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Article

Promotive Effect of Non-Woven Polylactide/Natural Rubber Composites on Growth and Biochemical Constituents of Purple Basil (*Ocimum basilicum* L.)

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Abstract: Presently, modern trends focused on eco-friendly "green" technologies are increasing the widespread use of biodegradable polymers and polymer composites in agricultural production. In this work, non-woven materials, polylactide/natural rubber (PLA/NR) composites with a different natural rubber content, were used as substrates for growing purple basil (*Ocimum basilicum* L.) in the multisoil compound in a phytochamber. It was shown that non-woven PLA/NR fabrics stimulate the growth and development of purple basil plants during the growing season. Compared to the control sample, the germination and biometric indicators of basil were higher when using PLA/NR substrates. The production of basil's photosynthetic pigments also increased. While using PLA/NR fabrics with a rubber content of 10 and 15 wt.%, the number of chlorophyll *a* was enhanced by 1.8–2.2 times and chlorophyll *b* by 2.5–3.2 times. In the process of the hydrolytic and enzymatic degradation of the polymer matrix, organic compounds are formed that provide additional nutrition for basil plants. Non-woven PLA/NR composites became brittle after the experiment. The PLA/NR morphology, structure, and rheological properties changed, which indicates the course of biodegradation processes in the polymer matrix.

Keywords: biodegradable composites; non-woven fibrous materials; polylactide; natural rubber; photosynthetic pigments; agrofabrics

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1. Introduction

Polymers and polymer composites have been successfully used in the agricultural industry for a long time [1,2]. Also, the food industry is one of the major consumers of polymer materials. Their application in the agroindustry leads to a significant technical and economic effect [3,4]. So, when transporting grain, instead of metal augers, augers with a working surface coated with polymers are used: polyurethane, polycaprolactam, and polytetrafluoroethylene. By reducing the coefficient of friction of the grain on the surface of the auger, transportation productivity increases by an average of 25% and, in addition, the grain is significantly less damaged.

Packaging materials occupy a special place in the use of polymers, since today it is a global industry covering almost all industries [5,6]. Materials for packaging and storing vegetable oil must be impervious to odors and fats; containers for ice cream, for example, must have sufficient frost resistance and resistance to aging, ensuring the safety of both the packaging itself and food products. For these purposes, polyethylene, polypropylene, their mixtures, and biobased polymers are used [7,8]. Many film materials must shrink, tightly fit products of complex configurations, and be suitable for ink printing.

Nowadays, the use of biodegradable materials appears as an attractive alternative for enhancing sustainable and environmentally friendly agricultural activities in mulching and cultivation [9]. Innovative biodegradable polylactide-, poly-3-hydroxybutyrate-, and polycaprolactone-based mulching films are under development in the course of many research projects [10,11]. The performance of these films compared to the performance of the conventional polyethylene films in the field under real cultivation conditions is under investigation.

Modern agriculture needs new methods and technologies of crop production. To increase plant productivity and yields, various measures are used: digital innovations in soil cultivation, new mineral fertilizers, and non-standard methods of growing agricultural crops [12–14]. The application of smart functional covering polymer materials and substrates for growing crops, especially in breeding, where the most expensive and valuable seed material is used, contributes to the development of the field of effective crop production [15,16]. However, polymer covering materials and substrates for sowing seeds, or their analogues, must meet all safety and environmental measures regarding soil covers and agricultural crops.

Furthermore, biodegradable polymer composite materials based on polyesters (polylactide, poly-3-hydroxybutyrate, and polycaprolactone) expand the range of eco-friendly composites intended for use as film and fibrous materials in the industry and the agricultural sector [17–19]. The unique qualities of fibrous non-woven fabrics are light, air, and moisture permeability, which provide comfortable conditions for the growth and development of the plant. Environmentally friendly, non-emitting toxic substances, and polymer biobased materials provide ecological crop production [20,21]. The composition of various biodegradable agricultural materials depends on their specific applications being considered and their biodegradability behavior. Developing biodegradable composites with an optimum combination of desirable properties and biodegradation efficiency represents a rather challenging multidisciplinary task.

In the current work, polymer composites made of polylactide (PLA) with the addition of natural rubber (NR) were obtained by electrospinning. PLA is a thermoplastic polymer obtained from renewable raw materials: beet, corn, and grain production waste [22]. PLA is non-toxic, compatible with the human body, and has high strength properties, which make it one of the most promising and studied polymers [23–25]. Having a range of advantages, PLA has a significant drawback; it is fragile. To increase elasticity, rubbers are used as the second component in mixtures with PLA [26,27].

Natural rubber is an elastomer whose monomer unit consists of 1,4-cis-isoprene. The source of natural rubber is the milky sap of rubber plants—latex. NR, like PLA, undergoes biological degradation by microorganisms: molds and bacteria [28,29]. Thus, PLA/NR polymer substrates are environmentally friendly materials that can be degraded in the environment without the formation of toxic compounds.

