical and biological properties that shape the fertility of soils. In the discussed studies, the environmental effects were assessed on the basis of changes of: soil fertility in nutrients (P, K, Mg), pH, organic matter content, microbiological properties of soils. The level of environmental risk and the level of sustainability of the assessed production (farming) systems were evaluated by calculating the NPK balances and the N_{min} content in the soil profile and soil water. Long-term studies on the impact of compared production systems on the natural environment have provided many interesting results that allow the following conclusions:

Soil fertility in nutrients and selected fertility indicators

- In the current (20-year) period of research, no significant changes in the basic indicators of soil fertility were found in compared production systems. In the organic farming system, a decrease of soil potassium and phosphorus was noted, but the use of appropriate fertilizers slowed down this negative tendency.
- There has been a trend of a decrease in soil pH in a conventional system and monoculture, which may be related to the acidifying activity of nitrogen fertilizers used in high doses on these sites.
- A positive balance of soil organic matter was recorded as an effect of long-term management in accordance with the assumptions of the compared systems. In organic farming system 0.8 t / ha / year of SOM and in the integrated system 0.4 t / ha / year of SOM surplus have been recorded. Intensive plant production based on simplified changes in the conventional system and monoculture caused a slight degradation of soil organic matter at the level of about 0.2 t / ha / year. Additional studies on the quality of organic matter show that the soil in the organic farming system contains the most labile fraction of SOM, which significantly affects the soil biological activity.
- Soil in the organic farming system was generally characterized by the largest populations of all groups of soil microorganisms involved in nitrogen and phosphorus transformations, in particular AzotobacteN_2 assimilators and symbiotic bacteria, ammonifiers, nitrifiers and endomycorrhizal fungi (VAM). This also applies to the enzymatic activity of the soil, mainly the content of phosphatases (acid and alkaline).

Environmental impacts

Nitrogen Phosphorus and Potassium balance sheets, N_{min} concentration in soil profile and soil water filtrates and nitrogen losses estimated with the NDICEA model were used as part of the assessment of correct management in the field of nutrient management and potential environmental threats in various management systems. The most important results, obtained in different periods of research, can be summarized as follows:

- The phosphorus balance in the organic farming system was negative (-10 kg P * $ha^{-1}year^{-1}$). After the first two five-year rotations of crops, fields of organic farming system showed the tendency of the soil to decrease phosphorus content. Thus, the need to use phosphate fertilizers certified to organic farming emerged. In the remaining farming systems, the balance differences of phosphorus were positive, on a level of 15-17 kg P * $ha^{-1}year^{-1}$ and caused a tendency to increase soil P content.
- The balance of potassium in the organic farming system, due to the very high yield of clover grass, was negative and amounted to -120 kg K * $ha^{-1}year^{-1}$. After 8 years, the soil content of K dropped, its low concentration caused deficiencies which were observed on potato plants. The introduction of potassium fertilizers certified to organic farming, allowed to positively balance its soil content. In the remaining farming systems, positive K balances were observed. In the integrated system it was 6 kg K * $ha^{-1}year^{-1}$, 50 kg K * $ha^{-1}year^{-1}$ of surplus in monoculture and 52 kg K * $ha^{-1}year^{-1}$ in the conventional farming system.
- Organic farming system had a positive and safe for the environment balance of nitrogen of, on average 11 kg N * $ha^{-1}year^{-1}$. In the conventional system, the balance surplus of this component was at a level of 49 kg N * $ha^{-1}year^{-1}$, in the integrated 36 kg N * $ha^{-1}year^{-1}$, and in monoculture 70 kg N * $ha^{-1}year^{-1}$.
- The results on the nitrogen balance and its components calculated by various methods indicate its underestimation by the Macrobil program in the organic farming system. The observed differences result from underestimated nitrogen content in post-harvest residues of legumes with grasses mixture.
- N_{min} content determined in the autumn in the 0-90 cm soil profile in organic farming system was at a level of 79-83 kg N_{min}* $ha^{-1}$and was lower than in conventional system by about 27%, lower by 37% in the integrated system and lower by 180% in monoculture.
- Analysis of soil filtrates showed that organic production system had lower concentration of N_{min} in soil filtrates throughout the year and lower infiltration rate of those filtrates into the profile compared to the conventional intensive and integrated farming systems.
- Detailed analysis of N_{min} in the soil profile and soil filtrates, combined with the soil water reserves assessment allowed to identify crops (elements of crop rotation) of the greatest N losses due to N leaching. These were: clovers with grass in the organic farming system, winter oilseed rape in a conventional farming system, potato and horse bean in an integrated system.

