A Comparative Investigation on the Physical Features and Productivity of Conventionally and Organically Cultivated *Avena Sativa*

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TIIVISTELMÄ
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Tämän tutkimuksen päämääränä oli selvittää luonnonmukaisen ja perinteisen viljelyn vaikutus kauran, *Avena Sativa*, rakenteeseen sekä sen tuottaman sadon määrään. Vertailevan tutkimuksen avulla määritettiin näiden kahden viljelytavan tuottamien kasvien rakenteelliset erovaisuudet sekä vaihtelut niiden keskimääräisissä jyvämäärissä. Selvityksen pohjana oli havainto, että teho- ja luonnonmukaista viljelyä vertailevia empiirisiä tutkimuksia on suoritettu suhteellisen vähän. Viljellyn kasvin ja viljelytavan välistä suhdetta tutkivan tieteellisen aineiston pieni määrä antoi kipinän tutkimuksen suorittamiselle.

Tutkielman kokeellisen osan perustana oli kolme eri tuotantotavoilla viljeltyä kaurapeltoa. Kaksi neliömetrin kokoista näytteenottoneliötä rajattiin luonnonmukaiselle, tehoviljellylle sekä täysin lannoittamattomalle pellolle, ja sattumanvaraisesti valituille kasviyksilöille ajettiin sarja erilaisia kokeita. Jokaisen tällaisen neliön sisällä kasvavien kasvien määrä, niiden biomassa, korren korkeus ja leveys, sekä yksilöiden tuottamien jyvien määrät ja massat laskettiin ja määritettiin. Jyvien ravintopitoisuuksia ei tutkittu.

Tutkielman tulokset viittasivat selkeään suhteeseen viljelytavan ja hyötykasvin rakenteen sekä sadon määrän välillä. Tulokset osoittavat luonnonmukaisesti viljeltyjen yksilöiden saavuttaneen suurimmat arvot kaikissa tutkituissa ominaisuuksissa, vaikkakin niiden suhteellinen määrä yhden neliömetrin alueella jäi pienemmäksi kuin muilla tavoin viljeltyjen yksilöiden. Tutkimuksen avulla päästiin johtopäätökseen, että luonnonmukaisella viljelyllä tuotetaan huomattavasti suurempia *Avena Sativa* yksilöitä kuin teho- tai lannoittamattomalla viljelyllä, ja sillä näin ollen saavutetaan myös suurin massallinen tuottavuus.

Luonnonmukainen maanviljely on ajankohtainen aihe tulevan vuosituhannen ruoantuotannosta puhuttaessa. Tämän tutkimuksen tuottamat tulokset ovat tärkeitä, sillä ne tarjoavat näkökulman luonnonmukaisen- ja tehotuotannon välille, jota on aiemmin tutkittu suhteellisen vähän. Kyseisen kahden viljelytavan vertailevaan tutkimukseen tulee panostaa, jotta ympäristöystävällisiä ja tuotannollisesti kestäviä viljelytapoja olisi mahdollista kehittää tulevaisuutta varten.

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ABSTRACT
Viksu

A Comparative Investigation on the Physical Features and Productivity of Conventionally and Organically Cultivated *Avena Sativa*

The purpose of this investigation was to determine the effect of conventional and organic cultivation on the structure and crop yield of oat, *Avena Sativa*. By means of comparative research, variation in physical features and grain production of plants cultivated using these practises of agriculture was examined. The basis for this study was the observation that little empirical comparative investigation has been performed on organic and conventional farming. The lack of scientific evidence on the relation between the method of farming and the cultivated plant made the subject a topic of personal interest.

The experimental was constituted of *Avena Sativa* cultivated on three fields by conventional, organic and natural means. Two quadrates of 1m × 1m in size was lined on every field and a series of experiments were run on randomly selected sets of individuals. The amount of plants in each quadrate and their height, width of stem and biomass, alongside with the biomass and number of the grains carried by an individual was determined.

The investigation results that the method of farming has a definite impact on the physical features and yield produced by *Avena Sativa*. According to this study, organically cultivated individuals reach highest values in all the examined properties, although experiencing the lowest number of plants inside the quadrate. Results show that organic cultivation produces significantly larger individuals than conventional and natural farming, yielding the largest mass of cereal.

Organic agriculture is a current subject when discussing about the direction of food production in the 21st century. This study was important in the sense that it provided an aspect on organic and conventional agriculture little investigated before. Comparative examination on organic and conventional agriculture is to be conducted, so that environmentally durable cultivation methods can be developed for the future.

Table of Contents

1 Introduction

Today's agriculture has developed side by side with technological development. Its ways of functioning have experienced a massive transformation from what they were 100 years ago. As industrialization conquered the western world, it dramatically changed the infrastructure of human societies, leading also to a definite change in the methods of agriculture. For the first time in history, the dimensions of crop production could be maximized, as the field size was no longer a limiting issue. Later on, farmers became accustomed to using chemical fertilizers and artificially refined seeds in their effort to attain more efficient crop production. Craving for larger and faster farming was intense, which is naturally understandable, as an increase in population requires an increase in food production as well. It worked fine, at least for a while.

However, today we have came across the problems that this method of farming, brought to its extremes, can cause. The soil cannot support massive amounts of plants, but loses its nutritional quality and decays. More fertilizers are needed, and traces of them can be found from the final products. Confronted with these issues, modern farming needs to reform its techniques.

It is difficult to say whether it actually was the cold scientific proof about the difficulties of modern farming, or simply the people's desire for something natural, but organic farming took on a true lease of life during the 1990s almost all around the world. The problems of overproduction in industrialised countries, underproduction in developing countries and the environmental impact of agriculture brought about a dramatic reassessment of the achievements of the beginning of the same century. Today, the effect can be seen in the range of policies which place greater emphasis on environmental considerations and also in the growth of the organic movement and the market for organically produced goods.[1]

In the year 2004, the European Commission decided to fund an inter-European CORE Organic –research program working together with a total of 11 member countries, investigating new possibilities and applications of organic production. Similarly, the Swedish capital city Stockholm declared that 15% of the food served in city facilities need to be produced organically.[2] In Finland, as many as 20% of the everyday shoppers purchase organic products.[3]

Indeed, organic agriculture has experienced a boom during the past 20 years. It is now increasingly recognised as a potential solution to many of the problems facing agriculture in both developed and developing countries.[4]

Agriculture has always fascinated me, because of family roots leading to the countryside. I consider organic agriculture as an interesting feature in the farming of the present day and wished to investigate its functions more thoroughly. For me it seemed intriguing to find out how exactly does the practise of this agriculture differ from the conventional, and what kind of physical variation is seen in plants cultivated by the two methods. The fact that little actual comparative data on the latter is available made the subject even more fascinating.

