Organic farming of pea in the northern hemisphere – a review

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Abstract

Pea (*Pisum sativum* L.) is a major human food crop. During the past two or three decades there has been a change towards organic cultivation. The aim here is to overview the main research results of the pea organic farming system to improve practices by farmers in northern hemisphere. Biofertilizers applied together with organic manures increase the yield of peas. Weeds can be reduced by the following methods: mulching, pre-emergence mechanical weed control at pre-emergence, harrowing in the early growth stages, a single pass of tine weeding either at pre-emergence or at the 2-leaf stage of the crop. On some occasions, two passes of the tine may be required to control new weed emergence. Pea varieties that grow fast and accumulate biomass (high seed weight cultivars) compete better with weeds. Foliar application of effective microorganisms with proper soil amendment and seed inoculation with *Rhizobium* coupled with soil application of organic manures can increase yields. Application of organic manures, irrespective of sources and rates, reduce the incidence of wilt. Choice of the right cultivar for organic cultivation is very important, but depends on local agro-climatic conditions. The chemical content of peas varies with different conditions.

Keywords: *Pisum sativum* L., chemical composition, growth, organic farming, plant protection, cultivars, yield

INTRODUCTION

Pisum sativum L. (field or garden pea), is a domesticated plant cultivated in Europe since ancient times (Taranovs, 1968). It is an herbaceous annual in the *Fabaceae* (formerly *Leguminosae*) family, originating from the Mediterraean basin and Near East, but now widely grown for its seed. It is a major human food crop; green pea production worldwide in 2011 was 17 Mt (FAOSTAT, 2013).

Peas are widely consumed due to their high nutritional value. They contain fiber, protein, vitamins (folate and vitamin C), minerals (iron, magnesium, phosphorus and zinc), and lutein (a yellow carotenoid pigment that benefits vision) (Issako, 1989).

From the second half of the 19th century growers around the world successfully developed and refined farming systems that relied on synthetic biocides or inorganic fertilizers. However, during the past two decades there has been a change once more towards organic cultivation (Olle and Williams, 2013).

The key factors affecting consumer demand for organic food is health consciousness and the willingness of the public to pay for high-quality high-priced produce. In general, consumers of organic products are an affluent, educated, and health conscious group spurred by strong consumer demand, generous price premium, and concerns about the environment. Because of these benefits, conventional growers are turning to organic farming. In Europe, government policies aim to stimulate the organic sector through subsidies, consumer education, and support in the form of research, education, and marketing (Yadav et al., 2013).

Since there is an increasing interest in organic farming of vegetable crops, the aim here is to review the main research results of the pea organic farming system to improve practices by farmers in northern hemisphere.

Acta Hortic. 1123. ISHS 2016. DOI 10.17660/ActaHortic.2016.1123.19
XXIX IHC – Proc. Int. Symp. on High Value Vegetables, Root and Tuber Crops, and Edible Fungi – Production, Supply and Demand
Eds.: C.J. Birch et al.

EMERGENCE, FERTILIZER APPLICATION AND NUTRIENT CONTENT OF PEAS

Faster emergence (20% after 14 days after planting compared to control) of pea seeds and reduced severity of damping-off has been obtained by combining seed priming (16 h) with biochar as a desiccant followed by Nordox an organic cuprous oxide seed treatment (Alcala et al., 2013). This faster emergence and reduced damping-off could translate to greater pea yields.

Application of biofertilizers containing native field *Rhizobium* strains can greatly enhance pea yield (Agrawal and Choure, 2011). Trials with farm yard manure and vermicompost, and dual inoculation with biofertilizers in different combinations, have shown that both *Azotobacter* and PSB (phosphorous solubilising biofertilizers e.g. *Bacillus* sp., *Pseudomonas* sp. and *Aspergillus* spp.), play a major role in increasing nutrient availability to the plants, which in turn is reflected in better quality of the produce and yield maximization. The biofertilizers, however, showed better responses when applied together with organic manures, since the manures provided a favourable environment for their activity (Sharma and Chauhan, 2011).

Increased pod yield (181.5 and 166.2%) over a control treatment of no fertilizer has been achieved with the application of farmyard manure at 20 and 15 t ha^{-1} respectively (Pandey et al., 2006). Mahmoud et al. (2013) reported that using compost and spraying pea plants with yeast extract solution at 2% improved vegetative growth and pod yield, and Mourão et al. (2013) reported that soil application of compost at a rate of 30 t ha^{-1} increased greenhouse grown organic pea yield. Determining the optimum compost rate that can be applied and ensuring sufficient nutrients are supplied to the crop that are comparable to chemical fertilizers is a next step to improve organic production.