As a part of smart farming, it is proposed to use compositions based on polylactide for pre-sowing seed treatment [30], as well as for the production of covering and mulching materials [31,32]. In the research [30], the authors studied the issue of seed encapsulation. When adhered to plants or plant parts, PLA materials can provide protection from insects and diseases pests. Also, in the work [33], the possibility of using non-woven agromaterials based on polylactide and poly-3-hydroxybutrate as substrates was investigated. The experiment was carried out in laboratory conditions. Germination and biometric parameters of wheat plants were determined on the 12th day of vegetation. In the control samples, without the application of polymer substrates, all numerical parameters were lower.

The purpose of this work is to evaluate the possibility of using the resulting non-woven PLA/NR composites for growing agricultural crops. Non-woven PLA/NR agrofabrics were used as substrates for growing purple basil (*Ocimum basilicum* L.) during vegetation. The basil plants passed the entire growing season until the flowering phase. The influence of the PLA/NR agrofabrics on the germination, growth, and development of basil in soil was studied. The photosynthetic activity of basil grown on PLA/NR agrofabrics was studied, and the content of chlorophyll *a*, chlorophyll *b*, and carotenoids was determined. At the same time, changes occurring in the polymer matrices were recorded. The structure and properties of the initial PLA/NR fibrous composites and after their application as substrates were controlled by optical, rheological, thermal, and X-ray methods.

2. Materials and Methods

2.1. Sample Preparation

Thermoplastic polylactide (PLA), 4032D: D-lactide is about 2%, with ρ = 1.24 g/cm^3 and a molecular weight (M_w) of 1.7×10^5 g/mol was procured from Nature Works (Minnetonka, MN, USA). Elastomer natural rubber (NR), SVR-3L with poly(cis-1,4-isoprene) content: 91–96, wt.%, Mooney viscosity 50 ± 5 (100 °C), and volatiles 0.8 wt.%, was kindly supplied by Vietnam Rubber Group (Ho Chi Minh City, Vietnam). Both polymers were used without any purification.

The non-woven PLA/NR agrofabrics were produced by electrospinning, as described in the work [33]. The ratio of the components (PLA/NR, wt.%) was 100/0, 95/5, 90/10, and 85/15.

2.2. The Cultivation of Purple Basil on Polymer Substrates in the Multisoil Compound

Purple basil seeds (Aelita Agrofirm, Moscow, Russia) in the amount of 25 pieces were evenly arranged on non-woven polymer substrates laid in the ground. A phytochamber (VIM, Moscow, Russia) was used to grow purple basil for 60 days. No polymer substrate was used in the control sample. In the same containers, 200 ± 20 g of soil of the brand “Soil Keva Bioterra”, (Gera LLC, Moscow Region, Lytkarino, Russia) with pH 6.3, was used. The content of the active substances was (N) $\geq$ 275 mg/L, (P_2O_5) $\geq$ 325 mg/L, and (K_2O) $\geq$ 325 mg/L. The experiment was carried out at a temperature of 25 ± 1 °C. During the experiment, all containers were moistened the same way. The experiment was carried out in four repetitions. The results presented in this article were calculated as the average value of the four experiments. The germination of basil was determined according to GOST 12038-84 (RU) [34]: Agricultural seeds. Methods for determination of germination.

2.3. Quantitative Determination of Photosynthetic Pigments

The determination of the content of chlorophyll and carotenoids was carried out according to the method in the work [35]. The quantitative analysis of pigments includes their extraction from plant fabrics using a solvent (acetone), the separation of the mixture into separate components, and spectrophotometry (Figure 1). The SF-104 spectrophotometer (Akvilon©, Podolsk, Russia) and chemically pure acetone from the Component-Reagent© (Moscow, Russia) were used in this work.

Figure 1. The resulting solutions for determining the content of photosynthetic pigments using the spectrophotometric method.

To do this, a die-cut weighing 0.1 g was weighed. After, the die-cutting was ground with a porcelain mortar with sand, chalk, and 2–3 mL of acetone. After grinding, the solution was placed in a Bunsen flask connected to a pump to filter the extract, which was then transferred to a measuring flask and brought to the mark with acetone. Then, the extract was poured into a quartz glass cuvette to determine the optical density of the pigment extract by wavelength on a spectrophotometer. In our research, three wavelengths were used: a wave of 662 nm for the determination of chlorophyll *a*, 644 nm for the determination of chlorophyll *b*, and 440.5 nm for the determination of carotenoids. The pigment concentration was calculated for 100% acetone (according to Holm–Wettstein):

$$C\ hl.a = 9.784 \times D662 - 0.990 \times D644$$
$$C\ hl.b = 21{,}426 \times D644 - 4.650 \times D662$$
$$C\ hl.a + hl.b = 5.134 \times D662 + 20.436 \times D644$$
$$C\ car. = 4.695 \times D440.5 - 0.268 \times C\ hl.a + hl.b,$$

where C *hl.a*—the concentration of chlorophyll *a*, mg/dm^3; C *hl.b*—the concentration of chlorophyll *b*, mg/dm^3; *D*—an optical density of the extract at wavelength.