- In the compared production systems, loss of nitrogen due to leaching, calculated at the level of the entire rotation using the NDICEA model, ranged from: 3 kg N * ha^{-1} in the organic farming system, 25 kg N * ha^{-1} in conventional, 17 kg N * ha^{-1} in the integrated and 31 kg N * ha^{-1} in monoculture of winter wheat.

The research results on this issues were published in scientific journals from category A A [II.A.2-3, II.A.5-8] and category B [II.D.15, II.D.23 – 5, II.D.28–37, II.D.39, II.D.43, II.D.46, II.D.62 – 63], and presented in the form of a paper and conference materials, posters [II.D.94-96, II.D.106-108]. Results were also used as workshop and training materials [[II.I.3, III.I.5, III.I.12, III.I.14, III.I.21-22].Detailed results of the above studies were also presented in the final report on the implementation of research topics [II.D.72, II.D.77, II.D.86].

4. Organic agriculture

The issues of organic farming are a significant part of my scientific interests. Also I have an extensive experience in organic research and project as well as dissemination and didactics of its results. The research presented in this section, due to the research base and methodological assumptions refer to the research presented in the previous chapter (p.3) - and relate to the organic farming system comparison with other management systems. It is complementary with my previous work and also an integral part of my scientific achievements in the field of organic farming.

Assessment of organic farming in the organizational context and possibilities for its development. Land structure, land use,cropping structure and linkage of plant and animal production of organic farms were included in this part of the research. In addition, an assessment of habitat conditions and the share of valuable areas (protected by law) of organic farms was also carried out. These analyzes were made at country level, but also at regional level of the Podlasie region, which is characterized by specific natural conditions (low index of valorisation of the agricultural production space, a large share of protected areas and permanent grassland, a significant share of milk production). The studies were based on the data of Main Inspectorate of Trade Quality of Agricultural and Food Products (GIJHARS), IUNG-PIB databases and GUS data. The development of organic farming have been divided into stages: the period before Poland's accession to the EU; the first support mechanisms from the national budget in the beginning of 2000; the dynamic development of organic farming after accession to the EU and the introduction of the CAP and the national agri-environmental programme in 2004. The analysis showed that in the years 2004-2012, the number of organic farms in Poland increased seven-fold, and the AL area 12-fold. Organic farms, on average at country level and regional level, were about three times larger in comparison to the average farm size. Organic farms had on average 25 ha of AL which ranged from 10-11 ha (małopolskie and świętokrzyskie voivodeships) to about 40 ha (zachodniopomorskie, lubuskie and wielkopolskie). The volume of organic commodity production in Poland is relatively small, as in organic farms about 60% of the land is taken up by fodder crops (permanently grassland and pasture land on arable land). The share of extensive orchards is around 12%, which is 5 times higher than the national average. In the structure of sowing (cropping pattern) of organic farms, the share of cereals, potatoes and vegetables is clearly smaller than national average. At the same time, it was found that the density of animals is more than twice lower than national average, and a particularly unfavorable situation occurs in larger farms (over 50 ha).

An important element of research on assessing the conditions for the development of organic farming in Poland were publications. Those papers aimed at presenting the relationship between natural and organizational conditions, and the number and distribution of ecological farms in Poland [II.D.33, II.D.38, II.D.42, II.D.50, II.D.51, II.D.74, II.D.76, II.D.79]. Detailed analyzes of the distribution of organic farms in the country showed that communes with the largest number of organic farms had lower values of the agricultural production space index, lower productivity of agricultural production and more than 50% share of the areas protected by law. This indicates that in poorer habitat conditions, organic farming can be an alternative to a conventional farming system. The analyzes showed organic farming development depends on economic and organizational factors to a much greater extent than from natural conditions.

An important part of my scientific and research achievements was participation in a team that developed expert opinions for the needs of the Ministry of Agriculture and Rural Development. Those expertise included: discussion on the current state of organic farming in Poland, with regional differentiation and applicable support systems, presentation of support systems in other EU countries, development of new variants and payments available in organic farming in the 2014-2020 perspective [III.M.1-2].

