Possibility of strawberry cultivation in intercropping with legumes: a review

S. Dane[1,2,a], V. Laugale[1], L. Lepse[1] and D. Šterne[2]

[1]Pure Horticultural Research Centre, Pure, Latvia; [2]University of Agriculture, Jelgava, Latvia.

Abstract

The aim of this literature survey was to obtain an overview of the latest research into strawberry cultivation and intercropping systems in order to assess the possibility of growing strawberries in intercrop with legumes. Strawberries (*Fragaria* × *ananassa* Duch.) are one of the most popular berries worldwide. The traditional cultivation of strawberries in rows with a considerable distance between them leaves a significant area of the soil surface unused. According to the current demand for sustainability, the maintenance of this unused soil surface is considered to be a loss. Intercropping offers a new approach to crop cultivation. This unused soil surface between strawberry rows is an area in which intercropping can be used. Legumes can provide nitrogen, as well as biological and physical barriers against pests and diseases. Since leguminous plants constitute an important part of food and feed, growing them as an intercrop makes it possible to optimize land use and to ensure protein output for consumption. Legumes are also used to improve soil quality. Introducing intercropping in horticulture is important due to the decrease in soil fertility caused by intensive and inappropriate land use. The main focus of this survey was on the use of legumes as intercrops in strawberry fields to maintain strawberry quality and possibly improve it. Intercropping systems require less pesticide use, thus diminishing the environmental load and ensuring consumer demand for healthy food. This system can be adapted to organic and integrated farming. The main disadvantages of intercropping are the more complicated maintenance of fields and the harvesting of both cultivated plants. An interplant (in this case – legumes) also results in lower yields than when it is planted as a monocrop. According to this literature survey, the intercropping of strawberries and legumes may be profitable. Field experiments need to be carried out to further evaluate this cultivation system within a horticultural context.

Keywords: *Fragaria* × *ananassa* Duch., peas, beans, clover, protein, sustainability

INTRODUCTION

The strawberry is one of the most popular berries grown due to its good taste, nutritional value, antioxidant properties (Giampieri et al., 2012; Tulipani et al., 2014) and its ability to adapt to climatic and soil conditions. The strawberry is also strongly recommended for human consumption for its health benefits (Nile and Park, 2014). As it is consumed not only for its taste but also for health, improvement in its growing conditions becomes increasingly important.

There are many growing technologies used in strawberry cultivation. Strawberries are grown in fields in rows with or without mulch, as well as in low and high tunnels and greenhouses. Field-grown strawberries are grown in rows with a rather wide distance between rows for machinery and berry collection. This free space can be used for intercropping to reduce unused soil surface.

This world faces desertification, salinity (D'Odorico et al., 2013) and a water deficit (Qadir et al., 2007). All these circumstances are strongly connected with agriculture. Sustainability in agriculture becomes increasingly essential. Intercropping is becoming more

[a]E-mail: sandra.dane@inbox.lv

popular due to its higher water use efficiency, higher solar radiation capture (Coll et al., 2012), more optimal land use (Crusciol et al., 2014), and reduction of disease (Sapoukhina et al., 2010) and pests, although in some cases pest populations have increased (Bukovinszky et al., 2004). Leguminous plants are popular for their ability to fix atmospheric nitrogen, for their high protein content as foods (Iqbal et al., 2006a) and feeds (Belel et al., 2014), and for the large amount of green mass that they produce. The biological nitrogen fixation (BNF) of leguminous plants allows for reduction in nitrogen fertiliser usage (Park et al., 2010).

Peas (*Pisum sativum* L.) and beans (*Vicia faba* L.) are frequently used in intercropping systems. They improve nitrogen content in soil and are strongly recommended for human consumption (Tharanathan and Mahadevamma, 2003) due to their protein and fibre content.

Currently, consumers are paying more attention to the healthiness of foods, as well as to where and how they are grown. Intercropping systems reduce pesticide and nitrogen fertilizer usage (Pelzer et al., 2012). These systems are becoming more appealing to consumers. This literature survey looks into the possibility of growing strawberries intercropped with beans and peas. To ensure that strawberries intercropped with legumes do not lose quality or suffer decreases in yield, the survey must also consider the intercrops' influence on factors determining strawberry yield.

MATERIAL AND METHODS

The survey was based on original studies and review articles published in the ScienceDirect database. For this review, 63 studies were screened, of which 21 were included. Article search was done from January 12-May 15, 2015. Articles reviewed were not published earlier than 2000. The searched keywords were as follows: agrochemistry, bean, benefit, clover, desertification, fertilizer, growing technology, intercropping, legumes, management, pea, pesticide, red clover, soil activity, strawberry, water deficit, water use.

