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THE GIANT BAMBOO AND THE EVOLUTION OF THE EUROPEAN INDUSTRY TOWARDS THE SUSTAINABILITY OF MATERIALS

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Abstract

The text is the result of four years of study and experimentation on giant bamboo, of which over 2000 hectares have been planted in Italy from 2015 to today. A small experimental cultivation has been present since 2016 at the UASVM Bucharest. More than 30 million hectares of bamboo are grown worldwide. For the characteristics of its wood and for the abundance and continuity of production, it is to be considered one of the fundamental resources that Europe can draw on for an industrial turn towards the sustainability of materials. Bamboo finds application in many supply chains and makes it possible to create products with a negative $C0_2$ rate. Having overcome the initial diffidence for something that does not belong to European culture and tradition, with our pioneering activity we have found that, with the appropriate care and the right techniques, the plant can thrive in the temperate areas of our continent exactly as it thrives on them latitudes of China. Planted once, it produces oxygen, food and sustainable raw materials for about 100 consecutive years. The researches that were the basis of the preparation of the present paper aimed, on the one hand, the increase of the aerial biomass production realized by the giant bamboo plants with the age of 4 years at the surface unit, the dynamics of the sequestration of the organic carbon from the atmosphere, but also the improvement of the physical characteristics (moisture content) and resistance to mechanical actions of fibers, all against the background of practicing technological links as gentle with the environment. The results of the research have shown that this species is a viable alternative for reducing greenhouse gas emissions due to the ability to sequester large quantities of CO_2 from the atmosphere, while also representing an excellent building material, due to the superior physical and mechanical properties of other woody species. Exactly what the world of the future needs.

Key words*: bamboo, farming, industry, sustainability, prosperity.*

INTRODUCTION

If there are things that you will always need, they are: oxygen, food and sustainable raw materials. Bamboo, the fastest growing plant in the world, produces all this with abundance and quality. The sustainability of raw materials is today the central theme at world level, governments are moving accordingly. It is therefore clear that the great business of the coming years is precisely represented by sustainability. The prosperity economy model is the natural evolution of the profit economy. Prosperity Economy identifies profit as the natural result of widespread well-being, a shift paradigm that improves the quality of the environment and our life. When a big change is coming, there are two choices: ride it or suffer it, so industry can see sustainability as a problem or an opportunity.

The program stems from the experience gained from years in the world of the giant bamboo cultivation in Italy, a new type of crop for the European market, with a huge development potential.

The program is based on the observation that our civilization is inevitably developing on the use of natural raw material and on the consumption of food of non-animal origin with a high nutritional content.

The pioneering experiences of the recent years have served to understand the correct agronomic needs of the plant, to acknowledge the rules of planting and cultivation, the suitability and preparation of the land, the procedures for the correct management of the plant in order to obtain abundance of production.

The cultivation of bamboo enhances the agricultural land through a rich production, abundant and suitable for many uses (Ashby M., 2009). A bamboo plant produces wood, food and oxygen, for 80 to 100 consecutive years. Bamboo is a giant grass, a grass that exists in over 1500 different species, partly with a tropical climate, partly with a temperate climate (Bezze G. et al., 2017). With over 30 million hectares spread throughout the world (FAO, 2010b) and annual sales of over 60 million dollars, bamboo offers a natural and abundant tool to alleviate poverty, protect the environment and mitigate climate change. The plant is intertwined with the tradition and culture of many rural and tribal populations and has been an integral part of their cultural, social and economic conditions since time immemorial (Pauli G.A., 2010). It was nicknamed "friend of the people", "green gas", "the plant with a thousand faces", "green steel", "green gold".

From 2015 to today in Italy crops have been started for a total of 2000 hectares. Reaches 25 meters in height and 15 cm in diameter it is considered one of the most nutritious foods in the world and has high CO_2 absorption values (Morris D., 2006). It's the fastest growing plant in the world with peaks of 1 m/day Due to its characteristics wood is called "green steel". Each hectare produces hundreds of tons of material annually. It is cultivated without the use of chemicals, preserving the organic life of soils and aquifers.

During its life, one hectare of bamboo absorbs 1000 tons of CO_2 and produces 20 m^3 of material every year. Bamboo production therefore has a negative CO_2 rate. We can reverse the CO_2 process. Due to the organoleptic characteristics of the sprout and the mechanical characteristics of its wood, the plant finds application in many sectors such as: cellulose, textiles, construction, objects, cosmetics, pharmaceuticals, biomass, animal feed.