The research results on this issues were published in scientific journals from category B [II.D.33, II.D.38, II.D.42, II.D.50, II.D.51, II.D.74, II.D.76, II.D.79] and presented in the form of a paper and conference materials, posters [II.D.102-103, II.B12, II.K.3.]. Results were also used as workshop and training materials [III.I.4, III.I.14, III.I.15, III.I.19]. Detailed results of the above studies were also presented in the final report on the implementation of research topics [II.E.11, II.E.14].

Evaluation of productivity and factors limiting crop yields, improvement of agrotechnics. I carried out research as part of research projects in IUNG's statutory activity - [[II.I.26, II.I.28-35, II.I.37-40], projects funded by the State Committee for Scientific Research [II.I.4], Subsidies of the Ministry of Agriculture and Rural Development for organic farming research and international projects [[II.I.5- 11, II.I.13-25].

A significant part of the results of yielding plants and the presence of factors limiting their efficiency are discussed in Chapter 3 and the part on scientific achievement. Additional research, which I carried out in the discussed thematic scope, concerned, inter alia:.:

- **assessment of the effects of farm transformation** from conventional farming system to organic farming system
- **assessment of various crop rotations representing different models of organic farms** in the context of the possibility of increasing nitrogen resources in soil and the impact on the value of the field (soil) and productivity of plants;-

- **agrotechnology improvement** through: searching for best weed infestation regulation methods and plant protection methods using biological preparations, evaluation of various forms of potato fertilization, selection of cereal varieties and assessment of their suitability for organic farming.

The transformation process of a farm from a conventional to organic farming system entails a number of organizational and economic issues. The effects of this process have been examined on the example of the Experimental Station in Grabów transformed into an organic farm with a milk production. Over the time of 4 years (2001-2005), carrying out the statutory research subject [II.I.30, II.I.35] a complete change in the organization of plant production was carried out, adapting it to the principles of organic farming. The introduced changes resulted in a decrease in yield of cereals, by about 50% in the case of winter wheat and by 22% in spring barley. The efficiency of organic crop rotation was lower than crop rotation in conventional farming system by 12.2 CU * Ha^{-1}. The reorganization of the feed base (involving a greater share of fodder production on arable lands and renovation of grassland) enabled a slight increase in milk production and productivity. The level of animal production expressed in cereal units per ha of AL increased by 16%. The increase in animal productivity was accompanied by an increase in the global area of fodder on average by approx. 10%. Organic management compared to the conventional one resulted in increased positive balance of organic matter of soil by 0.33 t * ha^{-1}. The organic farm recorded a negative balance of nitrogen balance - 18 kgN * ha^{-1} and potassium - 49 kgK * ha^{-1}. During 4 year transformation there was a decrease in the content of phosphorus on all fields. Also a tendency to decrease the potassium content was observed on some of fields. The results on the nitrogen balance and the monitoring of the N^{min} content in the soil, assessed at the level of the entire crop rotation, indicate that the organic farming system creates a small risk of nitrogen losses. During the transformation of the farm, an increase in revenues by 38% was recorded. In the analyzed period, the farm's profit increased by nearly 90%. The system of subsidies and subsidies for organic farming was of great importance in obtaining this result. The value of direct payments and organic production accounted for approx. 20% of the final production of the farm and approx. 57% of the farm's profit.

The use of synthetic nitrogen fertilizers is forbidden in organic farming system. This is probably the most important feature of agrotechnology in organic farms. Respecting this principle forces the search for other sources of nitrogen and methods of increasing its resources in the soil. The solution to this problem is, among others, cultivation of legumes and their proper use, eg selection of nitrogen-fixing crops and maintaining their high share in the sowings (cropping) structure. Duration of use of legume-grassy mixtures and soil tillage is also of great importance. I have carried out research on those issues within the project, which aimed at assessing various crop rotations, representing different models of organic farms. The project also assessed the possibility of increasing nitrogen resources in the soil and its impact on the soil (field) quality and plant productivity [II.I.39. The research was conducted in 2010 - 2014 at IUNG – PIB experimental station in Grabów. The scheme of the experiment included three crop rotations containing various species of fabaceae. The assessed crop rotations represented also different models (production profiles) of organic farms. Crop rotation A - the dairy farm model (maize ++ - cereal - legume mixture + undersown catch crop - red clover + grass 1st year - red clover + grass 2nd year - spring / winter wheat). Crop rotation B - the pig farm model (maize ++ - spring barley - cereal - legume mixture - peas - spring / winter wheat). Rop rotation C - the farm with no livestock model (maize ++ - cereal mixture - spring wheat + undersown catch crop - red clover - spring / winter wheat).