RESULTS AND DISCUSSION

Strawberry intercropping

According to climate conditions and growers' preferences, strawberries are grown in rows with or without mulch. Organic or inorganic mulch can be used as mulching material. There are many benefits to growing strawberries with organic or inorganic mulch. The main benefits are weed suppression, increased water use efficiency, and earlier yield compared to unmulched systems (Kikas and Luik, 2002). However, by growing strawberries in rows, a significant amount of the soil surface is left unused. Intercropping can be a new way to use that free soil. The space between rows can be filled with another crop for yield or to improve soil properties.

Legume intercropping

Peas and beans are most commonly intercropped with grain crops. According to research results, intercropping increases total protein content in yield, but peas and beans decrease yield for both the legume and the grain compared to monocrop. Intercropping also decreases the incidence of pests and diseases in the main crop (Jensen et al., 2010). The principal benefit of legumes is their ability to improve soil nitrogen content.

Benefits of intercropping systems

To increase strawberry fruit quality, disease and pest management needs to be used appropriately. Intercropped plants serve as biological and physical barriers against pests and diseases (La Mondia et al., 2002). Due to these properties, the incidence of diseases and pests is reduced in appropriate intercropping systems. Consequently, decreases of pesticide usage and a diminishing environmental load are possible outcomes, and these systems also meets customer demand for healthier food.

Weed suppression in strawberries is accomplished mostly by mulching and herbicides. It can also be accomplished by using intercrops (Poggio, 2005).

Disadvantages of intercropping systems

The main disadvantages of intercropping are complicated harvesting and plantation maintenance (Iqbal et al., 2006b). Pest and disease control in beans and peas can be more complicated during strawberry harvest, when no pesticide usage is allowed.

To ensure good strawberry yield, soil moisture needs to be appropriate. By using mulch, water loss is significantly decreased (Kumar and Dey, 2011). Intercropping cannot give the same results because intercropped plants use water themselves. Intercropping systems may increase water use efficiency, but water is needed more to support yield.

CONCLUSIONS

The following conclusions can been drawn from the study:

- One of the crucial points in agricultural policy is to improve soil quality. The use of legumes is one of the best ways to accomplish it.
- Strawberries are grown worldwide, and intercropping systems are designed for strawberry to share space with other plants.
- It is possible to grow strawberries by intercropping with legumes. In such systems, soil fertility is increased by BNF, which is accomplished by *Rhizobia* bacteria on the roots of legumes.
- Mulching with organic materials and intercropping can be combined.
- Field experiments need to be carried out to evaluate strawberry and legume intercropping.

ACKNOWLEDGEMENTS

This research was funded by the EUROLEGUME FP7 Research Project No. 613781.

Literature cited

Belel, M.D., Halim, R.A., Rafii, M.Y., and Saud, H.M. (2014). Intercropping of corn with some selected legumes for improved forage production: a Review. J. Agric. Sci. *6* (*3*), 48–62 10.5539/jas.v6n3p48.

Bukovinszky, T., Tréfás, H., van Lenteren, J.C., Vet, L.E.M., and Fremont, J. (2004). Plant competition in pest-suppressive intercropping systems complicates evaluation of herbivore responses. Agric. Ecosyst. Environ. *102* (*2*), 185–196 http://dx.doi.org/10.1016/j.agee.2003.08.008.

Coll, L., Cerrudo, A., Rizzalli, R., Monzon, J.P., and Andrade, F.H. (2012). Capture and use of water and radiation in summer intercrops in the south-east Pampas of Argentina. Field Crops Res. *134*, 105–113 http://dx.doi.org/10.1016/j.fcr.2012.05.005.

Crusciol, C.A.C., Nascente, A.S., Mateus, G.P., Pariz, C.M., Martins, P.O., and Borghi, E. (2014). Intercropping soybean and palisade grass for enhanced land use efficiency and revenue in a no till system. Eur. J. Agron. *58*, 53–62 http://dx.doi.org/10.1016/j.eja.2014.05.001.

D'Odorico, P., Bhattachan, A., Davis, K.F., Ravi, S., and Runyan, C.W. (2013). Global desertification: drivers and feedbacks. Adv. Water Resour. *51*, 326–344 http://dx.doi.org/10.1016/j.advwatres.2012.01.013.