Great strides are being made in the search for new materials based on vegetable fiber. Almost everything that is currently produced with plastic is replaceable, and in the future many products currently made of minerals and metals will also be replaceable.

Europe has always purchased raw materials from other countries. On this new industrial chain, we have the climatic conditions and the know-how to be producers of raw materials. Who produces the raw material is at the top of an industrial pyramid.

No chemical treatments are used, bamboo is antifungal and natural pesticide, the organic quality of the soil and the purity of the underlying aquifers are preserved.

This underground biomass makes bamboo capable of surviving and regenerating when surface biomass is destroyed by fire. Bamboo, once developed, is also tolerant to flooding and drought.

Several aspects of bamboo biology make it excellent for stabilizing unstable soil and preventing soil erosion, thanks to its extensive root systems, that can measure up to 100 kilometers per hectare and live for about a century (Liese W., 1998). Bamboo is included among the phytoremediation plants for the ability to grow in polluted sites, absorb the heavy metals present in the soil and thus carry out a real remediation action.

MATERIALS AND METHODS

The research objectives

The research was carried out during the year 2019 within a giant bamboo plantation that was established in 2016 in the Ripapersico area, Italy, on a type of clay-alluvial soil.

The fundamental purpose of the experiment was to verify the influence of the different technological links (planting density and fertilization scheme) on increasing the weight biomass production and the technological characteristics of the wood obtained at harvest in same time.

The objectives of the research were:

a) to identify the optimal technological links in order to increase biomass accumulation;

b) to identify the optimal technological links in order to increase carbon biomass accumulation;

c) determination of the physic-mechanical properties of the fibers belonging to giant bamboo plants aged 4 years.

The laboratory analyzes and determinations aimed at:

- biometric determinations regarding the production of fresh and dry biomass/plant - by summing the biomass of the biomass components of the plants, respectively stems, branches and leaves (kg/plant);
- biometric determinations regarding the production of total fresh and dried biomass (tons/ha) - by reference to the density of plants at the surface unit, according to the sowing scheme (1200 plants/ha);

- researches regarding sequestered carbon biomass in bamboo plants aged 4 years (kg/plant, respectively tons/ha);
- tests regarding the moisture content of bamboo fibers (%), within a certain time interval;
- tests regarding the compressive strength of bamboo fibers (N/mm^2), within a certain time interval.

The experimental method used in research

The experience with the giant bamboo was one of a bifactorial type, placed in the field according to the method of the subdivided plots, in three repetitions, the experimental factors considered in the study being the following:

FACTOR A - fertilization scheme, with 3 graduations:

a1 - non fertilized (Control);
a2 - fertilized with 250 kg/ha Zeolite;
a3 - fertilized with 500 kg/ha Zeolite.

FACTOR B: irrigation regime, with 3 graduations:

- b1 - non irrigated (Control);
- b2 - irrigated with a norm of 1000 l water/ha;
- b3 - irrigated with a norm of 1500 l water/ha.

By combining the two experimental factors resulted 9 experimental variants, the processing and interpretation of the experimental results being done by analyzing the variance, according to the method of field placement of the experiment.

Observations and determinations made during the research

To determine the components of the aerial biomass on the giant bamboo, destructive strains samples were collected separately for each experimental variant.

The samples were brought to the laboratory where the aerial biomass components were separated from the plants, respectively the culms, branches and leaves and their weighing, thus resulting in the production of fresh biomass reported on the plant, the results of the weighing being used subsequently to determine the total biomass production obtained at the surface unit. After the determination of the fresh biomass the analysis samples were dried in the oven, at a constant temperature of 60ºC, for 24 hours, for the culms and their branches, respectively 20ºC, for the leaves.

The biomass carbon sequestrated into bamboo plants been obtain by multiplying total biomass production resulted after the biometric tests with default carbon fraction value 0.47 (Eggleston H.S. et al., 2006).

In order to evaluate the physic-mechanical characteristics of the giant bamboo fibers, 5 culms from each experimental variant were selected, culms that were harvested by shaving at ground level and were then allowed to air dry 6 months, until the color of the stems became yellowish, specific to the bamboo wood for industrial processing.

The bamboo culms were cut into small samples being taken from the ridge internode in accordance with the provisions of ISO 22157: 2019, 1st Part. The samples were taken along the ridge length, from three different points, respectively at the base of the culm, at the middle and at the apical part of the culm, the selection internodes being free of knots.