Therefore, as the objective of this study I chose to investigate and compare the physical characteristics of *Avena Sativa*, oat - one of the most popular organic crops, cultivated by conventional- and organic agricultural means. **How does the method of farming effect the physical**

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[1] Lampkin 1990 p.1
[2] Pohjolan Luomu Finland 2004
[3] Kantén 2004
[4] Lampkin 1990 p.1

features and the yield produced by *Avena Sativa*? It is to be determined if either of the cultivation methods have a definitive effect on the biomass, height or thickness of the plant and its grains.

2 Background Information

2.1 What is Organic Farming?

Organic agriculture is based on holistic production management systems, which promote and enhance agro-ecosystem health. This includes biodiversity, biological cycles as well as soil activity. Indeed, organic farming emphasizes the use of management practises that take advantage of in-farm production, not forgetting that regional conditions require locally adapted systems. This kind of process is accomplished by using, cultural, biological and mechanical methods, as opposed to synthetic materials, to fulfil any specific function within the system.[5]

These principles and practises of organic agriculture can be deduced to a definitive listing of functions, which, for organic farmers worldwide, provide the basis for day-to-day farming practise. Food and Agriculture Organisation[6] defines that an organic system is designed to:

- *Enhance biological diversity within the whole system.*
- *Increase soil biological activity.*
- *Maintain long-term soil fertility.*
- *Recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimising the use of non-renewable resources.*
- *Rely on renewable resources in locally organised agricultural systems.*
- *Promote the healthy use of soil, water and air as well as minimising all forms of pollution that may result from agricultural practises.*

The concept of organic agriculture is relatively recent and what counts as an even more valuable definition for those who choose to practise the natural way of farming is the philosophy that lies behind these policy directives. Together with the international regulations and this ‘green idea’, the requirements and expectations for the practise of organic farming are determined.

2.2 The Philosophy of Organic Farming

Organic farming is possible to see as an approach to agriculture whose aim is to create integrated, humane, environmentally and economically sustainable agricultural production.[7] The term ‘organic’ is best thought of as referring to the type of inputs used and also to the concept of the farm as an organism in which all the components – the soil minerals, micro organisms, insects, plants, animals and humans – interact to create a self-regulating and stable system. Reliance on external inputs is reduced as far as possible.[8]

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[5] FAO 2002
[6] FAO 2002
[7] Dabbert *et al.* 2004 p.5
[8] Lampkin *et al*. 1999

The whole process relies on careful consideration of the agricultural cycle, so that the soil and its flora and fauna can be used with maximum efficiency, without causing unnecessary pressure on any of the contributors. In the early stages of the cycle, plants that store nitrogen to the soil, such as bean plants, are first planted to enrich the soil. On-farm produced animal manure is taken advantage of, if necessary. When the bean plants are harvested, the nitrogen will be left to the ground for upcoming plants. A beneficial environment for micro- and macro-organisms that mix the earth, such as earthworms, is ensured by not using chemical pesticides. The cycle continues with wheat plants followed by a natural hay field – leaving the field for cattle.[9]

In many European countries, organic agriculture is known as ecological or biological agriculture, reflecting idealism and the reliance on ecosystem management rather than external inputs.[10]

2.3 Conventional- and Organic Agriculture

Discussing the modern agriculture and its organic look-alike brings out the fact that both of these methods have their own problematic aspects, a feature that should be acknowledged.

One of the main issues is the usage of fertilizers. Very often, the fertilizing substances are flushed from the fields to the surrounding nature by rainfall, leading to entrophication of the proximate waters.[11] The synthetic fertilizers cause stress to the soil, but their usage is controlled by strict regulations and is always calculated very precisely - only an amount required by the crop is added. When dealing with organic fertilizers the amount of manure never as constant and far less regulated. This raises the question of pathogen transportation to the final product. Little studies have been performed on the behaviour of organic fertilizers when they are used in massive food production.

Nevertheless, it is clear that organic farming is the more natural way of agriculture. It stresses the environment far less than conventional ways of farming and obtains features that enhance biological activity on the field.

[9] Jaakkola-Siimes 2005
[10] Dabbert *et al.* 2004 p.5
[11] Köppä 1987

3 Experimental Method

3.1 Introduction

Avena Sativa plant was cultivated in three fields, all sharing one common line of contact. The surface area of the fields varied from 8 to 11 hectares. Before the cultivation process was begun, the qualities of the three soils were determined and the nutritional features concluded to be approximately the same. Similar weather conditions were expected, mainly because the areas were located so close to one another. The three fields appeared to be relatively the same, from the atmospheric surroundings to the quality of the soil. However, the methods of cultivation on them differed highly.

One of the fields was cultivated by conventional means, using chemical fertilizers and refined seeds. The two others obtained a status of organic and natural cultivation, involving non-modified seeds and in the first case, a natural fertilizer whilst in the latter, no fertilization at all. Table 1 describes the features of the investigated environments in summarized form.

All plants were seeded in mid-May, the modern field on the 10^{th} of May 2005 and the organic two on the 15th of May 2005. The fields in question situated in southern Finland, Varsinais-Suomi –area (Appendix 2), known as the agricultural region.

3.1.1 Variation Between Seed

Before examining the process of cultivation more thoroughly, it is important to focus on certain facts concerning the seeds used in the experiment. For the field cultivated by conventional means, Field I, a refined special type of seed was used. This brand of oat was called *Roope-kaura*. It is a certified seed obtaining a guaranteed high level of protein production[12] as well as high growth. *Roope-kaura* is always a first generation seed. New seeds are purchased from an industrial producer every year, in contrary to the traditional method where an amount of the previous years harvest is always conserved for cultivation of the next season. This quality is claimed to reduce the stress built up on the seeds when they are used generation after generation. A low stress factor indicates high probability for healthy growth.[13]

The seeds used for organic agriculture are always selected from previous years' harvest, making them relate years back. The seeds used for the Fields II and III were already the 9^{th} generation, descending from oats that were planted in 1997.[14]

3.1.2 Variation Between Fertilization

Alongside proper soil, an important factor affecting agriculture is fertilization. It is used to ensure that maximal crop production is reached, in terms of the number and the physical qualities of the plant as well as the size and amount of its grains. Inorganic compounds of elements crucial to the plants are most commonly used. These include nitrogen, phosphorous, potassium, magnesium, calcium and sulphur.[15] Artificial fertilizers are always produced in laboratory con-

[12] Boreal Kasvinjalostus 2005
[13] Nissilä 2005
[14] Jaakkola-Siimes 2005
[15] Janick *et al.* 1974

ditions and their usage is controlled by strict regulations. The product used for Field I contained nitrogen, potassium and phosphorous.