2.4. Morphology of the Sample

The morphology of the initial PLA and PLA/NR fabrics and after growing test was characterized by scanning electron microscopy using Philips SEM-500 (Eindhoven, The Netherlands) and the Olympus BX3M-PSLED (Olympus, Tokyo, Japan) optical microscope at different magnifications in reflected light.

2.5. Density of Non-Woven Fabric

The linear and volumetric density of non-woven 100% PLA and PLA/NR fabrics were calculated according to ISO 9073-2:1995 [36]. The average density values were calculated from five replicates for each sample.

2.6. X-ray Diffraction

The structure of the samples was studied on a Bruker D8 Advance X-ray diffractometer (Billerica, MA, USA) with an optical focusing of the X-ray beam and a linear coordinate detector (CuKα radiation). The step size was 0.01125°, and the signal accumulation time was at least 0.2 s. The test samples, rectangular in shape with a side length of 25 mm, were placed in a standard horizontal position in low-background cuvettes. The X-ray scattering intensity in the diffraction patterns was presented as a function of $S = 2\sin\theta/\lambda$ (θ is half the scattering angle, and λ is the X-ray wavelength).

2.7. Analysis of Crystallization

Thermal analysis was performed with a differential scanning calorimeter (DSC) using a DSC 204 F1 device (Netzsch, Selb, Germany) under a nitrogen atmosphere with the gas flow rate of 40 mL/min. Samples of about 5.0–5.5 mg sealed in aluminum pans were heated from room temperature to 200 °C at a rate of 10 °C/min. Indium with T_m = 156.6 °C was used as a calibrant. The PLA crystallinity (χ_c) was estimated from the first heating cycle using the following equation:

$$\chi_c\ (\%) = 100\% \times (\Delta H_m / \Delta H_m^*),$$

where ΔH_m is the enthalpy of melting during heating; ΔH_m^* is the enthalpy assuming 100% crystalline PLA homopolymer 93.1 J/g.

2.8. Melt Flow Rate Measurement

The melt flow rate (MFR) was determined in accordance with GOST 11645-73 (ISO 1133-76) [37] on the IIRT-5 device (Asma-Pribor, Moscow, Russia), which is based on the principle of a capillary viscometer. The average MFR values were calculated from five replicates for each sample.

2.9. Statistical Analysis

The experimental results were calculated as the arithmetic mean and its standard error. The calculations were performed using Statistica 8.0 software (Dell Software Inc., Round Rock, TX, USA) and Microsoft Excel 2007. The significant differences were evaluated by Student's *t*-test (represents $p < 0.05$).

3. Results and Discussion

The appearance and morphology of 100% PLA and PLA/NR agrofabrics obtained by electrospinning are shown in Figure 2. The process of obtaining non-woven PLA/NR composites is described in detail in the work [27]. Externally, the samples are identical, but the morphology of PLA and PLA/NR agrofabrics is different. Unlike 100% PLA, the PLA/NR composites have a "beaded" morphology due to the difference in viscosity and the thermodynamic incompatibility of polylactide and natural rubber.

