INFLUENCE OF INTERCROP ON PLANT GROWTH AND YIELD

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Abstract
The demand for healthy and reasonably cheap food is growing and governments are expanding policies to preserve soil fertility and nature. In addition, climatic conditions are changing. Arable lands are decreasing. Due to all of these changes food growers are looking for new growing technologies. A monographic method to tackle these problems has been used in this article. Intercropping is one of growing systems how to reduce negative climatic aspects and meet other demands. Intercrop is convenient for growers who grow plants in rows, and a companion plant can be sown or planted between rows. In this case farmers can get two yields from one plot. Thus, growers do not need two plots for growing different plants. The intercrop diminishes spreading of pests and diseases, suppresses weed growth, and reduces need for pesticides. Legume (\textit{Leguminosae}) intercrop gives extra nitrogen to companion plants. Those are aspects that we know intercrop can give, but we do not know how significant the influence is, what kind of influence on nature intercrops give in long term, what kind of influence they have on incomes, yield and its quality. This article shows that there are many intercropping systems to reduce some negative aspects and increase beneficial ones. Intercropping can reduce some pests and diseases, but promote other problems. Intercropping suppresses weeds. For some systems it gives bigger yield, for some smaller, but in total it gives bigger protein yield. There are still many unanswered questions and completely unexplained points.

Key words: companion plant, legume, growing system.

Introduction
It is well known that fertilizers are the most expensive compound in forming of crop prime cost. Nowadays fertilizer prices are increasing. Growers are interested in creating such technologies, which allow reducing of fertilizer usage. Consumers are more prone to choose healthier food. More and more pesticides are restricted from the usage. Due to these tendencies, growers are more open minded to nature friendly growing systems (LaMondia et al., 2002). Climatic conditions are also changing, and we are in need of new growing technologies that are more adaptable and sustainable. Intercropping is the cultivation of two or more crops simultaneously on the same field. It also means the growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development. The rationale behind intercropping is that the different crops planted are unlikely to share the same insect pests and diseases-causing pathogens (\textit{Colloquially}) and to conserve the soil (http://www.oisat.org/control_methods/ cultural\_practices/intercropping.html: found 13.03.2014). It can be one of the solutions to some of these problems. It is known that legumes can fixate atmospheric nitrogen. That could reduce nitrogen fertilizer usage. As mentioned in the definition of intercrop, it can reduce pests and diseases. These kinds of growing systems have been known for centuries, but they are not totally explored. In the beginning of 20\textsuperscript{th} century, the most popular intercropping systems included legumes. As synthetic mineral fertilizers became more popular and cheaper, plantations with legume intercropping decreased severely. Only organic farmers used it (Jensen et al., 2010). Nowadays it again becomes more popular due to increasing costs of mineral fertilizers (Mahieu et al., 2009) and the government policy to preserve soil fertility. There are still a lot of uncertainties regarding intercrop. For example, it is not clearly known what kind of influence on pests and diseases intercrop exactly makes.

The aim of this paper is to explore literature about intercropping systems in general and see what has been done to explore their benefits and reduce negative sides.

Materials and Methods
Monographic method has been used for this article. Information all around the world from journals published by Elsevier, like – Field Crop Research, Agricultural and Forest Meteorology, Agriculture, Ecosystems and Environment, Crop Protection, Agricultural systems, Acta Agriculturae Scandinavica, Section B – Soil and Plant Science, European Journal of Agronomy, Soil Biology and Biochemistry, Journal of Agricultural Science, Ecological Engineering was collected.

Results and Discussion
The most widespread intercropping systems

The most widely spread intercropping system is where cereals (\textit{Poaceae}) and legumes are grown. Mainly used for increased protein content in yield, nitrogen fixation is used to reduce fertilizer usage. As one of the main profits for intercropping with legumes, is their capability to give fixated atmospheric
nitrogen to component plant in system and to post crop (Jensen et al., 2010). However, the assessment tool for calculating fixed nitrogen is complex and expensive (Reining, 2005). It is still unexplored field how exactly legumes influence the fertilizer usage. Cereal growers, orchard farms and every single other farmer who is interested in preserving their money and nature are using these systems in hope that they are beneficial.