Giampieri, F., Tulipani, S., Alvarez-Suarez, J.M., Quiles, J.L., Mezzetti, B., and Battino, M. (2012). The strawberry: composition, nutritional quality, and impact on human health. Nutrition *28* (*1*), 9–19 http://dx.doi.org/10.1016/j.nut.2011.08.009. PubMed

Iqbal, A., Khalil, I.A., Ateeq, N., and Khan, M.S. (2006a). Nutritional quality of important food legumes. Food Chem. *97* (*2*), 331–335 http://dx.doi.org/10.1016/j.foodchem.2005.05.011.

Iqbal, S.M.M., Ireland, C.R., and Rodrigo, V.H.L. (2006b). Logistic analysis of the factors determining the decision of smallholder farmers to intercrop: A case study involving rubber-tea intercropping in Sri Lanka. Agric. Syst. *87* (*3*), 296–312 http://dx.doi.org/10.1016/j.agsy.2005.02.002.

Jensen, E., Peoples, M.B., and Hauggaard-Nielsen, H. (2010). Faba bean in cropping systems. Field Crops Res. *115* (*3*), 203–216 http://dx.doi.org/10.1016/j.fcr.2009.10.008.

Kikas, A., and Luik, A. (2002). The influence of different mulches on strawberry yield and beneficial entomofauna. Acta Hortic. *567*, 701–704 http://dx.doi.org/10.17660/ActaHortic.2002.567.154.

Kumar, S., and Dey, P. (2011). Effect of different mulches and irrigation methods on root growth, nutrient uptake, water-use efficiency and yield of strawberry. Sci. Hortic. (Amsterdam) *127* (*3*), 318–324 http://dx.doi.org/10.1016/j.scienta.2010.10.023.

LaMondia, J.A., Elmer, W.H., Mervosh, T.L., and Cowles, R.S. (2002). Integrated management of strawberry pests by rotation and intercropping. Crop Prot. *21* (*9*), 837–846 http://dx.doi.org/10.1016/S0261-2194(02)00050-9.

Nile, S.H., and Park, S.W. (2014). Edible berries: bioactive components and their effect on human health. Nutrition *30* (*2*), 134–144 http://dx.doi.org/10.1016/j.nut.2013.04.007. PubMed

Park, S.E., Webster, T.J., Horan, H.L., James, A.T., and Thorburn, P.J. (2010). A legume rotation crop lessens the need for nitrogen fertiliser throughout the sugarcane cropping cycle. Field Crops Res. *119* (*2-3*), 331–341 http://dx.doi.org/10.1016/j.fcr.2010.08.001.

Pelzer, E., Bazot, M., Makowski, D., Corre-Hellou, G., Naudin, C., Al Rifaï, M., Baranger, E., Bedoussac, L., Biarnès, V., Boucheny, P., et al. (2012). Pea-weat intercrops in low-input conditions combine high economic performances and low environmental impact. Eur. J. Agron. *40*, 39–53 http://dx.doi.org/10.1016/j.eja.2012.01.010.

Poggio, S.L. (2005). Structure of weed communities occurring in monoculture and intercropping of field pea and barley. Agric. Ecosyst. Environ. *109* (*1-2*), 48–58 http://dx.doi.org/10.1016/j.agee.2005.02.019.

Qadir, M., Sharma, B.R., Bruggeman, A., Choukr-Allah, R., and Karajeh, F. (2007). Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. Agric. Water Manage. *87* (*1*), 2–22 http://dx.doi.org/10.1016/j.agwat.2006.03.018.

Sapoukhina, N., Tyutyunov, Y., Sache, I., and Arditi, R. (2010). Spatially mixed crops to control the stratified dispersal of airborne fungal diseases. Ecol. Modell. *221* (*23*), 2793–2800 http://dx.doi.org/10.1016/j.ecolmodel.2010.08.020.

Tharanathan, R.N., and Mahadevamma, S. (2003). Grain legumes – a boon to human nutrition. Trends Food Sci. Technol. *14* (*12*), 507–518 http://dx.doi.org/10.1016/j.tifs.2003.07.002.

Tulipani, S., Armeni, T., Giampieri, F., Alvarez-Suarez, J.M., Gonzalez-Paramás, A.M., Santos-Buelga, C., Busco, F., Principato, G., Bompadre, S., Quiles, J.L., et al. (2014). Strawberry intake increases blood fluid, erythrocyte and mononuclear cell defenses against oxidative challenge. Food Chem *156*, 87–93 http://dx.doi.org/10.1016/j.foodchem.2014.01.098. PubMed