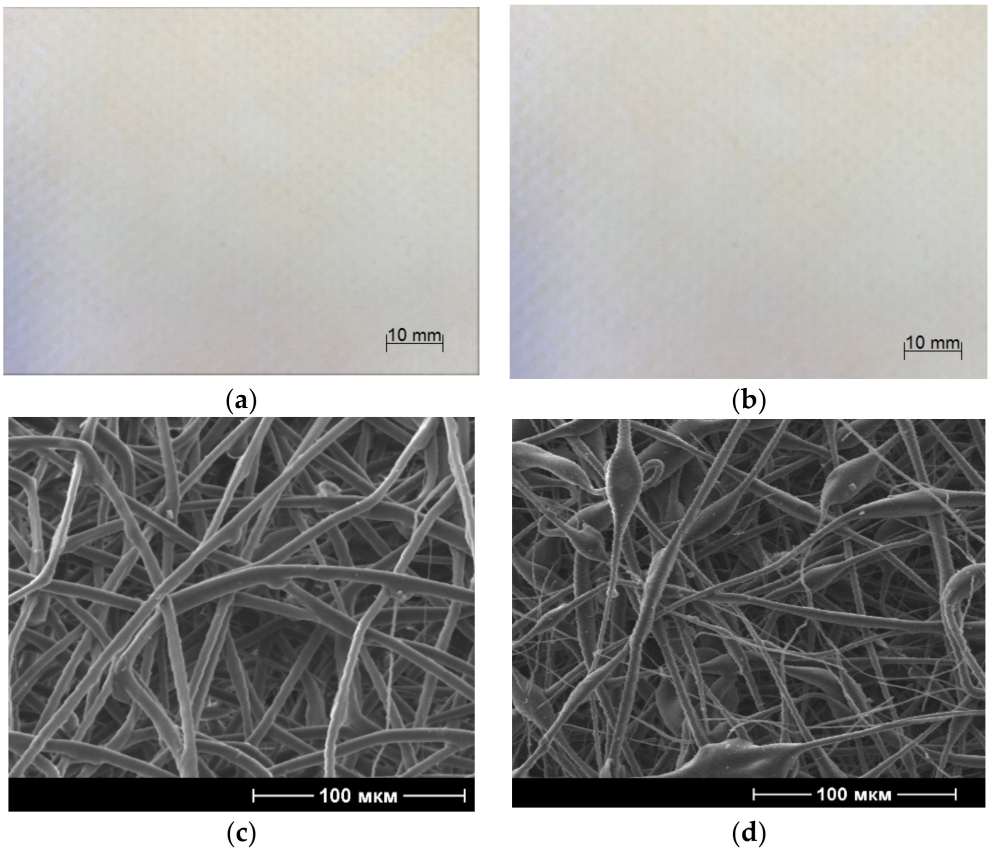


Figure 2. Morphology of initial samples—PLA (**a**) and 85PLA/15NR (**b**): digital camera; PLA (**c**) and 85PLA/15NR (**d**): SEM micrographs.

These polymer samples were used as a substrate for sowing basil seeds (Supplementary File). The growing season lasted 60 days before the basil bloomed. Figure 3 shows the appearance of basil plants in the control sample and using PLA substrate at the 40th day of vegetation. It is noticeable that the height of basil plants in the PLA sample is higher than the control sample.

Figure 3. Basil plants at the 40th day of vegetation: the control sample and PLA agrofabrics.

According to GOST 12038-84 [34], the germination of basil seeds was determined on the 10th day (Figure 4). The germination of basil in the control sample (70%) was lower than while using PLA/NR agrofabrics with (81–86%). Apparently, the polymer non-woven fabric absorbs moisture and the container with soil remains moistened longer compared to soil without a substrate. That is, at the initial stage, the main role is played by the process of water sorption by the polymer substrate and the diffusion of water into the soil. The correctness of the assumption is confirmed by the calculation of the structural parameters of the PLA/NR fiber: linear and volumetric density.

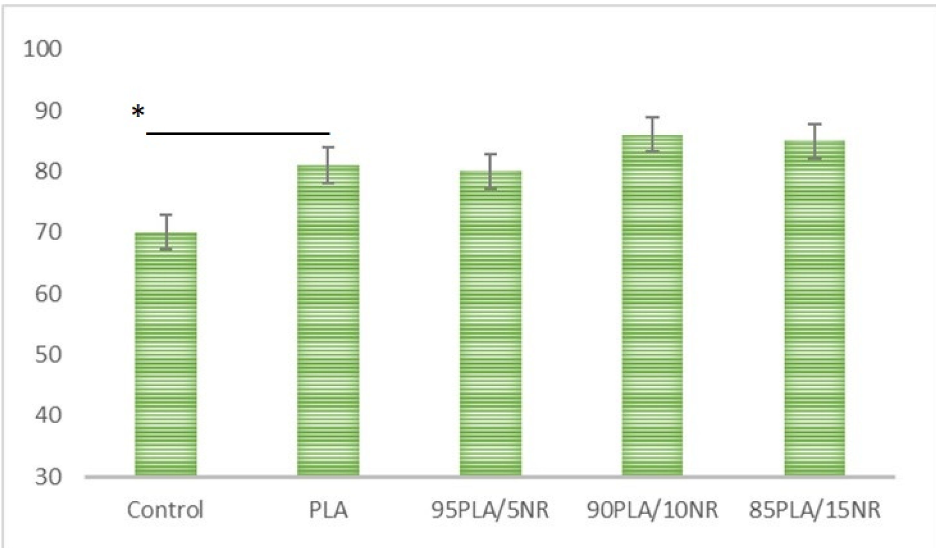


Figure 4. The germination of purple basil in the control sample and non-woven PLA and PLA/NR agrofabrics. The significant differences were evaluated by Student's *t*-test (* represents $p < 0.05$).

The germination of basil increases with the use of substrates and with the increasing density of polymer PLA/NR fabrics (Table 1). By absorbing moisture, a denser sample remains moistened longer, which contributes to the swelling of the seed and maintaining the moisture level at the initial stage of ontogenesis.