In organic agriculture, the usage of any synthetic products is forbidden, and thus other means of fertilization are necessary. Organic cultivation emphasizes the use of natural and local materials. Therefore the fertilizer used for Field II, was provided by a nearby poultry farm. Chicken manure, as a natural fertilizer, has high concentrations of both phosphorous and nitrogen.[16]

For Field III, no fertilization was used. The kind of organic farming that prohibits usage of any kind of external input is called natural agriculture. It is a rare type of production, and is regarded in this investigation as a comparative aid. The oat on Field III was produced without any extra substances, just like the plants growing wild in nature.

Table 1. Summarized presentation of the investigated environments.

	Status	Seed	Seed generation	Fertilization	Pesticides	Herbicides
Field I	Conventional	Laboratorial	1st	Synthetic	Yes	Yes
Field II	Organic	Natural	9th	Organic	No	No
Field III	Organic	Natural	9th	None	No	No

3.2 Sample Collection

For investigation on a subject to be possible, samples need to be collected. Two areas of $1m^2$ were restricted in each of the three fields. This took place after approximately 10 weeks of growth, on the 1st of August 2005. The locations of the quadrates were randomly selected, but they were generally situated between 60 to 100 meters from each other. It should be noted that the experiment bases itself on the principle of random sampling and that the reliability of the results depend on this feature.

The *Avena Sativa* plants were separated from their surrounding with some string and four sticks, so that a quadrate obtaining dimensions of 1m × 1m was created. The number of plants inside the quadrate was calculated and recorded.

Three sets of ten oat individuals were randomly selected from each quadrate, giving a total of 18 samples and 180 individuals.

The plants were carefully detached from earth, making sure that as much of the root texture as possible was conserved in the process. Each set of three plants was packed into individual containers, labelled and conserved for further investigation. Some soil and water was left on the bottom to prevent any denaturation from taking place.

3.3 Comparison Between Treatments

3.3.1 Physical Characteristics Determination

The height of a plant is important when considering the facilitation and efficiency of the harvesting process. Measuring from the beginning of the stem to the very tip of the plant, the heights of the samples were recorded.

[16] Källander 1989

Another crucial quality of a cultivated oat plant is the strength of its stem. A strong and a thick stem prevent the plant from bending during rainfall. This quality was investigated by measuring the diameter of every sample individual.

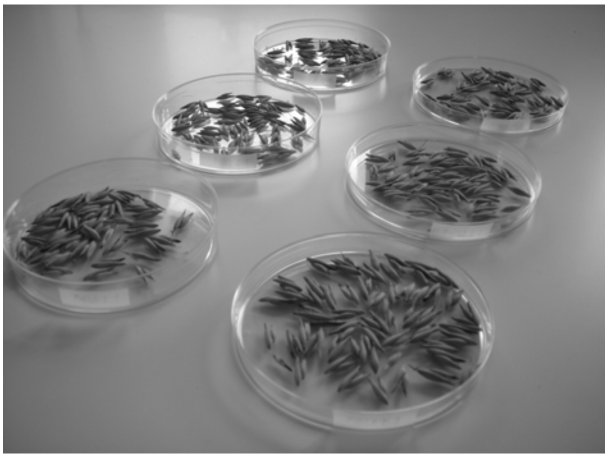
One of the most important physical qualities of a cultivated plant is naturally the amount of grains it is able to produce. *Avena Sativa* obtains a spike (Picture 1) that varies in size from individual to individual. Thus, the number of grains carried by each sample was calculated.

Picture 1. The large spike of *Avena Sativa.* The individual is an organically cultured, Field II *Avena Sativa* sample.

With these values, it was possible to determine the minimum, the maximum and the mean values for data of each growing environment. The sample data is fully present in Appendix 1.

3.3.2 Biomass Determination

The *Avena Sativa* samples were removed from their containers and carefully rinsed under fresh water to remove all additional matter, such as earth, worms and rotten material. This ensured that no soil was left to cause inaccuracies when determining the average biomass produced by an individual in all three of the growth milieus. The dried *Avena Sativa* samples were weighed in sets of ten on a digital scale, with an accuracy of ±0.01 grams. The average biomass of every individual was calculated. From all three of these dried samples, two sets of 100 grains were randomly collected, husked and weighed (Pictures 2 and 3). From the value obtained, it was possible to calculate the average biomass of one grain, cultivated in a given environment.



Picture 2. Three sets of two samples, each bearing 100 grains, were randomly collected among each growing environment, marked and weighed. One *Avena Sativa* grain obtains two seeds but the investigation was carried in terms of grains.

Picture 3. The Avena Sativa grains obtain a loose outer husk that was to be husked before determining the biomass of the grain. The two grains on the left are un-husked whereas the two on the right are already husked.

4 Results

The results obtained from this investigation are presented in tables and diagrams. All tables can be seen in their full appearance in Appendix 1.

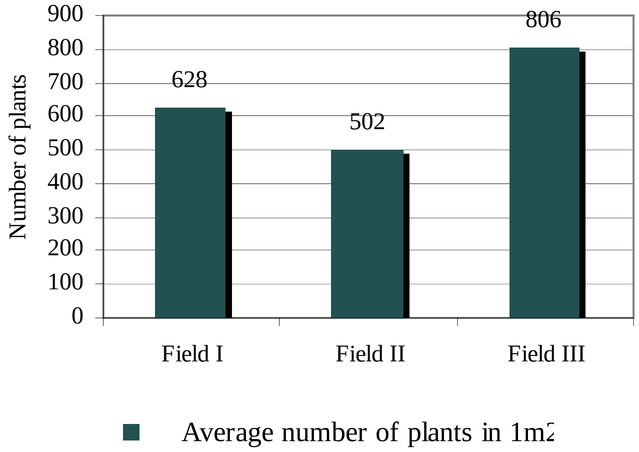
4.1 Variation Between Treatments

4.1.1 Plant Concentration

Before comparison of the physical differences between the plants, the amount of individuals inside the investigated quadrates, i.e. their concentration in a specific environment, will be considered. As could be expected, the relative number of plants varies depending on the milieu in which they grow. Indeed, it appears that the variance in the concentration of the plants is noticeable even within an area as limited in size as $1m^2$.

