BOOK OF ABSTRACTS

These project are supported by the European Union's Horizon 2020 research and innovation programme. The views expressed are the sole responsibility of the authors and do not necessarily reflect the official views of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the information provided.

Lentil-oat mixtures: stronger together by complementing each other?

Katrin Rehak*, Samuel Knapp, Despoina Sidiropoulou, Jürg Hiltbrunner±

Agroscope, Plants and Plant Products, Zurich, Switzerland

* Presenter;
± Corresponding author: juerg.hiltbrunner@agroscope.admin.ch

1 Introduction

Lentil (*Lens culinaris* Medikus) belongs to the legume family and is considered as one of the oldest domesticated grain legume crops (Cubero *et al*., 2009). Although its main cropping areas are outside of Europe (India, Canada), lentil is grown in some European countries on more than 10 000 ha (Turkey, Spain, France; FAO, 2016). The average grain yield in Europe is 7.6 dt ha^{-1}, which may vary depending on the region and cultivation method. To meet the increasing demand of consumers in Switzerland, the import of lentil seeds has increased from 2004 (1300 t) to 1900 t in the year 2014 (FCA, 2016). Although the area cropped in Switzerland with lentil increased during the past years it remains modest (estimation: 100 ha) and potential exists to increase surface.

Due to the comparatively low need for mineral nutrients, lentil is suitable for extensive cropping systems and is an interesting crop, due to the ability to fix nitrogen. Because of its poor early vigor, lentils competes poorly with weeds, which leads to a major challenge for the successful production of organic lentil (Gruber *et al*., 2012). Additionally, the poor resistance to lodging causes further efforts for eliminating stones and soil particles after harvest if lentils are established as monoculture. Intercropping is an interesting option to combine the advantages of two crops on a field in the same growing season. Aim of the study was to investigate lentil–oat (*Avena sativa* L.)–mixtures at different seeding densities as well as at different proportions in the mixtures.

2 Materials and Methods

The trials were conducted in 2014, 2016 and 2017 in the proximity of Zurich at the Agroscope site Reckenholz. The long-term precipitation and average temperature (1981–2010) between March and August at this site is 592 mm m^{-2} and 13.5°C. A short growing oat variety (cv. Kurt; I.G. Pflanzenzucht GmbH, Germany) and the lentil variety Anicia (Agri Obtentions, France) were established both row by row pure alternating or mixed before sowing in different proportions (100:0, 75:25, 50:50, 25:75, 0:100) and densities (120, 180, 240, 300 seeds m^{-2}). Neither fertilizer nor pesticides were applied. Trials were established as a randomized complete block design with three replicates. Plot size was 1.5m x 6m. Among other scores, lodging was recorded at harvest (evaluation, 1 = no lodging, 9 = complete lodging). Yield was evaluated on dried samples after harvest with an experimental combine (Wintersteiger, Ried Austria) and having separated the material with different lab equipment into pure fractions of lentil and oat, respectively. In order to evaluate the systems' productivity, land equivalent ratio (LER) was calculated (Mead and Willey, 2008). Statistical analysis was done by R-Studio (Version 1.1.463, RStudio Inc., Boston, USA) and for pair-wise comparisons, Tukey's HSD was applied. Figures were established with Excel and R-Studio.

3 Results

Grain yield of both crops strongly depended on the year but variation was bigger for lentil than for oat: in 2016 average yields were lowest (2.5 dt ha^{-1} for lentil and 21.1 dt ha^{-1} for oat) while in 2017 yields were highest (7.3 dt ha^{-1} for lentil and 46.4 dt ha^{-1} for oat; Figure 1a). The seeding density did not

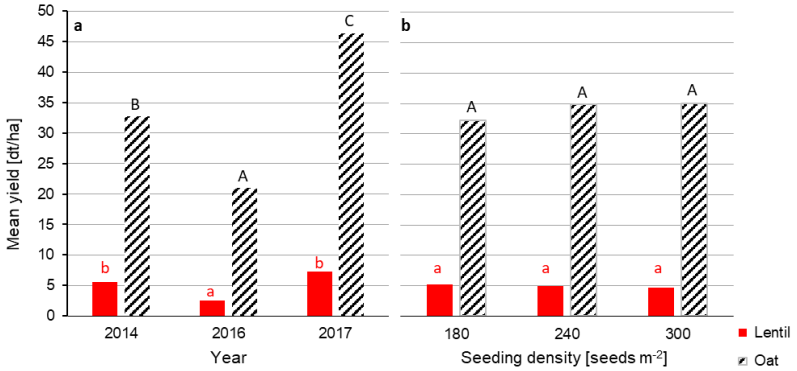

Figure 1. Grain yield of lentil (dt ha^{-1}, *standardized* to 8% H_2O) and oat (dt ha^{-1}, standardized to 14% H_2O) grown at different proportions, densities and arrangement of the partners in the field for (a) the three experimental years and (b) for the three seeding densities (180, 240, 300 seeds m^{-2}) at Zurich. Different letters indicate significant differences at α=0.05.

influence the yield of neither lentil nor of oat (Figure 1b). Grain yield of pure lentil was 16.0 dt ha^{-1} and significantly higher than in mixed cropping (Figure 2). With decreasing proportion of lentils in the mixtures, yield decreased but the yield reduction was more pronounced in the system with alternating rows when compared to the system where seeds were mixed prior to seeding. For the oat crop, the yield reduction was less pronounced in the mixtures when compared to the pure oat cropping and only significant if the proportion of oats in the mixture was reduced severely (Figure 2).