Table 1. Density of non-woven PLA and PLA/NR agrofabrics.

Composition of Samples, mass.%	Linear Density g/cm	Volumetric Density g/cm^3
100 PLA	0.0095 ± 0.00012	0.161 ± 0.011
95PLA/5NR	0.0096 ± 0.00014	0.175 ± 0.013
90PLA/10NR	0.0096 ± 0.00013	0.176 ± 0.013
85PLA/15NR	0.0098 ± 0.00015	0.182 ± 0.011

Then, after 60 days of vegetation of purple basil, biometric parameters were evaluated. According to Table 2, the height of the aboveground (green) part of basil plants grown on the substrate was 25–40% higher compared to the control sample. The length of the roots had a similar tendency.

Table 2. Biometric parameters of purple basil plants on the 60th day of vegetation.

Sample	Weight of One Plant, g	Shoot Height, cm	Root Length, cm
Control	10.5 ± 0.64	10.5 ± 0.64	5.7 ± 0.23
100 PLA	16.6 ± 0.78	16.6 ± 0.78	7.1 ± 0.25
95PLA/5NR	13.7 ± 0.56	13.7 ± 0.56	6.9 ± 0.28
90PLA/10NR	16.8 ± 0.61	16.8 ± 0.61	7.6 ± 0.32
85PLA/15NR	16.1 ± 0.66	16.1 ± 0.66	7.4 ± 0.30

The results obtained can be explained not only by the best supply of moisture to the root system, but also by the peculiarity of the chemical nature of polylactide. The PLA and PLA composites undergo hydrolytic destruction [38,39]. The presence of functional oxygen-containing groups ensures the hydrolysis process in the polymer matrix, because of which the main chain of the macromolecule breaks and compounds with a lower molecular weight are formed. Some of them dissolve in water. One of the decay products is lactic acid, which serves as an additional source of nutrition.

The basil root system plays an important role. In the process of growth, the roots mechanically destroy the fibrous PLA/NR composites and secrete enzymes that are involved in the process of the biodegradation of polymer substrates. In addition, the PLA/NR fabrics undergo biotic degradation under the influence of soil microorganisms. It is known that PLA and NR undergo enzymatic cleavage [40,41]. In the work [40], the biodegradation of PLA by a strain of Pseudomonas Aeruginosa was studied at a temperature of 30 °C. The change in the PLA structure was confirmed using Fourier-transform infrared spectroscopy and scanning electron microscopy. The hydrolysis of PLA films by purified esterase released oligomers of medium chain lengths (n = 6–13). Nanthini and co-authors [41] tested the activity of Streptomyces sp. on non-vulcanized and vulcanized latex. It showed a decrease in the number of cis-1,4 double bonds in the polyisoprene chain, the appearance of ketone, and the formation of aldehyde groups indicating an oxidative attack at the double bond of rubber hydrocarbon.

Thus, several factors contribute to the nutritional process of the basil plant, including the polymer substrate (Figure 5).

The PLA/NR composites as substrates affect not only the biometric parameters of purple basil, but also photosynthetic activity. The amount and ratio of pigments is an important and sensitive indicator of the physiological state of plants [42]. The composition and content of pigments can change under stress, during ontogenesis, when plants adapt to varying external conditions.

Photosynthetic pigments were determined by the spectrophotometric method: chlorophyll a, chlorophyll *b*, and carotenoids. From the data in Table 3, it can be concluded that using PLA/NR agrofabrics increases the content of all the studied pigments. The most striking results are observed for substrates with an NR content of 10 and 15 wt.%. The values of chlorophyll *a* enhance by 1.8–2.2 times, chlorophyll b by 2.5–3.2 times, and carotenoids by 2 times. The application of PLA/NR composites provides higher chloroplast activity, which leads to increased pigment production.

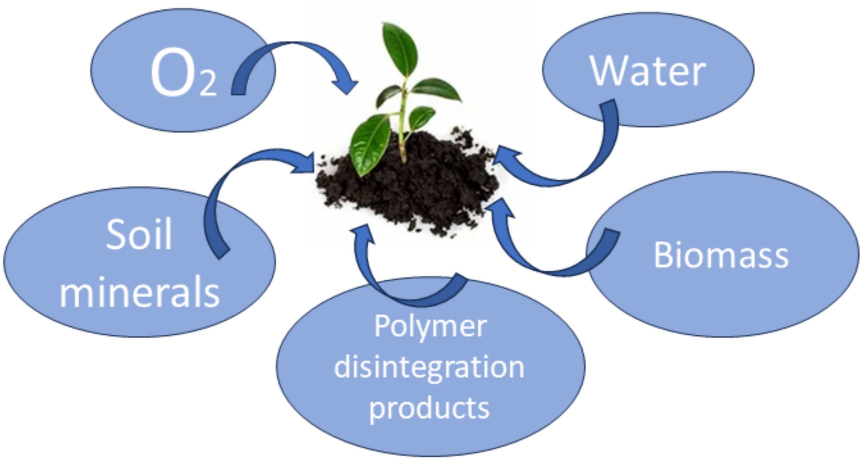


Figure 5. Plant nutrition diagram.