Among the compared crop rotations, the highest yield productivity in cereal units (CU) was observed in crop rotation A representing the dairy farm model. In the variant with winter wheat, 49CU ha * $^{-1}$ ha were obtained, and with spring wheat - 47CU ha * $^{-1}$ ha. The factor limiting the efficiency of particular crops and entire crop rotations was the limited availability of nitrogen critical periods of crop development. The nitrogen balance, on average for the entire study period, for the A and B crop rotation was similar. Its value, depending on the cultivated form of wheat, was - 4 kg N * ha^{-1} for winter wheat and 0.2 kg N * ha^{-1} for spring wheat. The highest surplus of N was observed in crop rotation C - 22 kg N * ha^{-1} for winter wheat or 26 kg N * ha^{-1} for spring wheat. The results (at the level of whole crop rotations) indicate the lack of potential threats related to nitrogen losses and its uncontrolled dispersion in the environment. A detailed analysis of the N_{min} content in the soil profile showed, however, that soil after clover grass cultivation had surpluses of 50-58 kg N * ha^{-1} which may potentially cause some N losses.

The research results on this issues were published in scientific journals from category A [II.A.8] and category B [II.B.11; II.B.14; II.B.22] and presented in the form of a paper and conference materials, posters [II,D.46, II.D.62,]. Results were also used as workshop and training materials [II.I.3-4, II.I.12-15]. Detailed results of the above studies were also presented in the final report on the implementation of research topics [II.E.5, II.E.11, II.E.14, II.I.18, II.I.23].

Another area of my interest is the improvement of organic farming agrotechnology aimed at improving the productivity and quality of plant production. The assessment of the effectiveness of selected agrotechnical methods of weed control in winter wheat, maize and sorghum have been done in the years 2010-2013 at the RZD Grabów organic farm. Evaluation of various methods of weed control was carried out in three independent experiments: winter wheat, maize and sorghum. The scheme of experiment with winter wheat included: various sowing methods and standards (mechanical row seeding method and broadcast seeding method with seeding density from 4.5 to 6.0 million grains / ha), mechanical weed control with weed harrower and undersown mustard. In the maize and sorghum experiments mechanical weed control methods were tested, including brush cultivator and lister cultivator. Also the impact of organic fertilizer applied at two levels of 20 and 40 t / ha was tested. The agricultural management of winter wheat crop with the harrow allowed us to limit the number and weight of weeds in the stage of stem elongation respectively by 35% and 27% in relation to the control, and in the ripening phase – 22% and 24%. Undersown mustard, despite its small biomass during the autumn vegetation, limited the weight of weeds regardless of the method of sowing. Among the tested sowing methods, broadcast seeding was the most effective in limiting weed mass (reduction of weed mass by 19% in relation to row sowing and by 21% in relation to dense sowing). Concentrated (dense) sowing did not significantly reduce the number and weight of weeds. Mechanical weed control of maize and sorghum has contributed to a significant reduction in weed mass. Brush cultivator used twice along with lister cultivator was the most effective method of mechanical weed control. The use of mechanical care weed control methods in maize resulted in increased share of seeds in the cob yield structure by an average of 15%. Increasing the dose of organic fertilization had relatively low impact on the share of seeds in the cob structure.

The aim of the studies on potato agrotechnology was to assess various forms of organic fertilization and to demonstrate their complementarity in affecting potato yield, It has been showed that combination of fertilization with compost and post-harvest plants residues biomass was much more efficient than fertilization with manure and green manure (catch crops) [II.D.12, II.D.70, II.D.93]. It was also found that the compost applied before the last mechanical weed control caused yield increase similar to that made by green manure itself. In other studies conducted jointly with the team from the IHAR - PIB, in various habitats and production systems (organic and integrated) the yield of potato varieties belonging to different groups of earliness was assessed. It was found that the production system had the biggest impact on the yield and its structure. The average potato yield in integrated system was over 30% higher than the organic system. Larger differences between systems were found on lighter soils. Differences between potato varieties concerned only the share of the largest class of tubers. The examined factors had minor influence on the share of tubers defects. There were no significant differences in the commercial quality of tubers in the compared production systems [II.D.63].