To perform the compression strength test we used a universal testing machine, applying a constant load of 0.01 mm/s on the test pieces, the maximum load obtained for each sample being recorded. After the compression test was completed, 25 mm x 25 mm specimens were taken to determine the moisture content of the fiber. For this purpose, the specimens were initially weighed and then dried in a hot air drying oven at 103 ± 2ºC for 24 hours. In order to quantify the amount of moisture remaining after being dried in the air-drying oven the samples were retested.

RESULTS AND DISCUSSIONS

Research results regarding fresh the aerial biomass production

The experimental results obtained from the determination of the aerial biomass of the bamboo plants belonging to each experimental variant (Table 1) showed a great variability due to the influence of the irrigation regime and the biological fertilization scheme practiced within the experiment, the values of this biometric parameter increasing directly in proportion to the quantity of water and the dose of fertilizer administered to the bamboo plants, with values that were between 4.73 kg fresh matter/plant, the lowest production of fresh biomass recorded in the case of the control variant (a1b1), in conditions of non-fertilization and non-irrigation of the plants and 64.33 kg fresh matter/plant, in the experimental variant a3b3, this variant realizing the highest production of fresh biomass, against the background of the basic fertilization of the plants with 500 kg/ha Zeolit and of the administration of a norm of irrigation of 1500 liters water/ha.

Performing a detailed analysis on the dynamics of biomass accumulation within the 9 experimental variants studied, it is found that, compared to the control variant a1b1, the rest of the experimental variants recorded production increases ranging between 1.76 kg fresh matter/plant and 59.60 kg fresh matter/plant, spores that had statistically insignificant positive assurance (-) or significantly positive (x), in the experimental variants in which the plants were irrigated with a norm of 1000 liters water/ha, respectively 1500 liters water/ha, under conditions of non-fertilisation a1b2 and a1b3), distinctly significantly positive (xx), in the variants in which the bamboo plants benefited from the nutritional contribution brought by the administration of 250 kg/ha Zeolit (a2b1, a2b2 and a2b3) and very significantly positive (xxx), under the conditions of fertilization with 500 kg/ha Zeolit, regardless of the irrigation norm administered to the plants (a3b1, a3b2 and a3b3).

Table 1. Fresh aerial biomass production as result of the experimental factors influence

Experimental variants	Aerial biomass (kg f.m./pl.)	Difference (kg f.m./pl.)	Total biomass (t f.m./ha)	Difference (t f.m./ha)	**Signification**	
a1b1 (Control)	**4.73**	**Control**	**5.67**	**Control**	**-**	**-**
a1b2	6.49	1.76	7.79	2.12	-	-
a1b3	8.99	4.26	10.78	5.11	x	x
a2b1	10.83	6.10	12.99	7.32	xx	xx
a2b2	14.63	9.90	15.55	9.88	xx	xx
a2b3	16.81	12.08	20.18	14.51	xx	xx
a3b1	52.98	48.25	63.58	57.91	xxx	xxx
a3b2	60,64	55.91	72.77	67.10	xxx	xxx
a3b3	64.33	59.60	77.19	71.52	xxx	xxx
$DL_{5\%}$ = 1.96; $DL_{1\%}$ = 4.64; $DL_{0,1\%}$ = 15.42 $DL_{5\%}$ = 2.32; $DL_{1\%}$ = 5.36; $DL_{0,1\%}$ = 18.19						

The total biomass production from the giant bamboo plants at the surface unit ranged from 5.67 tons fresh matter/ha to 77.19 tons fresh matter/ha, the highest yields being obtained when administering a dose of 500 kg/ha Zeolit, the plants belonging to these experimental variants producing over 57 tons fresh matter/ha, far superior to those obtained by practicing the other fertilization schemes, irrespective of the irrigation regime practiced within the experiment.

Compared to the control variant (a1b1), the production increases ranged from 2.12 tons fresh matter/ha and 71.52 tons fresh matter/ha, statistically insignificant positive (-), in the case of the experimental variant a1b2, significantly positive of 5.11 tons fresh matter/ha, variant a1b3, distinctly significantly positive (xx), between 7.32 tons fresh matter/ha and 14.51 tons fresh matter/ha in the variants a2b1, a2b2 and a3b3 and very significantly positive (xxx), between 57.91 tons fresh matter/ha and 71.52 tons fresh matter/ha in the experimental variants a3b1, a3b2 and a3b3, variants where the most efficient technological links were practiced, links that had a direct impact in increase the accumulation rate of biomass at the surface unit.