The average number of plants growing in two quadrates on Fields I, II and III – that is, under the influence of conventional, organic and natural culture, respectively – can be seen in Figure 1.

Graph 1. The average number of *Avena Sativa* growing inside 1m^2 in selected environments.



Interestingly enough, it seems that the average number of plants growing inside the investigated quadrates is the largest on Field III and lowest on Field II (Graph 1). This would indicate that a high plant concentration is obtained in an environment where no fertilization is present.

4.1.2 Plant Physical Features

When considering important features of a cultivated plant, physical features have a large significance. This section compares the detected differences of *Avena Sativa* cultivated by the different methods.

Height

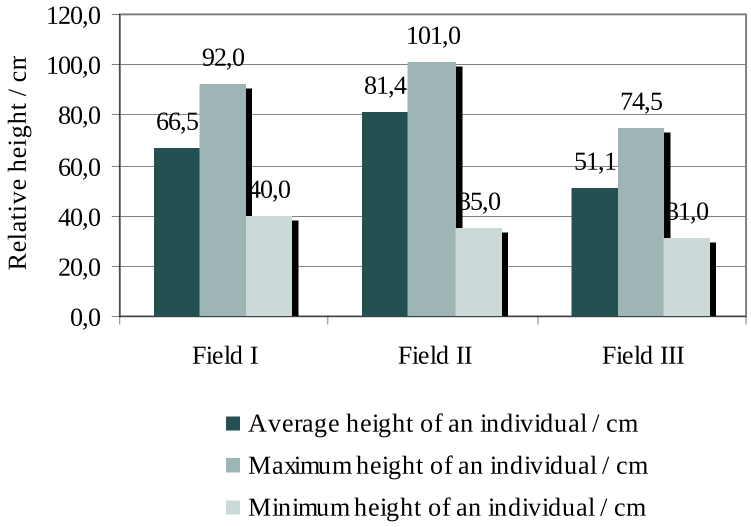
The height of the plants diverged depending on the method by which they were cultivated. As visible in Table 2, the average height of individuals found on Field II is the highest. The difference in average height is practically the same between Field II and Field I (14.9 cm) as it is between Fields I and III (15.4 cm). The maximum height of individuals is attained by the usage of organic cultivation methods.

Table 2. Height of the *Avena Sativa* in the reported environments / cm

	Field I	**Field II**	**Field III**
Average height of an individual / cm	66,5	81,4	51,1
Standard Deviation	10,4	11,3	7,4
Maximum height of an individual / cm	92,0	101,0	74,5
Minimum height of an individual / cm	40,0	35,0	31,0

Along with average height, Table 2 presents the range of values and the recorded maximum and minimum heights in the selected environments. The seemingly large values of standard deviation arise from the high range of plant heights within an environment. This was to be expected, given the results of maximum and minimum that extend to irregular extremes. Nevertheless, the average value of plant height gives an accurate estimation of relative height. The results are graphically summarized in Graph 2.

Graph 2. Height of the *Avena Sativa* growing in the selected environments



Width of stem

As can be seen in Table 3, the average stem width was largest with individuals collected from Field II. However, the difference between individuals of Field I was only 0,001 cm, which means that the widths could essentially be considered the same.

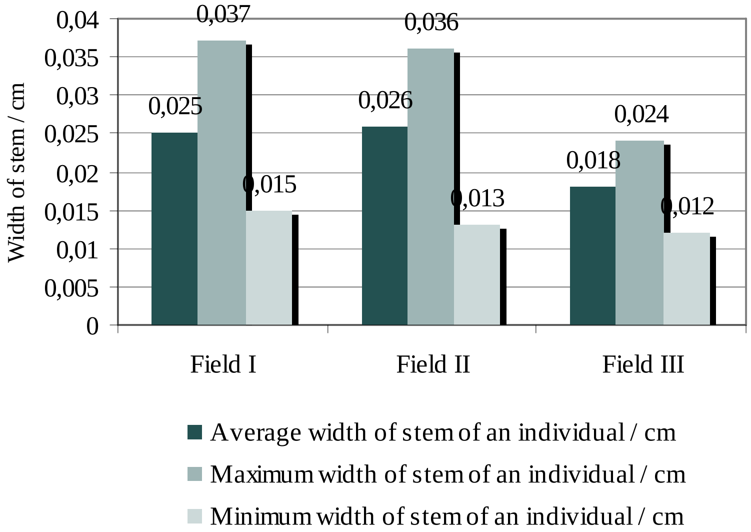
Table 3. Width of stem of the *Avena Sativa* in the reported environments / cm

	Field I	**Field II**	**Field III**
Average width of stem of an individual / cm	0,025	0,026	0,018
Standard Deviation	0,007	0,008	0,006
Maximum width of stem of an individual / cm	0,037	0,036	0,024
Minimum width of stem of an individual / cm	0,015	0,013	0,012

It is noted that with the *Avena Sativa* cultivated on Field I, both the minimum and maximum stem widths are larger than those of Avena Sativa cultivated on Field II, even tough the average value was higher for the latter.

Compared to the height of individuals, the general range and standard deviation of the stem widths are relatively small. As visible in Graph 3, little variation in the average stem width is detected.

Graph 3. Width of stem of the *Avena Sativa* within the reported environments



Biomass

The average biomass of an individual was derived from the biomass of ten individuals (Table 4). It appears that the average biomass of the individuals cultured with organic means, in Field II, are almost double the mass of individuals collected from Fields I and III. It is evident that the average plant biomass in Fields I and III is practically the same.

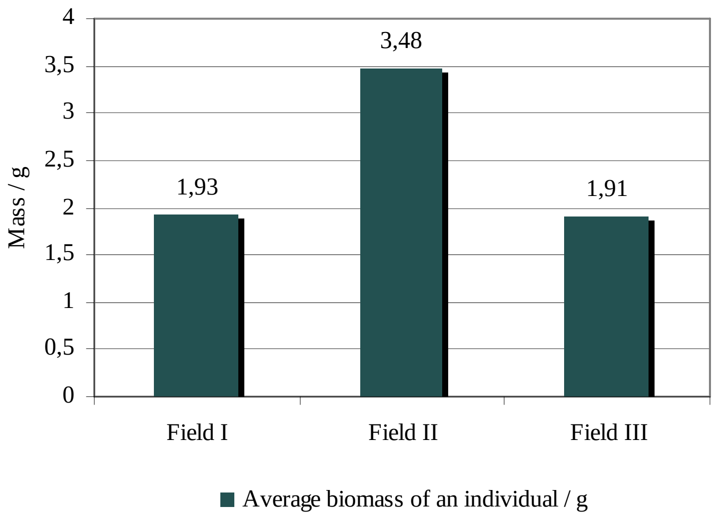
Table 4. Average plant biomass of *A. Sativa* in the reported environments / g

	Field I	Field II	Field III
Average biomass of an individual / g	1,93	3,48	1,91
Standard Deviation	0,36	0,39	0,77
Biomass of 10 individuals / g	19,3	34,76	19,1

The reliability of results is supported by the standard deviation in Fields I and III. The large standard deviation associated with the data collected from Field III implies that variation between samples is considerable. This implies a wide range between minimum and maximum biomass and natural deviation between the plants.

