Common vetch in rotation with barley: a sustainable farming system for a cool, semi-arid Mediterranean area

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Abstract

A cereal monoculture is potentially unsustainable. The objectives of this study were: (1) to find whether the common vetch-barley rotation is profitable, and (2) to test whether cumin and safflower are suitable crops for rotation with barley. The study was conducted for two seasons (2001-02 and 2002-03) as a part of a larger 2-course (i.e., 2-year) rotation trial that was set up in 1994-95 in the Bekaa Valley of Lebanon under rainfed conditions at the Agricultural Research and Educational Center. There was no significant rotation effect on barley seed and straw yield. Vetch gave a higher seed yield than cumin and safflower. Vetch also gave a higher straw yield than the other three crops. Thus its rotation with barley led to the highest overall dry-matter yield. Common vetch, cumin and safflower left higher soil moisture than barley at 25 cm depth. Despite the higher cost of production, the vetch-barley rotation gave the highest net revenue, followed by the cumin-barley rotation. The higher dry-matter yield and net revenue of the vetch-barley rotation showed clearly that farmers in the Bekaa should be encouraged to adopt such a rotation and abandon barley monoculture. Cumin and safflower may be useful crops to break barley monoculture, but further evaluation is needed.

Media summary

Common vetch-barley rotation gave the highest dry-matter yield and net income per rotation cycle when compared with cumin-barley and safflower-barley rotations and barley monoculture.

Key words

Vicia sativa, safflower, cumin, seed yield, straw yield, income

Introduction

Barley (*Hordeum vulgare* L.) cropping and sheep husbandry are the two most important agricultural activities in arid and semi-arid areas of West Asia and North Africa (WANA), including the northern Bekaa Valley of Lebanon. Barley grain is the traditional and predominant feed for sheep. Barley straw and stubble after grain harvest are also important feed sources in the summer. As the numbers of sheep and goats kept in the region has increased rapidly due to demographic and economic reasons, a feed shortage has arisen. The increase in feed demand has led many farmers to grow barley continuously. Studies, locally and elsewhere, have shown that a cereal monoculture is unsustainable, because it may deplete soil nutrients and increase disease, pest, and weed populations, leading to reductions in yield and farmers' profit (Pala et al., 2000; Jones and Singh, 2000b; Yau et al., 2003).

The planting of legumes in rotation with cereals has been demonstrated to be beneficial to yield and profit in many semi-arid areas (Jones and Singh, 2000a). Common vetch (*Vicia sativa*) is one of the leguminous feed crops that have the potential for being used in rotation with barley. In the northern Bekaa Valley of Lebanon, a recent study over 6 years showed that among the barley-legume rotations, the barley-common vetch for seed rotation gave the highest and most stable dry matter yield (Yau et al., 2003). However, the authors of this study stopped short of carrying out an economic analysis to show that the barley-common vetch rotation gave the highest income.

In the last 4-5 years, many farmers in the arid and semi-arid areas of Syria shifted to growing cumin (*Cuminum cyminum* L.), which is a spice. Cumin produces less seed and straw than barley, but the higher price of its seed most probably gives a better income to many Syrian farmers than growing barley. Besides, its shorter growing cycle and less biological production may mean conservation of some moisture, which could benefit the following barley crop. No scientific reports have been published on the evaluation of cumin in rotation with barley.

Safflower (*Carthamus tinctorius* L.), which is an oil-seed crop, originates from the eastern Mediterranean region. It is known to be drought resistant, because it has long, deep roots. In India, it is considered to be the most drought-resistant of all oil-seed annuals. Research conducted under rainfed conditions in the Bekaa Valley of Lebanon showed that safflower gave similar seed yield to barley but much higher straw yield (Yau, 2004). It may be a good break crop for the cereal/cereal rotation, and Yau et al. (1999) gave other reasons supporting its re-introduction into Lebanon.

The objectives of the present research were: (1) to show that common vetch-barley rotation is sustainable as it gives higher income, besides higher yield, than continuous barley cultivation, and (2) to test whether cumin and safflower are suitable crops for rotation with barley in the Bekaa Valley of Lebanon.