Research results regarding the dry aerial biomass

Following the determination of the aerial biomass production as a dry substance (Table 2) the same dynamics of growth production was observed with the increase of the Zeolite dose and the irrigation norm, the biomass productions that were recorded between 3.31 kg dry matter/plant and 25.83 kg dry matter/plant, minimum production of dry aerial biomass obtained in the case of control variant a1b1, higher quantities of dry matter being stored in the bamboo plants tested in the experimental variants where for the filling of the nutrients needed of the plants administered 500 kg/ha Zeolit, against the background of administering an irrigation norm of 1000 liters water/ha or 1500 liters water/ha (a3b2 and a3b3).

Compared with the control of the experience (a1b1), the production differences were between 0.99 kg dry matter/plant and 22.52 kg dry matter/plant, differences that were provided statistically insignificant positive (-), in the experimental variant a1b2, significantly positive (x), for variants a1b3, a2b1, a2b2 and a2b3 and very significantly positive (xxx), for experimental variants a3b1, a3b2 and a3b3.

Table 2. Dry aerial biomass production as result of the experimental factors influence

Experimental variants	Aerial biomass (kg d.m./pl.)	Difference (kg d.m./pl.)	Total biomass (t d.m./ha)	Difference (t d.m./ha)	**Signification**	
a1b1 (Control)	**3.31**	**Control**	**3.97**	**Control**	**-**	**-**
a1b2	4.30	0.99	5.16	1.19	-	-
a1b3	5.78	2.47	6.93	2.96	x	X
a2b1	5.57	2.26	6.68	2.71	x	X
a2b2	7.13	3.82	8.55	4.58	x	Xx
a2b3	8.36	5.05	10.03	6.06	x	Xx
a3b1	20.56	17.25	24.67	20.70	xxx	Xxx
a3b2	24.09	20.78	28.90	24.93	xxx	Xxx
a3b3	25.83	22.52	30.99	27.02	xxx	Xxx
$DL_{5\%}$ = 1.44; $DL_{1\%}$ = 7.13; $DL_{0,1\%}$ = 11.90 $DL_{5\%}$ = 1.32; $DL_{1\%}$ = 3.99; $DL_{0,1\%}$ = 10.12						

The experimental results regarding the total biomass production, demonstrated a linear increase of the values of this biometric parameter, directly correlated with the increase of the water quantity and of the fertilizer dose applied to the plants, the best answer to the practice of these technological links obtained on the bamboo plants that were fertilized with 500 kg/ha Zeolit, the total biomass production of dry matter for these experimental variants ranging from 24.67 tons dry matter/plant and 30.99 tons dry matter/ha (Table 2.). These results can be attributed both to the contribution of microelements present in this natural fertilizer and to the ability of Zeolite to favor water conservation in the soil for a long time and to favor cationic exchange in soil solution, thus increasing the accessibility for plants of the nutrients present in the soil.

The differences regarding the production of dry biomass realized at the surface unit within the 8 experimental variants, compared with the control variant, non-fertilized and non-irrigated (a1b1) ranged between 1.19 tons dry matter/plant and 27.02 tons dry matter/ha, differences statistically insignificant positive (-) of 1.19 tons dry matter/plant (a1b2), significantly positive with production increases between 2.96 tons dry matter/plant and 2.71 tons dry matter/plant in variants a1b3, respectively a2b1, distinctly significantly positive (xx) between 4.58 tons dry matter/plant (a2b2) and 6.06 tons dry matter/plant (a2b3) and very significantly positive (xxx) with production increases of over 20.70 tons dry matter/plant in experimental variants a3b1, a3b2 and a3b3.

Research results regarding carbon biomass sequestrated

The results regarding the carbon biomass sequestered by the giant bamboo plants of 4 years old are centralized in Table 3. Analyzing the data entered in this table it is observed that the capacity of the plants to sequester the organic carbons from the atmosphere has registered very large variations between the experimental variants taken in the study, there is a direct correlation between the irrigation regime, the fertilization scheme and the values recorded by this parameter, the rate of growth and vegetative development of the plants and implicitly of carbon assimilation being maximum (12.14 kg carbon biomass/plant) under the conditions of the administration of 500 kg/ha Zeolit, against the background of the administration during the vegetation period of the plants of an irrigation norm of 1500 liters water/ha (a3b2).