Foliar application of effective microorganisms in combination with proper soil cultivation has improved nodulation and yield in pea (Javaid, 2006). When used with an NPK fertilizer application effective microorganisms increased nodule number by 217% and nodule biomass by 167%, but this effect was not prevalent with compost application. However, when a green manure was incorporated into the soil and a foliar application of effective microorganisms made, grain yield increased by 145%, whereas with NPK amendment grain yield incrased by only 126%. A similar results was found by Singh et al. (2011), where seed inoculation with *Rhizobium* coupled with soil application of organic manures, particularly vermicompost (10 t ha^{-1}) enhanced most of the growth and yield attributes in garden pea.

Not only yield, but also the nutritional value of pea grains is strongly influenced by soil nutritional conditions. Singh et al. (2011) reported that the highest protein content in edible pea grains (26.1%) was measured when standard NPK fertilisers were used. However, the highest vitamin C content in pea pods was obtained when grown with different organic manures and fertilisers, the exceptions being sole applications of vermin-compost or poultry manure. The highest vitamin C content in pods was observed with combined application of vermicompost and phosphate solubilizing bacteria (6.54 mg 100 g^{-1}) (Singh et al., 2011).

Yields are influenced by seasonal climate conditions and farming system; in 1998-2007 higher yields were obtained in the conventional system than in the organic system (Marta and Lehocka, 2009). The influence of adequate nutritional supply from organic soil amendments for pea growth should be further investigated to help improve yields in organic systems.

PLANT PROTECTION

Organic farming demands appropriate and timely plant protection measures. Weed control is one of the challenges and mulches are often used. Bakht et al. (2009) demonstrated that some mulches were more efficient in controlling weeds in pea than others; polyethylene (black) and newspaper mulches gave better results than wheat straw, saw dust, and white polyethylene mulches.

Johnson and Holm (2010) investigated pre-emergence mechanical weed control in field pea. They described that a strategy for field pea producers who choose not to use herbicides would be to delay seeding until some weeds emerge and to sow at a 7.5-cm depth

followed by two sequential rod-weeding passes prior to crop emergence. The uprooting effect of harrowing has been shown to be more important for weed control at early growth stages of crops than at later stages; crop damage by harrowing was less at the late post-emergence (beginning of stem elongation) stage (Velykis et al., 2009).

Significant weed control was achieved with a single pass of tine weeding either at pre-emergence mechanical weed control in field pea, in early growth stages of pea crops the harrowing, pre-emergence or at the 2-leaf stage of the crop, while on some occasions two passes of a tine were required to control new weeds (Dastgheib, 2004).

Application of organic manures, irrespective of sources and rates, gave significant reduction in the incidence of wilt (*Fusarium oxysporum* f. sp. *pisi*) on peas (Pandey et al., 2006). In contrast the control of *Pythium ultimum* or *Rhizoctonia solani* seems to depend on the amount of compost added. In pot experiments under controlled environmental conditions the addition of 8, 10 and 30% composted household waste to the potting material which was artificially infested with *Pythium ultimum* or *Rhizoctonia solani* considerably reduced the incidence of disease in different cultivars of peas. The degree of protection provided by compost depends upon the amount of compost added and upon the vulnerability of the host plant to infection (Schüler et al., 1989). There seems considerable scope for establishing approaches to improve control of soil borne diseases using appropriate organic compost additions to soils.

CULTIVARS

Genotype has significant influence on plant habit and consequently on the weed suppressing ability by biomass. Field experiments in Denmark during 1997, 1998 and 2000 showed the effects of genotype and sowing rate on the competitive ability of green pea crops against weeds in organic production. The cultivars with high biomass accumulation (Ambassador, Greenshaft, Jaguar, Zelda and DS8903) were highly competitive against weeds while the small-sized pea cultivars (Dinos, Argona and Wizard) had low competitive ability against weeds and were unsuitable for organic pea production. Pea cultivars that grow fast and accumulate biomass (high seed weight cultivars) are better at competing with weeds (Grevsen, 2003). Similarly, increased pea sowing rate improved weed suppression (Munakamwe et al., 2012). Most common pea sowing rate is 120 emerging seeds per m^2, increasing this rate can lead to better weed supressing ability in organic cultivation systems.