Within the crop mixtures, highest yield of lentil was observed at the proportion 75% lentil and 25% oat for the mixed seeding structure. Lodging in pure lentil cropping (8.6) was similar to the system with alternating rows (8.5) but significantly higher as in the system with mixed seeds (5.5). The LER was distinctly higher in the system of the seed mixtures (LER = 1.2) compared with the system with alternating rows (LER = 1.0).

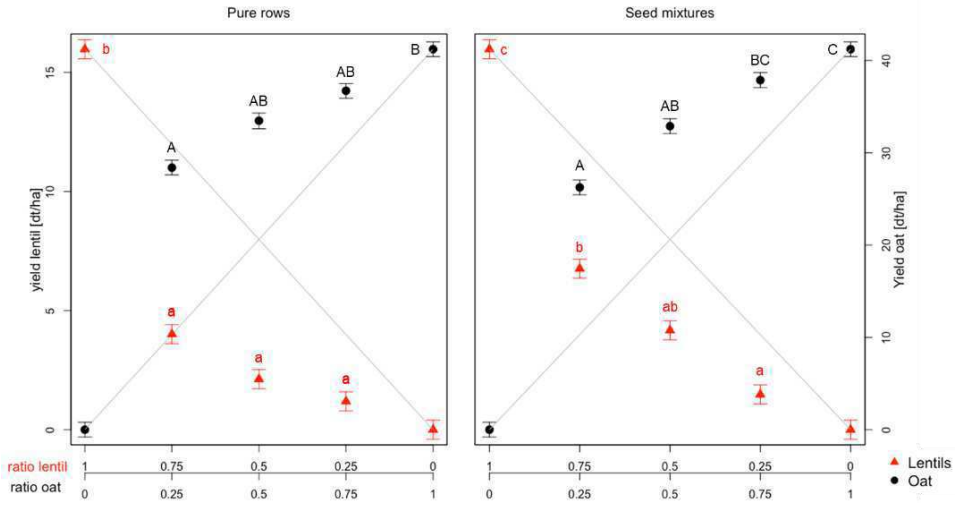

Figure 2. Grain yield of lentil (dt ha^{-1}, standardized to 8% H_2O) and oat (dt ha^{-1}, standardized to 14% H_2O) for different proportions (100:0; 75:25; 50:50; 75:25; 0:100) grown in alternating rows (pure, left) or as seed mixtures (right) at Zurich during the years 2014, 2016, and 2017. Error bars indicate standard error. Different letters indicate significant differences at α=0.05.

4 Discussion and Conclusions

Cropping of pure lentil in the region of Zurich is possible, however rainy summer increase risk of crop failure due to poor drying of the canopy and the risk of rotting in the field due to the tiny pinna. Although intercropping significantly reduces yield of lentil, the mixing of the species prior to seeding is a more promising strategy than the cropping with alternating rows, which allows the well-distributed oat plants better to prevent lentil from lodging and as a consequence to facilitate harvest. On the other hand, reduction of grain yield for oats was less distinct when compared with the pure cropping and the proportion in the harvested material in the respective mixtures was always higher for oats than for lentil. Consequently, oat is more competitive compared with lentil. Results of the LER show, that lentil growing in crop mixtures is a promising option to increase the system output and could help to increase stability of a system. Since additional efforts are needed after the harvest to separate seeds of the species, other partners' suitability as pea [*Pisum sativum* L.) or cameline (*Camelina sativa* (L.) Crantz] to intercropping with lentil should be evaluated to look for species being less competitive compared to lentils, being more easily separated while maintaining advantages to reduce lodging and suppressing weeds. To allow for overall conclusions of intercropping systems with lentil, economical aspects also need to be considered.

Acknowledgements

Funding by Bio Suisse and Fondation Sur-La-Croix, providing seeds by breeders, as well as inspiring discussions with various persons are gratefully acknowledged.

References

Cubero J.J., Pérez de la Vega M., Fratini R. 2009. Origin, Phylogeny, Domestication and Spread. In The lentil: botany, production and uses. Eds W. Erkine, F.J. Muehlbauer, A. Sarker and B. Sharma. Wallingford, UK: CAB International.

Gruber S., Wahl E., Zikeli S., Claupein W. 2012. Perspectives and limitations of weed control in organic lentils (*Lens culinaris*). Journal für Kulturpflanzen, 64:365–377.

FCA. 2016. Schweizerische Aussenhandelsstatistik. Swiss Federal Customs Administration, Bern. Access: http://www.swiss-impex.ezv.admin.ch/ [25.2.2016].

FAO. 2016. FAOSTAT database 2013. Food and Agriculture Organization of the United Nations, Rome. Access: http://faostat3.fao.org [25.2.2016].

Mead, R., & Willey, R. (1980). The Concept of a 'Land Equivalent Ratio' and Advantages in Yields from Intercropping. Experimental Agriculture, 16(3), 217-228. doi:10.1017/S0014479700010978