In the experimental variants in which the fertilization of the plants was done with a dose of 250 kg/ha Zeolit the biomass of carbon sequestered in the plants ranged between 2.62 kg carbon biomass/plant and 3.93 kg carbon biomass/plant while, in the case of the non-fertilized bamboo plants due to the deficient growth and vegetative development the rate of carbon sequestration has been greatly diminished the values of this indicator being between 1.56 kg carbon biomass/plant and 2.72 kg carbon biomass/plant.

Compared with the control variant a1b1 for which the carbon biomass was only 1.56 kg carbon biomass/plant, the rest of the experimental variants tested in the research registered differences from a statistical point of view from insignificant positive (-) in variants a1b2 and a2b1, significantly positive (x) of 1.16 kg carbon biomass/plant in the case of variants a1b3, distinctly significantly positive (xx) between 1.78 kg carbon biomass/plant and 2.37 kg carbon biomass/plant in the case of experimental variants a2b2 and a2b3, differences that have become very significantly positive (xxx) with more than 8.11 kg carbon biomass/plant in the experimental variants in which the plants benefited from the optimal supply with the nutrients essential for the good development of physiological processes responsible for the growth and harmonious development of plants.

Table 3. Carbon biomass sequestrated as result of the experimental factors influence

Experimental variants	Carbon biomass (kg/pl.)	Difference (kg/pl.)	Total carbon biomass (t/ha)	Difference (t/ha)	**Signification**	
a1b1 (Control)	**1.56**	**Control**	**1.87**	**Control**	**-**	**-**
a1b2	2.02	0.46	2.43	0.56	-	-
a1b3	2.72	1.16	3.26	1.39	x	X
a2b1	2.62	1.06	3.14	1.28	-	X
a2b2	3.35	1.78	4.02	2.15	xx	Xx
a2b3	3.93	2.37	4.71	2.85	xx	Xx
a3b1	9.66	8.11	11.60	9.73	xxx	Xxx
a3b2	11.32	9.76	13.58	11.72	xxx	Xxx
a3b3	12.14	10.59	14.57	12.70	xxx	Xxx
$DL_{5\%} = 1.12$; $DL_{1\%} = 1.59$; $DL_{0,1\%} = 5.13$ $DL_{5\%} = 0.83$; $DL_{1\%} = 1.68$; $DL_{0,1\%} = 6.34$						

The same evolution is also observed when analyzing the total biomass of carbon sequestered by giant bamboo plants at the surface unit (Table 3.) the assimilation of organic carbon from the atmosphere intensifying with the increase of the amount of water and natural fertilizer administered to the plants.

The values of this indicator were between 1.87 tons carbon biomass/ha and 14.57 tons carbon biomass/ha, the most valuable in terms of the capacity of assimilation and sequestration of the carbon from the atmosphere being the bamboo plants with the most intense vegetative growths, the contribution Zeolite administration as a natural fertilizer against the background of optimum supply of water plants finding in the increase in height and diameter of the culms and also in increasing the value of the leaf surface index of the leaves, vegetative organs in which was sequestered large amount of organic carbon.

Compared to the control of the experience (a1b1) in the rest of the experimental variants studied the capacity of the bamboo plants to assimilate the organic carbon from the atmosphere increased with differences recorded being between 0.56 tons carbon biomass/ha and 12.70 tons carbon biomass/ha with statistically assurance insignificant positive (-) to variant a1b2, significantly positive (x) to variants a1b3 and a2b1, distinctly significantly positive (xx) in the case of experimental variants fertilized with 250 kg/ha Zeolite and irrigated with a norm of 1000 liters of water/ha (a2b2) or 1500 liters water/ha (a2b3) and very significantly positive (xxx) under the conditions of administration of 500 kg/ha Zeolit regardless of the irrigation rule administered to plants.

Research results regarding the bamboo fibers moisture content

The tests on the water content of the bamboo fibers determined at 1 month, respectively 6 months after the air drying time, showed that the values of this physical parameter were influenced by both experimental factors (the fertilizer dose and the amount of water administered to the bamboo plants) and as well from the sampling place of the wood samples, respectively from the base, the middle or the top of the culm, the experimental results obtained from the determinations being centralized in Table 4.