Fungal diseases are the most important factor that significantly limits the yield of cereals and affects the deterioration of grain quality in organic farming system. The methods and protection measures recommended in organic farming have a limited effect on improving the sanitary status of plants. Therefore, there is a need to search for and evaluate new protective measures in organic cereal cultivation. Bearing in mind the mentioned conditions, a research on the use of plant protection products certified to be used in organic cereals have been made. The following products were tested: BION, Biosept 33SL, UG max soil fertilizer II.D.27, II.D.52, II.56].

Four varieties cultivated in organic and conventional farming systems were considered in BION experiments,. The better effects of the BION product on the yield and improvement of the plant's sanitary status were noted under the conditions of conventional system in which BION was used in combination with conventional protection measures. The effectiveness of BION in conditions of greater paralysis by fungal diseases in organic farming system was limited.

The evaluation of the effectiveness of BIOSEPT 33 SL was carried out in the cultivation of winter wheat. The research methodology included the use of BIOSEPT 33 SL in varying concentrations and frequency of application. The selection of varieties was an additional factor. Yields of crops protected with BIOSEPT, depending on the number of treatments and varieties, were higher than control yields by 6-16%. BIOSEPT spraying on three dates made it possible to obtain higher yields of wheat varieties: Kobra by 12% and Juma by 16%. BIOSEPT showed the highest efficacy against *Puccinia recondita*, but the inhibiting effects dissappeard after a short time. The effectiveness of the product agaist other pathogens, mainly *Fusarium* fungi was limited. There was a small 21% effectiveness of the productn in the protection of spikes against infection by *Septoria nodorum*.

The assessment of the UG max Soil Fertilizer interaction was made in the experiment with winter wheat. The studies included analysis of the basic elements of the yield structure, assessment of the presence of fungal pathogens and the effect of the fertilizer on selected growth parameters and nitrogen nutritional status of crops. The use of soil fertilizer in the organic cultivation of winter wheat resulted in increased grain yield, an average of 6%, and in increased weight of 1000 grains by 4%. Higher yield increase due to the use of the product (9-16%) was recorded in the so-called "Old varieties". The assessment of phytosanitary status of plants showed that in objects after application of the soil fertilizer, the development of most of the pathogens was limited. The application of the product resulted in the increase of LAI leaf area index and better nutritional status of plants with nitrogen.

The importance of varieties selection is of particular importance in organic farming as industrial means of production are forbidden in this production system. The selection of the right variety of cereals is an element of agrotechnics, which, apart from crop rotation, is of fundamental importance for the size and stability of yields and their quality. Research on the selection of varieties for organic farming was initiated at IUNG - PIB in 2004. The thematic scope of the work in the first research period included fewer varieties and included tasks aimed at identifying the main problems in organic production. Also studies on elaborating initial selection criteria and creating a research base for organic farms in various regions of the country were made. The head of the research team until 2010 was prof. dr hab. Jan Kuś. I participated in conducting research related to the improvement of agrotechnology in organic cereal cultivation and assessment of environmental effects related to the implementation of the principles of organic farming. Since 2011, the research on the varieties selection is coordinated by me. In the first period of the study, winter wheat and spring wheat were included, and in the following years they were extended to rye and winter triticale. In recent years I am coordinating work on assessing the suitability of winter cereal varieties for organic farming and I participate as a contractor in analogous studies with spring cereals [II.I.4-25]. In the methodological assumptions of the study, 12 to 16 varieties in three-year cycles has been accepted for tests. This allows to indicate a list of varieties best suited to the conditions of organic production and direct use of the results in practice. The results of research were the basis for the development of publications in scientific journals [II.D.35, II.D.40, II.D.47-49, II.D.57-59, II.D.61, II.D.64, II.D.65] and the release of training materials and implementation instructions [II.I.6-10, II.I.22-23, II.I.25, II.I.28]. The research network located in various regions of the country serves as demonstration objects and is used in numerous trainings. An Organic Variety Experiment network (EDO) was created jointly with the Central Research Center for Cultivar Varieties as the effect of the project that I coordinated in 2018 and many years of experience of the IUNG - PIB team in research with cereal varieties selection. The basic objective of the Organic Variety Experiment network is to assess the suitability of varieties of different groups of plants for cultivation in organic production conditions. The first studies within the EDO system included the assessment of varieties of spring cereals: wheat, barley and oats. In subsequent years, it is planned to increase the range of species covered by the research and the number of experimental points. The meaning and value of research within EDO is, among others, the assessment of varieties to a wider extent than in the post-registration multi-environment trials (PDO) testing system run by COBORU and conducting research in the organic farming conditions.