Table 3. The content of photosynthetic pigments (chlorophyll *a*, chlorophyll *b*, and carotenoids) in purple basil plants grown using non-woven PLA/NR agrofabrics and in the control sample.

Sample	Content of Chlorophyll *a*	Content of Chlorophyll *b*	Content of Carotenoids
Control	1.75 ± 0.09	0.23 ± 0.013	0.11 ± 0.021
100 PLA	3.03 ± 0.13	0.36 ± 0.013	0.15 ± 0.025
95PLA/5NR	2.86 ± 0.11	0.51 ± 0.020	0.13 ± 0.022
90PLA/10NR	3.32 ± 0.17	0.56 ± 0.033	0.21 ± 0.018
85PLA/15NR	3.82 ± 0.15	0.88 ± 0.032	0.25 ± 0.016

Beta-carotene, broken down into two components, turns into vitamin A, which is a precursor of retinol. For example, the carotenoid lutein is very beneficial for the eyes, protecting them from UV radiation. Carotenoids are not synthesized in the human body; they come only from plant foods. Increasing the content of these nutrients in basil enhances the nutritional value of this crop. The excellent organoleptic properties of grown basil have been determined. Smell, appearance, and taste were rated 5 points. The control basil received 4 points for appearance and smell.

It should be noted that the basil plants did not experience stress. It is known that the response of the biological system to stress is a decrease in the height of the plant and its weight. In parallel with these manifestations, a large amount of photosynthetic pigments accumulates, since the plant strives to withstand external conditions. In the experiment conducted, such behavior was not observed. The use of polymer non-woven agricultural fabrics leads to an increase in both biometric indicators and the amount of chlorophyll *a*, chlorophyll *b*, and carotenoids.

At the next stage, non-woven PLA/NR samples were characterized by various polymer research methods. Figure 6 shows the dependence of the change in the degree of crystallinity of polylactide in the initial PLA/NR samples (curve 1) and after the experiment (curve 2). In the original fibrous materials, the degree of PLA crystallinity slightly enhances with increasing NR content (curve 1). Researchers have repeatedly discovered an increase in the degree of crystallinity of 100% PLA during degradation due to the decomposition of the amorphous phase under the influence of water, enzymes, ozone, and UV radiation [18,24,38,43–45]. Only with a high degree of destruction in the polylactide matrix does the degree of crystallinity decrease.

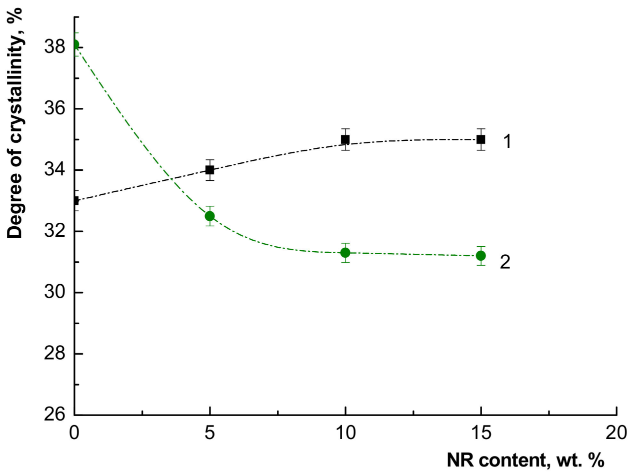
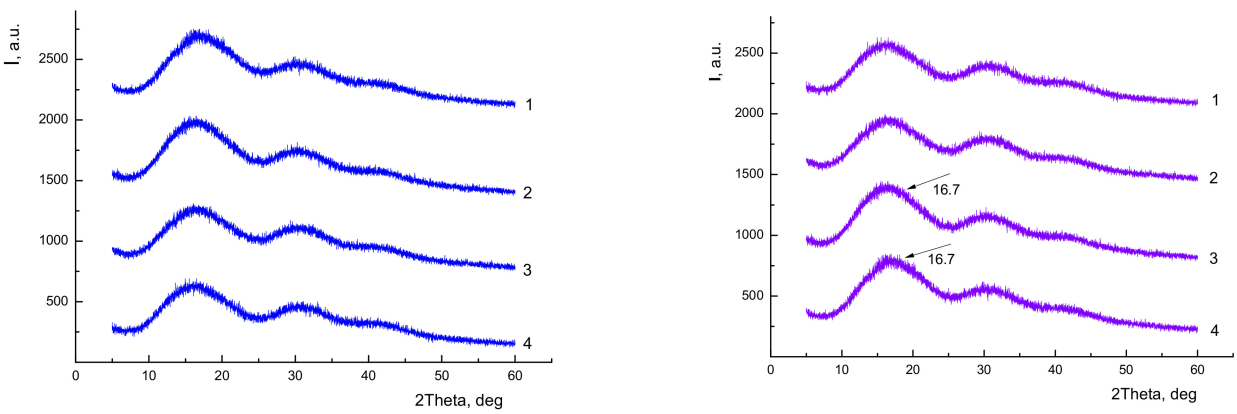