Overall, the average water content of giant bamboo fibers at 1 month after the air drying time of the culms was between 19.15%, the minimum value obtained in the case of the control variant (a1b1) and 21.05%, the content the highest in water of fibers recorded in the

samples from the variant in which the plants were optimally supplied with both water and nutrients (a3b3).
In a detailed analysis of the results recorded after determining the water content of the bamboo fibers taken from the 9 experimental variants studied we find that in the samples collected from the base of the culm the humidity of the fibers varied between 18.23% and 19.62%, in the samples taken from the middle of the culm the values of the recorded humidity were between 19.11% and 21.73% whereas, the samples collected from the apical internode of the culm had a moisture content that oscillated between the limits of 20.13 % and 21.81%, the variation of this parameter increasing by approximately one percentage unit from the base to the tip of the stem.

Table 4. Bamboo fibers moisture content as result of the experimental factors influence

Experimental variants		Moisture content after 1 month (%)	Average after 1 month (%)	Difference after 1 month (%)	Moisture content after 6 months (%)	Average after 6 months (%)	Difference after 6 months (%)	**Signification**	
a1b1 (Control)	Bottom	**18.23**			**13.25**				
	Middle	**19.11**	**19.15**	**Control**	**14.22**	**14.20**	**Control**	**-**	**-**
	Top	**20.13**			**15.15**				
a1b2	Bottom	18.34			13.32			x	-
	Middle	19.53	19.49	0.34	14.55	14.50	0.30		
	Top	20.61			15.63				
a1b3	Bottom	18.46			13.48			x	x
	Middle	19.59	19.58	0.43	14.61	14.60	0.40		
	Top	20.71			15.73				
a2b1	Bottom	18.63			13.65			xx	x
	Middle	19.72	19.74	0.59	14.74	14.76	0.56		
	Top	20.87			15.89				
a2b2	Bottom	18.92			13.94			xx	xx
	Middle	19.88	19.92	0.77	14.90	14.94	0.74		
	Top	20.97			15,99				
a2b3	Bottom	19.03			14.05			xxx	xxx
	Middle	21.09	20.51	1.36	16.11	15.53	1.33		
	Top	21.42			16.44				
a3b1	Bottom	19.27			14.29			xxx	xxx
	Middle	21.16	20.64	1.49	16.18	15.66	1.46		
	Top	21.51			16.53				
a3b2	Bottom	19.48			14.50			xxx	xxx
	Middle	21.33	20.81	1.66	16.35	15.83	1.63		
	Top	21.64			16.66				
a3b3	Bottom	19.62			14.64			xxx	xxx
	Middle	21.73	21.05	1.90	16.20	15.86	1.66		
	Top	21.81			16.75				
$DL_{5\%} = 0.33$; $DL_{1\%} = 0.48$; $DL_{0,1\%} = 0.92$									
$DL_{5\%} = 0.38$; $DL_{1\%} = 0.61$; $DL_{0,1\%} = 0.87$									

The water content of the samples collected from the 8 experimental variants registered compared with the control variant differences between 0.34 and 1.90 percentage points being from a statistically significant positive point (x) to the samples collected from the unfertilized experimental variants (a1b2 and a1b3), distinctly significantly positive in the samples collected from the variants in which the plants were fertilized with 250 kg/ha Zeolite, under non-irrigation or irrigation conditions with a irrigation norm of 1000 liters water/ha (a2b1 and a2b2) and very significantly positive (xxx) in the case of the experimental variant where on the background of the fertilization with 250 kg/ha Zeolit was administered during the vegetation period of the plants an irrigation norm of 1500 liters water/ha (a2b3), as well as in the samples that were taken from the culms of the plants that benefited from supplementing the necessary nutrients by administering 500 kg/ha Zeolite (a3b1, a3b 2 and a3b3).
As the drying time of the bamboo culms collected from the 9 experimental variants increased the moisture content of the fibers decreased by about 5 percentage points compared to the initial moment of the determinations (after 1 month) so that the values of this physical indicator approached the considered value reference STAS regarding the moisture content of the

fibers, respectively 12%. Thus, we observe the same dynamics of moisture loss inside the fibers as we move from the tip of the culms to their base, the lowest humidity being determined in the case of samples taken from the internodes from the base of the culm with values between 13.25% and 14.64%, followed closely by the samples collected from the internodes from the middle of the culm with values between 14.22% and 16.20% and those collected from their apical internodes with values that ranged between 15.15% and 16.75%.