Suitability for organic farming is determined not only by the weed suppressing ability of the cultivar, but also its ability to give high and stable yields. Several authors have evaluated pea cultivars for organic farming. The suitability of the Latvian origin cultivars of *Pisum sitivum* subsp. *arvense* L. (pink flower cultivars) 'Retrija', 'Almara' and 'Vitra', and two cultivars of *Pisum sativum* L. (white flower cultivars) 'Lāsma' and 'Zaiga', for organic farming has been investigated (Agafonova et al., 2011). All were suitable for organic farming in Latvian climatic conditions on sod-podzol sandy-loam soil, though the study lacked a comparison with conventional production practices. The best yielding cultivar among white flower cultivars was 'Zaiga' and the most productive among pink flower peas cultivars was 'Almara'. 'Retrija' was deemed best in terms of total protein content and taste (Agafonova et al., 2011). Gopinath et al. (2009) found that of garden pea cultivars, 'Azad pea 1', 'Vivek Matar 8' and 'Vivek Matar 9' were suitable for organic cultivation at Almora (Indian Himalayas), though yields were lower than conventional production practices. Their conclusions are that a price premium of 20% is needed to offset the higher cost of organic cultivation and crop yields. In the Slovak Republic, the new cultivar 'Achat' (grown in the years 2003-2007) had higher yields than the cultivar 'Olivin' (grown in the years 1998-2002) under organic production, though yields were approximately 13% higher in conventional systems than organic systems (Marta and Lehocka, 2009).

CONCLUSIONS

Biofertilizers applied together with organic manures increase the yield of peas. Higher yields (approximately 26-82%) have been obtained by using organic manures or compost (15-20 t ha^{-1}) for fertilization compared to no fertiliser application. Significant success in

weed control has been achieved with a single pass of tine weeding either at pre-emergence or at the 2-leaf stage of the crop. On some occasions two passes of tine have been required to control newly emerged weeds. Foliar application of beneficial microorganisms with proper soil amendment and seed inoculation with *Rhizobium* coupled with soil application of organic manures could increase yield in pea. Chemical content of peas is variable and dependent on different conditions.

Pea cultivars that grow fast and accumulate biomass (high seed weight cultivars) are better at competing with weeds (all leafy pea cultivars, for example pea cultivar Seko in 80% of cases, depends on agro-climatic conditions). Application of organic manures, irrespective of sources and rates, reduced the incidence of wilt on the pea crop.

Choice of the right cultivar of pea for organic cultivation is very important, but this depends on local agro-climatic conditions.

ACKNOWLEDGEMENTS

The article is developed with the help of project EUROLEGUME. This project has received funding from the European Union's Seventh Framework Programme for Research, Technological Development and Demonstration under grant agreement no. 613781. It was also supported by grant 8895 of the Estonian Science Foundation, project no. P9003 and the Estonian Ministry of Education and Research targeted financing project no. SF0170057s09.

Literature cited

Agafonova, L., Vigovskis, J., and Švarta, A. (2011). Yields and quality of peas varieties in Latvian agroclimatic conditions for organic farming. Paper presented at: 8th International Scientific and Practical Conference 11: 287-289.

Agrawal, S., and Choure, R.G. (2011). Use of indigenous *Rhizobia* as effective bioinoculants for *Pisum sativum*. Int. J Biotech. &. Biosci. *1* (*1*), 89–96.

Alcala, A.C., du Toit, L.J., Derie, M.L., Holmes, B.J., Coffman, G., Gatch, E.W., and Porter, L.D. (2013). Evaluation of priming and Nordox seed treatment for controlling damping-off in organic pea crops in central Washington, 2012. Plant Disease Management Reports *7*, ST002.

Bakht, T., Khan, I.A., Khan, M.I., Khan, I., and Khattak, A.M. (2009). Weed control in pea (*Pisum sativum* L.) through mulching. Pak. J. Weed Sci. Res. *15* (*1*), 83–89.

Dastgheib, F. (2004). Optimizing tine weeding in organic pea crops. N. Z. Plant Prot. *57*, 45–48.

FAOSTAT. (2013). FAO Statistical Yearbook 2013. World Food and Agriculture (Rome: Food and Agriculture Organization of the United Nations).