The relationship between the mass and biomass of individuals cultured in specific environments is presented in Graph 4.

Graph 4. Plant biomass of *Avena Sativa* in the reported environments / g



4.1.3 Grain Characteristics

From the perspective of efficient agricultural production, the most important feature of cultured plants is naturally the characteristics of the grains. Along with such properties as colour and nutritional values, the amount of grains produced by one plant, not to mention the mass of the grains, is the most important property of efficient production. However, since this investigation focuses on physical properties, colour and nutritional content will not be discussed.

As shown in Table 5, *Avena Sativa* individuals cultured by organic means seem to attain the highest mean number of grains per individual. On average, plants growing on Field II produced almost twice as many grains as the plants cultivated by conventional means on Field I. In addition, the maximum and minimum productions appear larger with organic cultivation.

Table 5. Average number of seeds in the *Avena Sativa* in the reported environments.

	Field I	**Field II**	**Field III**
Average number of seeds in an individual	13	24	9
Standard Deviation	7,3	8,5	3,8
Maximum number of seeds	38	51	27
Minimum number of seeds	2	5	4

Besides the average number of seeds, Table 5 presents the range of values, i.e. the recorded maximum and minimum numbers of seeds produced in the selected environments. Bearing in mind the natural tendency for irregular extremes, the rather high values of standard deviation are a result of the fact that the ranges vary greatly across the environments.

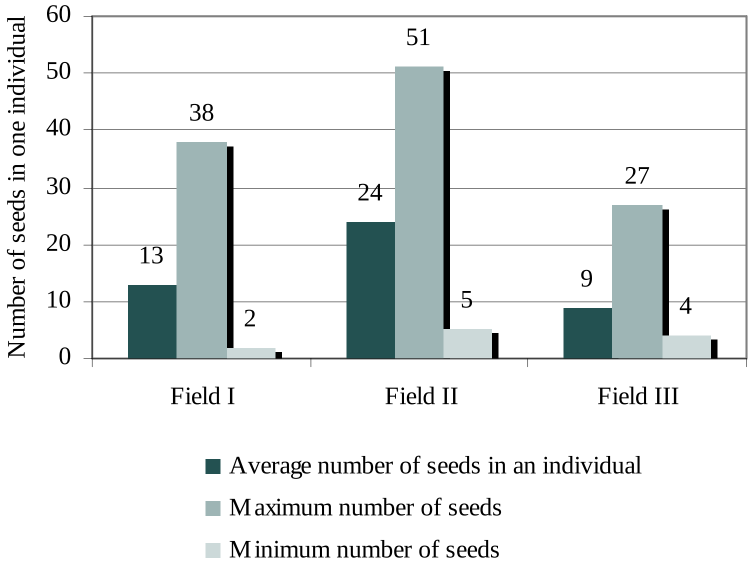
The average mass of one grain produced by an individual in a given environment is derived from the mass of 100 individuals. The biomass of one grain occurs of being highest with the plants cultured organically on Field II. These grains' biomass is two times as high as that of the plants in Field I and III.

Table 6. Average grain biomass of *Avena Sativa* in the reported environments / g

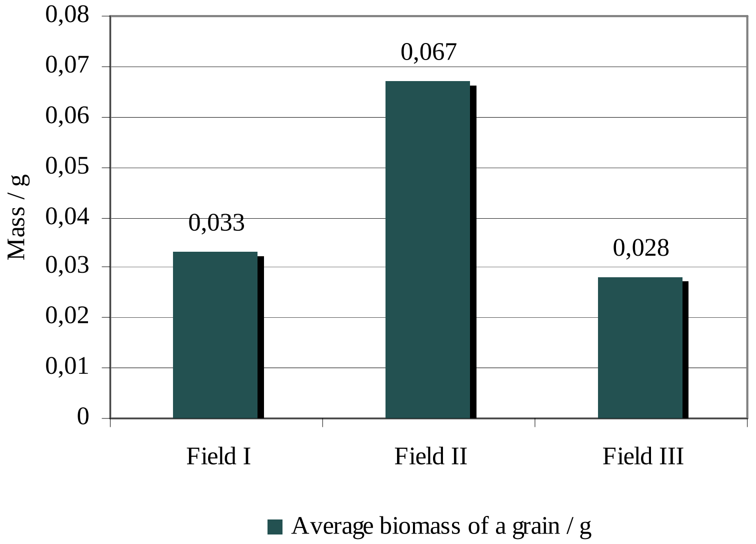
	Field I	Field II	Field III
Average mass of 100 grains / g	3,268	6,656	2,828
Average mass of a grain / g	0,033	0,067	0,028

Graphs 5 and 6 present the number and biomass of grains produced by *Avena Sativa* as a comparative chart.

Graph 5. Number of seeds within the *Avena Sativa* in the reported environments.



Graph 6. Average biomass of an *Avena Sativa* grain in the reported environments.



5 Discussion

This investigation focused on the physical properties and the intensity of grain production of *Avena Sativa* cultured by conventional and organic methods on three fields. The results indicate visible divergence between the three groups in all the investigated properties. Fields I and II were generally close to each other in obtained values, and Field III remained as the least successful in most of the determinations.

The results show that the organically cultivated *Avena Sativa* samples obtained the highest average values for almost all qualities examined. These plants grew higher and they attained a larger biomass than the samples cultivated conventionally and naturally on Fields I and III. The highest average mass and amount of seeds produced by one plant was similarly detected in the samples cultivated organically with fertilizing on Field II.

The reasons for this can be found from the method of fertilization, namely the usage of poultry manure as an alternative for chemical compounds. It offers a facile and effective way of fertilization that makes use of on-farm produced waste. However, it should be noted that there is little regulation concerning the use of poultry manure; furthermore, there is the potential for health hazards.