Following the free air drying of the bamboo culms for 6 months the average moisture content of the specimens varied between 14.20% and 15.86%, the bamboo fibers being considered to be of good quality as a result of the combined action of the experimental factors studied (fertilization scheme x irrigation scheme), from the point of view of this physical indicator the differences from the control variant a1b1 being very close between 0.30 and 1.66 percentage points with statistical assurance of from insignificant positive (-), to very significantly positive (xxx).

Research results regarding the bamboo fibers compressive strength

The samples taken from the giant bamboo stalks air-dried for 1 month had a different resistance to compression, resistance that increased as the determinations advanced from the base to the top of the culms regardless of the experimental variant from which the culms were collected. Thus, the fibers present in the samples taken from the base of the culms have the least resistance to the compression test being recorded values of this mechanical indicator between 48.17 N/mm^2 and 77.43 N/mm^2, those collected from the middle the culms have an increased compressive strength, respectively between 53.12 N/mm^2 and 78.54 N/mm^2, the samples taken from the apical internode of the culms being the most resistant to the mechanical action on the fibers, the compression resistance in these fibers varying between 57.34 N/mm^2 and 79.41 N/mm^2 (Table 5).

Table 5. Bamboo fibers compressive strength as result of the experimental factors influence

Experimental variants		Compressive strength after 1 month (N/mm^2)	Average after 1 month (N/mm^2)	Difference after 1 month (N/mm^2)	Compressive strength after 6 months (N/mm^2)	Average after 6 months (N/mm^2)	Difference after 6 months (N/mm^2)	**Signification**	
a1b1 (Control)	Bottom	**48.17**	**52.87**	**Control**	**53.77**	**58.49**	**Control**	**-**	**-**
	Middle	**53.12**			**58.75**				
	Top	**57.34**			**62.97**				
a1b2	Bottom	51.43	58.28	5.41	57.06	63.91	5.42	x	x
	Middle	58.96			64.59				
	Top	64.47			70.10				
a1b3	Bottom	58.12	64.13	11.26	63.75	69.79	11.30	xx	xx
	Middle	66.13			71.76				
	Top	68.24			73.87				
a2b1	Bottom	60.03	66.33	13.46	65.66	71.96	13.47	xxx	xxx
	Middle	67.92			73.55				
	Top	71.05			76.68				
a2b2	Bottom	62.13	68.18	15.31	67.76	73.81	15.32	xxx	xxx
	Middle	68.33			73.96				
	Top	74.08			79.71				
a2b3	Bottom	66.23	70.31	17.44	71.86	72.61	14.12	xxx	xxx
	Middle	69.56			75.19				
	Top	75.16			80.79				
a3b1	Bottom	69.06	73.51	20.64	74.69	79.14	20.65	xxx	xxx
	Middle	74.67			80.30				
	Top	76.81			82.44				
a3b2	Bottom	72.18	75.45	22.58	77.81	81.08	22.59	xxx	xxx
	Middle	76.13			81.76				
	Top	78.06			83.69				
a3b3	Bottom	77.43	78.46	25.59	83.06	84.09	25.60	xxx	xxx
	Middle	78.54			84.17				
	Top	79.41			85.04				
$DL_{5\%} = 4.02$; $DL_{1\%} = 9.97$; $DL_{0,1\%} = 11.33$ $DL_{5\%} = 4.36$; $DL_{1\%} = 10.03$; $DL_{0,1\%} = 12.71$									

The average values of the compressive strength of the bamboo fibers were also influenced by the interaction of the experimental factors studied in this research so that, under conditions of non-fertilization of the plants the compressive strength of the fibers as a mean of the irrigation regime ranged from 52,87 N/mm^2 and 64.13 N/mm^2. Following the administration of a dose of 250 kg/ha Zeolite the fibers were more resistant to mechanical action with average values between 66.33 N/mm^2 and 70.31 N/mm^2 by supplying 500 kg/ha Zeolite the opposite resistance of fibers to the mechanical action of compression increasing significantly, their compressive strength exceeding 73.00 N/mm^2 (77.43 N/mm^2 - 78.46 N/mm^2).