Materials and methods

The rotation trial was set up in the Bekaa Valley of Lebanon under rainfed conditions at the Agricultural Research and Educational Center (33? 56′ N, 36? 5′ E, 995 m above sea level). The long-term annual precipitation of the Center is 513 mm, 58% of which falls in December to February. The long-term mean annual temperature is 13.9 ?C. The soil is an alkaline (pH 8.0), gravelly-clayey, Vertic Xerochrept. Depth to gravel is generally between 50-70 cm.

This study was conducted for two seasons (2001-02 and 2002-03) as a part of a larger 2-course (i.e., 2-year) rotation trial that was set up in 1994-95. The barley-cumin and barley-safflower rotations were initiated in 2000-01. The barley monoculture and the barley-common vetch rotations existed since 1994-95. The facultative 6-row barley ‘Rihane-03’, Syrian local common vetch (ICARDA accession 2541), Syrian local cumin, and ‘Gila’ safflower were used. The experiment was in a randomised complete block design with two replicates. The size of the plots was 0.1 ha (10 m by 100 m) for barley-barley and barley-cumin, and 0.05 ha (5 m by 100 m) for barley-vetch and barley-safflower. Both phases of each treatment were present each year.

Sowing of barley, vetch, and safflower took place in November, which is the optimal sowing time for the northern Bekaa. Cumin was sown in March. Seeds were drilled in rows spaced 15 cm apart. Sowing rates in kg ha^{-1} were: 120 for barley, 100 for common vetch, 30 for cumin, and 25 for safflower. Selective herbicides were sprayed to control grass weeds in vetch, cumin, and safflower, and to control broad-leaf weeds in barley. Soil samples were collected to 20-cm depth in September 2000. Olsen P, NH_4-N, NO_3-N, Kjeldahl N and organic matter were measured. Nitrogen was broadcast by hand at a rate of 30 kg N ha^{-1} in the spring as ammonium nitrate to the barley plots only. Since the Olsen-P level was >25 mg kg^{-1}, no phosphate fertiliser was applied. Soil moisture was measured by using a TDR meter after harvest.

Harvest was carried out at physiological maturity for barley and safflower. Vetch and cumin was harvested before physiological maturity in May to prevent seed shattering and leaf loss. Three 1-m^2 samples from representative spots in each plot were cut at ground level, oven-dried at 80C for 48 hr, weighed, and threshed. The ANOVA directive of the Genstat package was used for the analysis of variance. In the combined ANOVA analysis, the random-year and fixed-treatment model was adopted (McIntosh, 1983).

Current seed and straw prices paid to farmers around the Centre were collected in 2003. Since safflower is not grown in Lebanon, and not widely grown in the world, the price of safflower paid to farmers in California, USA was adopted (Kearney *et al.*, 2000). The straw price of safflower was assumed to be half that of barley. The price of 1 t of cumin straw was assumed to be equivalent to the cost of stubble grazing 1 ha of barley field. It should be noted that the use of an overseas seed price did not necessarily over-

estimate the benefit of safflower since the local prices of the other three crops were higher than those prevailing in the world market. The costs of land preparation, seeds, seeding, fertilizers, herbicides and pesticides, including their application, and harvesting were included in the total cost. Barley and safflower were assumed to be combine-harvested but common vetch and cumin were hand-harvested.

Results and discussion

Precipitation was below normal (419 mm) but had a good distribution in 2001-02. In 2002-03, precipitation was high (928 mm) but the lower than normal sunshine hours led to lower yields than expected.