The width of stem showed the least variation between treatments: its value was practically the same for conventional and organic environments.

The result that introduced an interesting aspect to the investigation was the amount of plants detected inside the $1m^2$. The investigation showed that the environment that produced most plants was Field III, where natural agriculture was used. This implies that the amount of plants decreases when the amount of fertilization increases. Undeniably, when no fertilization is provided, all the seeds planted produced modest individuals. Considering the matter, it can be stated that when fertilization is present only the strongest seeds grow, producing large and potent individuals.

In agriculture, the magnitude of yield produced is the most important feature of the plants. Discussing the average mass of the grains, taking into account the average amount of plants produced by one $1m^2$ and considering the average amount of grains produced by an individual, the amounts of final product produced by a milieu were possible to be calculated. Field I produced approximately 269 grams/m^2, Field II 807 grams/m^2 and Field III 203 grams/m^2. The result suggests that organic agriculture produced between 2-4 times as much cereal per m^2 than conventional and natural farming. Although this investigation would imply the opposite, organic agriculture is generally thought to yield less products than the conventional way of farming.[17]

It is probable that the feature that produced most of the differences detected in plants of different treatments in this experiment is fertilization. Poultry manure is a very efficient fertilizer even when compared to chemical products. Considering this fact and that of manure usage being less strictly controlled than chemical compounds, it is understandable that more efficient production was obtained.

It should be taken into account that this investigation focused on the physical features detectable by empirical means. For a wider perspective of the matter, more variables should be taken

[17] *Luonnonmukainen kasvituotanto* 2005

into account, including microorganism levels as well as the accurate nitrogen levels in the soil. In order for reliable results to be obtained, an experiment of a longer time span, containing a larger amount of quadrates and more fields, should be performed. The impact of different cultivation methods could be investigated on various types of plants.

6 Conclusion

The aim of this investigation was to investigate possible variation of the physical features, grain amount and biomass of *Avena Sativa* cultivated conventionally, organically and naturally. Impact was placed on the number of plants within $1m^2$, plant height and stem width. The investigation composed a theoretical analysis of organic agriculture and an empirical investigation performed to determine the impact of cultivation method on the development of *Avena Sativa*.

Differences between plants of different agricultural background were detected. Results clearly show that organically cultivated individuals reached highest values in all the examined properties, although their relative number inside $1m^2$ was the lowest. Significant differences were detected especially in cereal properties. The biomass and number of grains produced by one individual were highest with plants cultivated by organic means.

According to this investigation, the method of farming has a definite impact on the physical features and yield produced by *Avena Sativa*. Organic cultivation produces significantly larger individuals and on total, yields the most cereal.

Environmentally friendly and productive cultivation methods are to be investigated so that the food production of the future can be ensured. Not alone conventional or organic productions can fulfill this need, but further investigation on the possibilities of combining the two should be encouraged.

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8 Appendix 1

All the collected data is presented in the following, respecting the order of discussion in section 4 - Results.

Number of individuals of *A. Sativa* within 1m^2

Environment	CON I	CON II	ORG I	ORG II	NAT I	NAT II
Number of plants in 1m^2	*700*	*556*	*516*	*488*	*928*	*684*

Average number of individuals of *A. Sativa* within 1m^2

Environment	CON	ORG	NAT
Number of plants in 1m^2	*628*	*502*	*806*

The number of plants is calculated with an accuracy of ±2 plants

Abbreviations: CON - Conventional farming / ORG - Organic with fertilizing / NAT - Natural, with no fertilization.

Heights of investigated *A. Sativa* individuals in various environments

Environment	CON I	CON I	CON I	CON II	CON II	CON II
Set number	1	2	3	1	2	3
Height of one individual / cm	*45,5*	*40,0*	*45,5*	*51,0*	*45,5*	*57,0*
	46,0	*54,5*	*62,0*	*56,5*	*68,0*	*61,0*
	48,0	*56,5*	*62,5*	*57,0*	*75,5*	*70,0*
	49,5	*60,5*	*63,0*	*60,0*	*76,5*	*70,5*
	55,0	*61,0*	*63,0*	*60,0*	*77,5*	*76,5*
	56,0	*62,0*	*63,5*	*72,5*	*79,5*	*82,0*
	59,0	*62,5*	*64,0*	*78,0*	*80,0*	*82,5*
	59,0	*63,5*	*64,0*	*78,5*	*80,0*	*89,5*
	61,0	*70,0*	*68,5*	*82,0*	*83,5*	*90,0*
	68,5	*73,0*	*71,0*	*87,0*	*92,0*	*91,0*
Average height of an individual / cm	*54,8*	*60,4*	*62,7*	*68,3*	*75,8*	*77,0*
Standard Deviation	7,5	9,0	6,7	12,7	12,3	12,1
MAX height of an individual / cm	*68,5*	*73,0*	*71,0*	*87,0*	*92,0*	*91,0*
MIN height of an individual / cm	*45,5*	*40,0*	*45,5*	*51,0*	*45,5*	*57,0*

Environment	ORG I	ORG I	ORG I	ORG II	ORG II	ORG II
Set number	1	2	3	1	2	3
Height of one individual / cm	*86,0*	*45,5*	*74,0*	*66,0*	*35,0*	*69,5*
	89,5	*68,0*	*78,0*	*70,5*	*57,0*	*71,5*
	92,0	*75,5*	*83,5*	*72,0*	*67,0*	*73,0*
	94,0	*76,5*	*85,0*	*72,5*	*74,0*	*77,5*
	94,0	*77,5*	*88,0*	*74,5*	*75,0*	*78,0*
	94,5	*79,5*	*90,5*	*82,0*	*85,0*	*80,0*
	95,0	*80,0*	*91,5*	*88,0*	*85,0*	*81,0*
	95,5	*80,0*	*91,5*	*88,0*	*88,0*	*81,5*
	97,5	*83,5*	*95,0*	*88,0*	*89,0*	*82,0*
	101,0	*92,0*	*95,0*	*88,5*	*90,0*	*83,5*
Average height of an individual / cm	*93,9*	*75,8*	*87,2*	*79,0*	*74,5*	*77,8*
Standard Deviation	4,1	12,3	7,1	8,8	17,6	4,8
MAX height of an individual / cm	*101,0*	*92,0*	*95,0*	*88,5*	*90,0*	*83,5*
MIN height of an individual / cm	*86,0*	*45,5*	*74,0*	*66,0*	*35,0*	*69,5*