An additional value of the discussed research is the possibility of implementing projects in interdisciplinary teams with IUNG - PIB, UTP in Bydgoszcz, and SGGW in Warsaw. The thematic scope of this work includes, among others: assessment of microbiological profile of rhizosphere of winter wheat cultivars, susceptibility of varieties to spike infection, colonization of grains by fungi of the *Fusarium* spp. genus, Comprehensive assessment of the technological value of winter wheat grain, assessment of the content of bioactive compounds in cereal grain. As a result of many years of cooperation within the discussed projects, publications presented as a scientific achievement and other publications in which I am an author or co-author [II.A.1-6, II.D.40, II.D.44, II.D.49, II.D.58, II.D.59, II.D.64] were published. I also presented the results of work on the assessment of varieties at conferences and workshops [II.K.4, II.K.12, II.K.20, II.K.26, II.K.34] .

Profile and research results on varieties selection for organic farming and the implementation of EDO system initiated cooperation and my participation as contractors in the international LIVESDEED project [II.I.3].The project involves various scientific units, breeding and seed companies as well as organizations from all over Europe. The main goal of the project is to develop best practices in the field of: implementing legal regulations, breeding, testing, creating databases and the availability of organic seed material.

In 2010, as organic farming in Poland and the development of the organic food market rapidly grew, I made efforts to obtain funds from the Operational Program Development of Eastern Poland for the implementation of the project: "Cluster growth. Ecological Food Valley”. Project **„Organic Food Valley Cluster” (OFV)**, which I managed in the years 2010 - 2013 was aimed at building a supra-regional cooperation platform for the development and promotion of organic food products in Eastern Poland. The existence of the OFV cluster was also aimed at developing cooperation between scientific centers, entities acting for the promotion of organic farming and value chain actors involved in the production, processing and distribution of organic products. A very important goal of the OFV cluster was to increase the competitiveness and innovation of enterprises associated in the cluster, increase the scale of organic production and increase the number of jobs in the organic products sector. As part of the cluster's operation, a thematic geoportal and a teleinformation services system were launched to improve access to information and knowledge on the production, processing and marketing of organic products. Dissemination and Exploitation of the knowledge obtained in the project was also a important part of the project which allowed to identify and solve problems of organic food producers. It should be emphasized that in five voivodships belonging to the area of Eastern Poland (Podkarpackie, Lublin, Świętokrzyskie, Podlasie, Warmian-Masurian Voivodships), over 47% of all polish organic farms and 26% of all polish small-scale industries that processes organic food were located in this period. Partners participating in the project representing various processing industries and producer groups willingly used the possibility of performing specialized laboratory analyzes. The results of analyzes were used, among others for implementing new recipes and innovative solutions at the technological level, improving agrotechnics and improving the raw material base, evaluation of raw materials and market-ready products. During the project a broad information and promotional campaign was conducted. The promotion of the Cluster of the Ecological Food Valley had a two-way character. Information activities addressed to two groups of recipients were carried out. The first group were present and potential members of the cluster of the Ecological Food Valley, the second group - consumers of organic food. During the project, two nationwide scientific conferences, press conferences, economic missions, numerous trainings and workshops focused on knowledge transfer and promotion of the idea of organic farming were implemented. The effects of dissemination activities and promotion of organic farming principles implemented during the OFV project were awarded in competitions organized by the Ministry of Regional Development and the Polish Agency for Entrepreneurship Support - third place in the "Promuj z pomysłem" (“promote with an idea”) competition and the first place in the "Show your website" competition.

The list of publications, other scientific and research achievements, information on didactic achievements and scientific cooperation and the dissemination of research results are provided in Annex 3.