There are also other popular intercropping systems like wheat (Triticum spp.) and cotton (Gossypium spp.) in China (Zhang et al., 2008). In Sri Lanka the government explores policy to promote growers use intercropping system in growing of rubber trees (Heveinae brasiliensis) and tea (Camellia sinensis). In this system with rubber tree and tea, the need for labour is bigger and they need to be more skilled, that increases yield cost (Iqbal et al., 2006). There are many other intercrop systems in the world, and it is impossible to summarize all combinations. Some of intercrop systems and research done are shown in Table.

**Intercrop influence on plant growth**

As previously mentioned, the most popular intercropping system is grain with legume. It is stated by some scientists that this kind of system improves health of planting that enhances plant growth. According to research results, it reduces aphids for both plants and reduces spreading of diseases (Hooks and Johnson, 2003).

In systems where both plants are coalescent plants or trees and bushes, there can be problems with shading effect. It increases risk for mildews, rots and other diseases which have favourable growing conditions in increased moisture and decreased aridity. Shading can also lead to thinner stems, increased height which can lead to lodge (Yang et al., 2014).

Intercrop can suppress weeds (Oswald et al., 2002; Midega et al., 2013) that reduce the competition between cultivated plants and weeds for water and nutrition and succeed the growth of cultivated plants. The availability of nutrients are playing very important role in plant development. Intercropping systems with legumes can supply with nitrogen not

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**Intercropping systems evaluated and main aims of the research**

<table>
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only a companion plant but also post crop (Haynes et al., 1993; Kumar, Goh, 2000; Pappa et al., 2012). Intercropping is also used in orchards, where between rows there is grass with legumes, mostly clover (Trifolium spp.) grown (Jiao et al., 2013). This system gives not only nitrogen but also helps to maintain clean machinery. For this system it is important that grass is highly transport durable (García and Miñarro, 2014).

**Intercrop influence on yield**

Intercrop influence on yield has proven to give different effects. The decrease in yield for about 20% compared to solo crop in intercropping system with soybean (Glycina max), maize and sunflower (Helianthus annuus) (Coll et al., 2012) has been observed. However, the water usage efficiency and productivity, radiation use efficiency was increased in intercrop. On contradiction, in other experiment barley intercropped with clover showed significantly higher grain yield than growing alone (Pappa et al., 2012). In the experiment carried out in China by L. Mao et al. (2012), where intercropping of maize with pea was evaluated, the yields of both crops in intercropping system were smaller than in solo crops. However, the intercropping increased land and water use efficiency. With the usage of film covers over the field, where distance between maize and pea rows was 0.40 m, they gained almost the same maize yield as in integrated growing system, and additionally pea yield, which can increase farmer income. In experiment carried out in France in 15 institutions by E. Palzer et al. (2012), using intercropping system of peas with wheat gave almost the same yield as integrated growing of solo crop and additionally pea crop.

Intercropping that is used in orchards, where between rows there is grass (mostly clover) with legumes, grown, pollinator amount increases in orchards. Subsequently, there is better flower pollination and higher yield (García and Miñarro, 2014).

The most positive thing is that in intercropping system it is possible to get two separate yields form one plot and economically use the land resources, as, for example, in systems with rubber tree and tea bushes (Iqbal et al., 2006). Intercrop can also increase total protein yield if grown with cereals (Lithourgidis, 2011). Farmers can get two yields in one year, but it also increases growing costs and complicates cropping.

**Some controversial aspects of intercropping**

There are many opinions on how big benefits of intercropping there really are. There can be problems with shading effect. Competition for nutrition is also a problem (Fukai and Trenbath, 1993; Reynolds et al., 2007). It may take bigger investments in mineral fertilizers. To use all benefits of intercropping, crops need to be in similar needs of fertilizers, soil pH reaction. The yielding times need to be the same or with big gap between them, that harvesting of one doesn’t bother harvesting of other plant or is harvested at the same time. For these kinds of systems special machinery and skilled labour is needed. These aspects increase cost of yields, but farmers are not interested in increase of costs. Scientists should find the most optimal growing system (Mucheru-Muna et al., 2010).

**Conclusions**

Intercropping is becoming more popular. There are many combinations practiced worldwide. Main reasons for using this system is to diversify agro system, suppress weeds, possibility to reduce diseases and pests, increase income, improve land use, improve water, radiation usage in order to get healthier food, succeed in environmentally friendly growing systems. Scientists are coming closer to create best intercropping systems for these days’ demands and weather conditions, but there are still many issues on which they have to work. Further research on nitrogen cycling and legume influence on it is needed, relationship between companion plants and economic aspects of intercropping to make it more acceptable for growers should be explored.

**References**