Environment	NAT I	NAT I	NAT I	NAT II	NAT II	NAT II
Set number	1	2	3	1	2	3
Height of one individual / cm	*36,5*	*31,0*	*38,0*	*44,0*	*53,0*	*43,5*
	40,5	*39,0*	*41,0*	*47,0*	*56,0*	*50,5*
	41,0	*39,5*	*42,5*	*48,0*	*57,0*	*51,0*
	42,0	*40,0*	*44,0*	*50,0*	*63,0*	*53,5*
	42,5	*43,0*	*46,5*	*51,0*	*63,5*	*54,0*
	44,5	*49,0*	*49,5*	*51,5*	*64,0*	*54,0*
	46,0	*49,5*	*50,0*	*52,0*	*65,0*	*55,0*
	50,5	*50,0*	*51,5*	*53,0*	*71,0*	*56,5*
	51,0	*50,5*	*57,5*	*54,5*	*73,0*	*62,5*
	51,5	*52,0*	*64,0*	*56,0*	*74,5*	*64,0*
Average height of an individual / cm	*44,6*	*44,4*	*48,5*	*50,7*	*64,0*	*54,5*
Standard Deviation	5,076	6,892	7,9	3,6	7,3	5,9
MAX height of an individual / cm	*51,5*	*52,0*	*64,0*	*56,0*	*74,5*	*64,0*
MIN height of an individual / cm	*36,5*	*31,0*	*38,0*	*44,0*	*53,0*	*43,5*

Average height of *A. Sativa* individuals in various environments

Environment	CON I	CON II	ORG I	ORG II	NAT I	NAT II
Average height an individual / cm	*59,3*	*73,7*	*85,6*	*77,1*	*45,8*	*56,4*
Standard Deviation	8,25	12,57	11,19	11,43	6,76	7,97
Average MAX of an individual / cm	*70,8*	*90*	*96*	*87,3*	*55,8*	*64,8*
Average MIN of an individual / cm	*43,7*	*51,2*	*85,6*	*56,8*	*35,2*	*46,8*

Environment	Average CON	Average ORG	Average NAT
Average height an individual / cm	*66,5*	*81,4*	*51,1*
Standard Deviation	10,4	11,3	7,4
Average MAX of an individual / cm	*80,4*	*91,7*	*60,3*
Average MIN of an individual / cm	*47,4*	*71,2*	*41,0*

The heights of individuals are demonstrated in centimetres / cm with an accuracy of 0.1cm

Abbreviations: CON - Conventional farming / ORG - Organic with fertilizing / NAT - Natural, with no fertilization.

Width of stem of the investigated *A. Sativa* individuals in various environments

Environment	CON I	CON II	ORG I	ORG II	NAT I	NAT II
Width of stem of one individual / cm	*0,015*	*0,016*	*0,038*	*0,011*	*0,029*	*0,013*
	0,019	*0,018*	*0,018*	*0,032*	*0,025*	*0,017*
	0,021	*0,030*	*0,018*	*0,030*	*0,022*	*0,009*
	0,020	*0,031*	*0,030*	*0,028*	*0,025*	*0,014*
	0,022	*0,022*	*0,036*	*0,028*	*0,016*	*0,018*
	0,026	*0,024*	*0,029*	*0,029*	*0,021*	*0,012*
	0,038	*0,021*	*0,035*	*0,016*	*0,018*	*0,012*
	0,032	*0,014*	*0,033*	*0,034*	*0,028*	*0,010*
	0,028	*0,032*	*0,027*	*0,019*	*0,023*	*0,008*
	0,041	*0,028*	*0,014*	*0,022*	*0,017*	*0,019*
Average Width of stem of an individual / cm	0,026	*0,024*	*0,028*	*0,025*	*0,022*	*0,013*
MAX Width of stem of an individual / cm	*0,041*	*0,032*	*0,038*	*0,034*	*0,029*	*0,019*
MIN Width of stem of an individual / cm	*0,015*	*0,014*	*0,014*	*0,011*	*0,016*	*0,008*

Average width of stem of the investigated *A. Sativa* individuals in various environments

Environment	Average CON	Average ORG	Average NAT
Average width of stem of an individual / cm	*0,025*	*0,026*	*0,018*
Standard Deviation	0,007	0,008	0,006
MAX width of stem of an individual / cm	*0,037*	*0,036*	*0,024*
MIN width of stem of an individual / cm	*0,015*	*0,013*	*0,012*

The widths of individuals are demonstrated in centimetres / cm with an accuracy of 0.001 cm

Abbreviations: CON - Conventional farming / ORG - Organic with fertilizing / NAT - Natural, with no fertilization.

Mass of investigated *A. Sativa* individuals in the determined environments

Environment	CON I	CON I	CON I	CON II	CON II	CON II
Set number	1	2	3	1	2	3
Mass of 10 individuals / g	*59,34*	*45,13*	*53,15*	*36,31*	*38,07*	*24,18*
Average mass of an individual / g	*5,93*	*4,51*	*5,32*	*3,63*	*3,81*	*2,42*
Biomass of 10 individuals / g	*21,43*	*13,34*	*19,28*	*19,23*	*24,06*	*18,48*
Average biomass of an individual / g	*2,14*	*1,33*	*1,93*	*1,92*	*2,41*	*1,85*

Environment	ORG I	ORG I	ORG I	ORG II	ORG II	ORG II
Set number	1	2	3	1	2	3
Mass of 10 individuals / g	*87,26*	*109,13*	*102,32*	*88,24*	*89,46*	*80,17*
Average mass of an individual / g	*8,73*	*10,91*	*10,23*	*8,82*	*8,95*	*8,02*
Biomass of 10 individuals / g	*31,09*	*37,89*	*36,78*	*31,29*	*31,67*	*39,83*
Average biomass of an individual / g	*3,11*	*3,79*	*3,68*	*3,13*	*3,17*	*3,98*

Environment	NAT I	NAT I	NAT I	NAT II	NAT II	NAT II
Set number	1	2	3	1	2	3
Mass of 10 individuals / g	*18,46*	*27,73*	*22,67*	*49,91*	*23,18*	*27,04*
Average mass of an individual / g	*1,85*	*2,77*	*2,27*	*4,99*	*2,32*	*2,70*
Biomass of 10 individuals / g	*13,25*	*15,98*	*13,34*	*33,61*	*17,23*	*21,17*
Average biomass of an individual / g	*1,33*	*1,60*	*1,33*	*3,36*	*1,72*	*2,12*