The differences recorded after the determination of the resistance of the giant bamboo fibers to compression, in comparison with the variant taken as an experimental control had a statistically significantly positive assurance in the case of the a1b2 variant (5.42 N/mm^2), distinctly significantly positive (xx), at variant α1b3 (11.26 N/mm^2) and very significantly positive (xxx) at the rest of the experimental variants with differences ranging from 13.46 N/mm^2 to 25.59 N/mm^2.

After 6 months of natural drying of the stems, the resistance of the fibers to compression has increased significantly especially due to the reduction of their moisture content, the average values recorded being between 58.49 N/mm^2, the lowest compression resistance manifested by the fibers belonging to of the culms harvested from the control variant (a1b1) and 84.09 N/mm^2 in the case of fibers belonging to the strains harvested from the experimental variant a3b3.

Throughout the strain the resistance of the fibers to the mechanical action followed the same trend as in the first stage of the compression tests (1 month after the drying of the culms), increasing from the base to the tip of the culm with the average value between 53.77 N/mm^2 and 83.06 N/mm^2 in the case of samples taken from the basal internode of the culm, between 58.75 N/mm^2 and 84.17 N/mm^2 in the samples collected from the internode from the middle of the culm, respectively between 62.97 N/mm^2 and 85.04 N/mm^2 for the fibers present in the specimens collected from the apical internode of the culm.

Compared with the compressive strength opposed by the samples belonging to the control variant (a1b1), in the case of the other experimental variants tested during the research the compressive strength of the fibers increased after 6 months by over 5.42 N/mm^2 being insured from the point of view statistically significant positive (x) in variant a1b2, distinctly significantly positive (xx) at variant a1b3 and very significantly positive (xxx) for the rest of experimental variants studied.

The evolution of the mechanical characteristics of the giant bamboo fibers with the age of 4 years can be taken into account the specific anatomical and biological particularities of this species, with the dynamics of fiber formation inside the strain depending on the intensity of the vascularization of the strain, with the physiological process that takes place with the highest intensity in the apical part of the culm which is why the higher number of fibers are formed in the upper internodes of the stem, thus increasing their resistance to mechanical actions.

CONCLUSIONS

Due to its many and varied uses giant bamboo is the species with the fastest growth rate, the extraordinary capacity of regeneration of this plant being the reason why the culture has started to gain more and more land not only in the countries with tradition in the cultivation of bamboo, but also in the area of temperate climate, including in Romania.

The production of biomass (fresh and dried matter) was directly influenced by the mineral fertilization scheme and irrigation regime practiced during the research, the highest biomass production being realized in the case of the bamboo plants that were optimally supplied with water as well as with the nutrients necessary for the growth and harmonious development of the plants, thus obtaining yields of over 77 tons fresh biomass, respectively productions of over 30 tons dry matter at the surface unit the giant bamboo thus representing a sustainable source of biomass that can be used as a raw material in the pulp and paper industry or as a renewable source of green energy.

Although at present the giant bamboo culture in Europe is regarded as a challenge, in the near future this culture will certainly be regarded as an alternative in reducing greenhouse gases, due both to the rapid growth rate, the extraordinary capacity of regeneration, the longevity of the species, but also the extraordinary ability of this species to fix CO_2 from the atmosphere, the plants tested in the present research sequestering over 14.5 tons carbon biomass/ha by using friendly practices with the environment.

The moisture content of the fibers was influenced by both the experimental factors studied in the study and the sampling point of the culms, the values of this physical parameter increasing from the base of the stalk to its apical part and directly proportional to the dose of fertilizer and the amount of water administered to the plants during the vegetation period, the humidity of the fibers after 6 months of air drying being about 16%.

The resistance of the fibers to compression was influenced by their moisture content at the time of the mechanical tests but also by the anatomical-morphological properties of the species, the highest resistance to the mechanical action being recorded in the samples taken from the apical internodes of the culm which are highly vascularized and in which the greatest number of fibers are formed.

The compressive strength of giant bamboo fibers after the natural drying of the stems for 6 months increased directly in proportion to the increase in the number of fibers formed in the culm internodes and inversely proportional to the moisture content of the fibers, the values recorded by this parameter exceeding 79 N/mm^2 (higher than steel) under the conditions of practicing efficient technological links which makes the bamboo stems to be considered very resistant to mechanical actions, thus being successfully used as a resistance material in the field of construction.

In these new industrial chains, Europe no longer needs them: we have the know-how and we have the climate to produce the raw material for the next years on our own. And we know that whoever produces the raw material is placed at the top of the pyramid of an industrial chain and therefore has control over it.

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