Figure 6. Change in the PLA degree of crystallinity: 1—initial PLA/NR samples; 2—PLA/NR samples after the experiment.

In the experiment with basil, a similar dependence for the degree of pure PLA crystallinity is observed (Supplementary File). After exposure to soil microbiota, the PLA degree of crystallinity increased by approximately 5% (Figure 6, curve 2). The PLA degree of crystallinity of PLA/NR composites changes slightly during the experiment but tends to decrease. The PLA melting point varies by 1–1.5 °C in all fibrous agromaterials. There is no global rearrangement of chains in fibrils, which is confirmed by X-ray diffraction.

It was found that all the resulting fibrous composites are X-ray amorphous (Figure 7). On the abscissa axis, diffraction maxima corresponding to the position of the main reflections of the α-form of the orthorhombic PLA lattice were not observed. After the experiment on growing basil, the diffraction patterns of non-woven PLA/NR agrofabrics did not change, which indicates the absence of the recrystallization process characteristic of polylactide. Apparently, the recrystallization process requires a temperature above the glass transition temperature of PLA, which is in the range of 50–60 °C.



(**a**) (**b**)

Figure 7. XRD patterns of non-woven PLA/NR samples with the NR content, wt.%: (1)—0, (2)—5, (3)—10, and (4)—15: (**a**)—initial samples, (**b**)—after the experiment.

In the work [46], the change in the crystal structure of PLA during annealing in water at T = 90 °C was studied. The diffraction patterns of PLA samples varied from X-ray amorphous to those characteristic of crystalline PLA formations with two clear maxima at 16.8 and 19.2 (2θ, deg). In the study, the temperature did not exceed 25 °C, which was insufficient to increase the mobility of segments of PLA macrochains even in the presence of soil moisture and metabolic products of microorganisms.

An important quantity characterizing the rheological properties of a polymer is the melt flow rate. For all fibrous samples, the MFR value was determined initially before and after using non-woven PLA/NR agrofabrics as substrates (Figure 8).

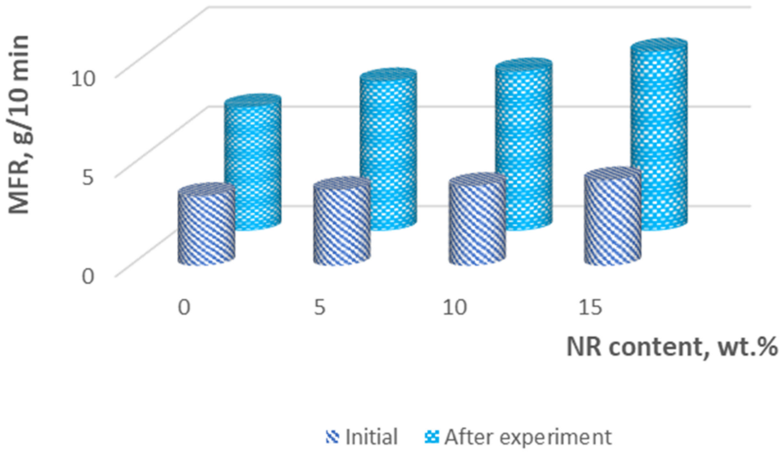
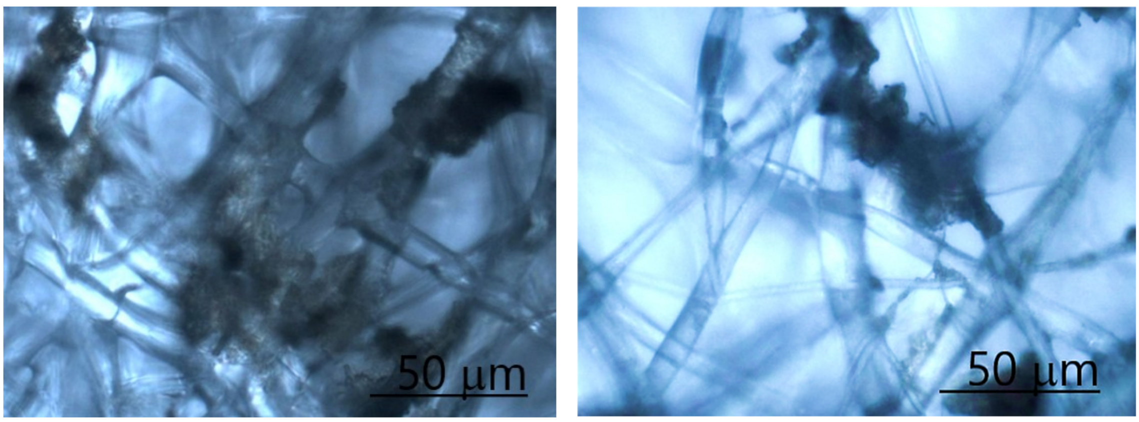