Gopinath, K.A., Saha, S., Mina, B.L., Pande, H., Kumar, N., Srivastva, A.K., and Gupta, H.S. (2009). Yield potential of garden pea (*Pisum sativum* L.) varieties, and soil properties under organic and integrated nutrient management systems. Arch. Agron. Soil Sci. *55* (*2*), 157–167 http://dx.doi.org/10.1080/ 03650340802382207.

Grevsen, K. (2003). Weed competitive ability of green peas (*Pisum sativum* L.) affected by seeding rate and genotype characteristics. Biol. Agric. Hortic. *21* (*3*), 247–261 http://dx.doi.org/10.1080/ 01448765.2003.9755268.

Issako, L. (1989). Köögiviljad ja maitsetaimed. Tallinn, Valgus, 160 lk.

Javaid, A. (2006). Foliar application of effective microorganisms on pea as an alternative fertilizer. Agron. Sustain. Dev. *26* (*4*), 257–262 http://dx.doi.org/10.1051/agro:2006024.

Johnson, E.N., and Holm, F.A. (2010). Pre-emergence mechanical weed control in field pea (*Pisum sativum* L.). Can. J. Plant Sci. *90* (*1*), 133–138 http://dx.doi.org/10.4141/CJPS09049.

Mahmoud, R.A., EL-Desuki, M., Abdel-Mouty, M.M., and Ali, A.H. (2013). Effect of Compost levels and yeast extract application on the pea plant growth, pod yield and quality. J. of Appl. Sci. Res. *9* (*1*), 149–155.

Marta, K. and Lehocka, Z. (2009). Analyze of different cropping systems and year conditions on grain yields and thousand-kernel weight of pea (*Pisum sativum* L.). Agricultura – Stiinta si practica *1* (*2*), 33–39.

Mourão, I., Pinto, R., Brito, L.M., and Rodrigues, R. (2012). Response of protected organic pea crop to increased application rate of manure compost. Acta Hortic. *933*, 181–186 http://dx.doi.org/ 10.17660/ActaHortic.2012.933.21.

Munakamwe, Z., Hill, G.D., and McKenzie, B.A. (2012). Yield response to pea (*Pisum sativum* L.) genotype,

population and sowing date. Open Agriculture Journal *6* (*1*), 47–56 http://dx.doi.org/10.2174/1874331501206010047.

Olle, M., and Williams, I.H. (2013). Effective microorganisms and their influence on vegetable production – a review. J. Hortic. Sci. Biotechnol. *88* (*4*), 380–386 http://dx.doi.org/10.1080/14620316.2013.11512979.

Pandey, A.K., Gopinath, K.A., Chattacharya, P., Hooda, K.S., Sushil, S.N., Kundu, S., Selvakumar, G., and Gupta, H.S. (2006). Effect of source and rate of organic manures on yield attributes, pod yield and economics of organic garden pea (*Pisum sativum* subsp *hortense*) in north west Himalaya. Indian J. Agric. Sci. *76* (*4*), 230–234.

Schüler, C., Biala, J., Bruns, C., Gottschall, R., Ahlers, S., and Vogtmann, H. (1989). Suppression of root rot on peas, beans and beetroots caused by *Pythium ultimum* and *Rhizoctonia solani* through the amendment of growing media with composted organic household waste. J. Phytopathol. *127* (*3*), 227–238 http://dx.doi.org/10.1111/j.1439-0434.1989.tb01133.x.

Sharma, U., and Chauhan, J.K. (2011). Influence of integrated use of inorganic and organic sources of nutrients on growth and production of pea. Journal of Farm Sciences *1* (*1*), 14–1.

Singh, N.K., Deshmukh, K.K., and Bhandarkar, A.P. (2011). Effect of organic manures and inoculation of beneficial microorganisms on growth yield and economics of garden pea (*Pisum sativum* L.). Vegetable Science *38* (*2*), 140–142.

Taranovs, V. (1968). Dārzeņkopība Latvijā. Rīga, Liesma.

Velykis, A., Maiksteniene, S., Arlauskiene, A., Kristaponyte, I., and Satkus, A. (2009). Mechanical weed control in organically grown spring oat and field pea crops. Agronomy Research 7 (*Special issue I*), 542-547.

Yadav, S.K., Babu, S., Yadav, M.K., Singh, K., Yadav, G.S., and Pal, S.A. (2013). Review of Organic Farming for Sustainable Agriculture in Northern India. International Journal of Agronomy 2013 (Article ID 718145), pp.8 http://dx.doi.org/10.1155/2013/718145.