Average mass of *A. Sativa* individuals in the investigated environments

Environment	CON I	CON II	ORG I	ORG II	NAT I	NAT II
Average mass of 10 individuals / g	*52,54*	*32,85*	*99,57*	*85,96*	*22,95*	*33,38*
Average mass of an individual / g	*5,25*	*3,29*	*9,96*	*8,60*	*2,30*	*3,34*
Average biomass of 10 individuals / g	*18,02*	*20,59*	*35,25*	*34,26*	*14,19*	*24,00*
Average biomass of an individual / g	*1,80*	*2,06*	*3,53*	*3,43*	*1,42*	*2,40*

Environment	Average CON	Average ORG	Average NAT
Average mass of 10 individuals / g	*42,70*	*92,76*	*28,17*
Average mass of an individual / g	*4,27*	*9,28*	*2,82*
Standard Deviation	1,26	1,08	1,12
Average biomass of 10 individuals / g	*19,30*	*34,76*	*19,10*
Average biomass of an individual / g	*1,93*	*3,48*	*1,91*
Standard Deviation	0,36	0,39	0,77

The masses of individuals are demonstrated in grams / g with an accuracy of 0,01grams / g

Abbreviations: CON - Conventional farming / ORG - Organic with fertilizing / NAT - Natural, organic with no fertilization.

Number of seeds within individuals of the investigated *A. Sativa*

Environment	CON I	CON I	CON I	CON II	CON II	CON II
Set number	1	2	3	1	2	3
Number of seeds in one individual	*2*	*5*	*6*	*4*	*6*	*3*
	2	*9*	*6*	*7*	*6*	*5*
	4	*9*	*6*	*9*	*9*	*6*
	11	*10*	*8*	*9*	*10*	*6*
	15	*11*	*12*	*10*	*10*	*7*
	21	*13*	*13*	*11*	*11*	*7*
	24	*14*	*16*	*14*	*11*	*7*
	25	*21*	*19*	*15*	*12*	*8*
	28	*21*	*26*	*21*	*19*	*9*
	38	*25*	*28*	*22*	*24*	*20*
Total number of seeds in 10 individuals	*170*	*138*	*140*	*122*	*118*	*78*
Average number of seeds in an individual	*17*	*14*	*14*	*12*	*12*	*8*
Number of seeds MAX	*38*	*25*	*28*	*22*	*24*	*20*
Number of seeds MIN	*2*	*5*	*6*	*4*	*6*	*3*

Environment	ORG I	ORG I	ORG I	ORG II	ORG II	ORG II
Set number	1	2	3	1	2	3
Number of seeds in one plant	*15*	*16*	*15*	*6*	*19*	*5*
	16	*20*	*16*	*12*	*19*	*9*
	17	*24*	*19*	*18*	*20*	*12*
	17	*27*	*22*	*19*	*20*	*14*
	19	*28*	*25*	*21*	*20*	*17*
	19	*30*	*25*	*22*	*22*	*24*
	20	*32*	*26*	*26*	*23*	*30*
	26	*35*	*26*	*31*	*23*	*35*
	28	*35*	*28*	*37*	*25*	*35*
	39	*36*	*31*	*51*	*31*	*37*
Total number of seeds in 10 individuals	*216*	*283*	*233*	*243*	*222*	*218*
Average number of seeds in an individual	*22*	*28*	*23*	*24*	*22*	*22*
Number of seeds MAX	*39*	*36*	*31*	*51*	*31*	*37*
Number of seeds MIN	*15*	*16*	*15*	*6*	*19*	*5*

Environment	NAT I	NAT I	NAT I	NAT II	NAT II	NAT II
Set number	1	2	3	1	2	3
Number of seeds in one plant	*4*	*4*	*5*	*10*	*5*	*6*
	4	*4*	*7*	*11*	*6*	*8*
	5	*4*	*7*	*12*	*6*	*8*
	6	*5*	*7*	*12*	*6*	*9*
	6	*5*	*8*	*14*	*6*	*9*
	6	*6*	*8*	*15*	*7*	*10*
	6	*9*	*10*	*16*	*7*	*10*
	9	*9*	*10*	*17*	*7*	*10*
	11	*10*	*11*	*20*	*8*	*11*
	13	*12*	*11*	*27*	*13*	*14*
Total number of seeds in 10 individuals	*70*	*68*	*84*	*154*	*71*	*95*
Average number of seeds in an individual	*7*	*7*	*8*	*15*	*7*	*10*
Number of seeds MAX	*13*	*12*	*11*	*27*	*13*	*14*
Number of seeds MIN	*4*	*4*	*5*	*10*	*5*	*6*

Average number of seeds within individuals of the investigated *A. Sativa*

Environment	CON I	CON II	ORG I	ORG II	NAT I	NAT II
Average number of seeds in 10 plants	*149,3*	*106,0*	*244,0*	*227,7*	*74,0*	*106,7*
Average number of seeds in individual	*14,9*	*10,6*	*24,4*	*22,8*	*7,4*	*10,7*
Standard Deviation	9,1	5,6	6,9	10,0	2,7	4,9
Average MAX number of seeds	*30,3*	*22,0*	*35,3*	*39,7*	*12,0*	*18,0*
Average MIN number of seeds	*4,3*	*4,3*	*15,3*	*10,0*	*4,3*	*7,0*

Environment	Average CON	Average ORG	Average NAT
Average number of seeds in 10 plants	*128*	*236*	*90*
Average number of seeds in individual	*13*	*24*	*9*
Standard Deviation	7,3	8,5	3,8
Average MAX number of seeds	*26*	*38*	*15*
Average MIN number of seeds	*4*	*13*	*6*

The number within an individual is presented with an accuracy of ±1 seed/grain

Average mass of *A. Sativa* **grains in the investigated environments**

Environment	CON I	CON II	ORG I	ORG II	NAT I	NAT II
Average mass of 100 grains / g	*3,222*	*3,313*	*6,762*	*6,549*	*2,843*	*2,812*
Average mass of a grain / g	*0,032*	*0,033*	*0,068*	*0,065*	*0,028*	*0,028*

Environment	Average CON	Average ORG	Average NAT
Average mass of 100 grains / g	*3,268*	*6,656*	*2,828*
Average mass of a grain / g	*0,033*	*0,067*	*0,028*

The masses of individuals are demonstrated in gramms / g with an accuracy of 0,001grammes / g

Abbriviations: CON - Conventional farming / ORG - Organic with fertilizing / NAT - Natural, organic with no fertilization.

9 Appendix 2

The cultivated three fields were situated in Oripää, a village in the south-west of Finland.