Figure 8. Melt flow rate of non-woven PLA/NR agrofabrics containing 0, 5, 10, and 15 wt.% of NR.

In the original composites, the MFR increases slightly with the addition of rubber. A sample with the NR content of 15 wt.% shows an increase in the MFR by 0.5 g/10 min compared to pure PLA. The adding of an amorphous component (NR) into the matrix of a crystallizing polymer (PLA) will increase the proportion of the amorphous phase in the non-woven composites, which in turn will necessarily affect the characteristics of the agrofabrics. After using PLA/NR composites as substrates for growing basil, the MFR value increases, indicating a decrease in the viscosity of the fibrous samples and their defectiveness. The process of PLA and PLA composites' biodegradation is a complex system of chemical and biological interactions, which may include hydrolysis and the action of enzymes secreted by microorganisms [18,21,38]. The hydrolytic and enzymatic cleavage of side bonds triggers the polymer degradation mechanism, which affects the rheological characteristics.

Also, PLA/NR agrofabrics were examined by optical microscopy. The microphotograph (Figure 9a) shows indelible darkening, which appears as a result of exposure to soil microorganisms and holes from basil roots.



(**a**) (**b**)

Figure 9. Micrographs of PLA/NR substrates after an experiment on growing purple basil: 95PLA/5NR (**a**) and 90PLA/10NR (**b**).

The impact of soil microbiota is clearly visible in Figure 9b. The volumetric domains created by microorganisms and the darkening of individual fibers are clearly observed in the micrograph. In addition to bacteria, any soil contains molds. The main plastic degraders are *Aspergillus*, *Penicillium*, and *Mucor* molds with highly active extracellular hydrolases, phosphatases, and other enzymes [47,48]. After soil degradation, the polymer agromaterial becomes fragile and brittle, which indicates the processes of biotic and hydrolytic degradation in the polymer matrix (Supplementary File). The PLA/NR non-woven composites lose their performance characteristics.

The issues of the biodegradation of PLA and PLA composites are widely covered by the scientific community [21,38,43,49–52]. In this work, another fact is important—the stimulating effect of the resulting non-woven composites. When biodegradable polymers break down, they form non-toxic compounds that do not harm the environment. On the contrary, decay products can serve as an additional source of nutrition for agricultural crops. The use of this technology can facilitate the metered supply of mineral fertilizers and protective agents, especially in granulation technology. Seed granulation is another direction of "smart" agriculture, which is gaining momentum in the modern agricultural industry. Alternative methods of crop production using biodegradable agrofabrics are quite competitive and environmentally friendly, especially compared to polyethylene and polyethylene terephthalate [53]. However, the effect of the long-term use of biodegradable polymers on soil covers has not been sufficiently studied. Studies of the effect of the polymer matrix decomposition products on the soil is the next planned stage of work.

4. Conclusions

Non-woven PLA/NR composites were obtained by electrospinning. PLA/NR samples containing 5, 10, and 15 wt.% NR were used as substrates for growing basil before the flowering stage. The application of polymer non-woven agricultural fabrics has led to an increase in both biometric parameters and the amount of chlorophyll *a*, chlorophyll *b*, and carotenoids. The values of germination, plant height, and root length were also superior to the control sample grown traditionally.

Presumably, the stimulating effect is associated with the absorption of water by the agrofabrics and a more uniform supply of water to the seed, which is an important factor at the initial stage of ontogenesis. During the experiment, the PLA/NR polymer matrices were exposed to moisture and soil microbiota. Due to hydrolytic and enzymatic degradation, the structural characteristics and rheological properties of the composites changed. The fibrous matrices were destroyed, forming organic substances that provided additional nutrition for the basil. Thus, the resulting nonwoven PLA/NR composites can be considered promising for the agricultural industry. However, a further study of the effect of polymer composites on the fauna and biochemical composition of the soil is required.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/jcs8030102/s1, Figure S1. The initial stage of basil vegetation; Figure S2. The non-woven 90PLA/10NR sample after biodegradation in soil; Figure S3. DSC thermograms of the initial non-woven PLA/NR agrofabrics containing 0, 5, 10 and 15 wt.% of NR.

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