In the barley phase, there was no significant rotation (Table 1), year or year-by-rotation effect on seed and straw yield. In the non-barley phase, rotation and year effects were significant, but year-by-rotation was not significant. Vetch gave a higher seed yield than cumin and safflower. Vetch also gave a higher straw yield than the other three crops. As expected, cumin gave the lowest yields. Results on the non-significant difference in seed yield between barley and safflower supported an earlier rainfed trial at the same site, but the relatively poor straw yield of safflower in this study was in contrast with the earlier study (Yau, 2004). The reason for the poor stand of safflower was not identified; safflower is known to perform well in deep soils and it may have been less suited to the shallow soil of the trial site. When the seed and straw yield of the two phases were combined, the year-by-rotation term was not significant. The vetch-barley rotation gave a higher dry-matter yield per cycle than cumin-barley and safflower-barley rotations. Results of this study showed clearly that vetch is a productive crop in the cool, semi-arid Bekaa Valley of Lebanon, thus its rotation with barley led to the highest dry-matter yield, giving further support to the earlier report of Yau et al. (2003).

Table 1. Mean seed and straw yield (kg/ha) of the different rotations (2001-02 and 2002-03).

Crops in rotation with barley	Seed yield of barley	Straw yield of barley	Seed yield of the other crop	Straw yield of the other crop	Dry-matter yield per cycle
Barley	1020	2210	1020	2210	6460
Common vetch	1500	2150	1470	3590	8710
Cumin	1320	2760	490	1060	5630
Safflower	1580	2470	680	1560	6290
L.S.D. (5%)	788 (n.s.)	547 (n.s.)	527	1339	2318

After harvest, there was no significant difference in soil moisture content at 25 cm depth between the different barley crops, but common vetch, cumin and safflower left higher soil moisture than barley (Table 2). Comparing table 1 with table 2, it appears that there is a relationship between the higher barley grain or straw yield after each of the broadleaf crops with the higher soil moisture left by the broadleaf crops. Further study is needed to confirm this. The highest moisture content was recorded under safflower at 25 cm depth and there was no significant difference in soil moisture content between the rotations at 50 cm depth. This result was unexpected, as safflower is known to have deep roots that will extract soil moisture deep down. Such a result most probably was caused by the poor stand of safflower in this trial.

Table 2. Mean soil moisture content (%) after harvest at 25 and 50 cm depths under the different rotations in 2002-03.

Crops in rotation with barley	25 cm, after barley	25 cm, after the other crop	50 cm, after barley	50 cm, after the other crop
Barley	9.8		18.9	
Common vetch	12.2	17.6	21.8	23.4
Cumin	13.5	18.7	25.7	26.3
Safflower	12.8	21.8	23.5	26.3
L.S.D. (5%)	4.7		8.5 (n.s.)	

Barley and cumin had the lowest and highest seed price, respectively (Table 3). The straw of vetch fetched the highest price because of its higher nutritive value. The costs of producing vetch and cumin were higher than that for barley and safflower due to the fact that many labourers were needed to harvest the vetch and cumin by hand. Despite the higher cost of production, the vetch-barley rotation gave the highest net revenue, followed by the cumin-barley rotation. The higher dry-matter yield and net revenue of the vetch-barley rotation showed clearly that farmers in the Bekaa should be encouraged to adopt such a rotation and abandon barley monoculture.

On the issue of vetch harvesting, the ICARDA scientists introduced a mechanized technique of rolling to make an even seedbed, and cutting and swathing to do the harvesting (ICARDA, 1999). This technique will reduce the cost of vetch harvesting, and higher net revenue from the vetch-barley rotation is expected.

Table 3. Mean seed and straw prices, cost of production and net revenue per rotation cycle of the different rotations.

Crops in rotation with barley	Seed price ($\$ t^{-1}$)	Straw price ($\$ t^{-1}$)	Production cost ($\$ ha^{-1}$)	Net revenue ($\$ ha^{-1}$)
Barley	133	130	253	340
Common vetch	400	150	540	813
Cumin	1200	30	460	441
Safflower	290	65	276	301

The results of the study could give one explanation of why farmers in Syria have adopted the cumin-barley rotation in recent years. However, more time is needed to tell whether this is a sustainable rotation. It is believed that the present high price of cumin is not going to last. Besides, replacing barley production by cumin may increase the price of barley straw and feed may need to be imported. The authors believe that the cumin-barley rotation would not be a good choice in the Bekaa Valley at this moment.

Although results of this study showed that the safflower-barley rotation would not be a good choice, we have not lost our interest in safflower. The field in which the trial was carried out may not be suitable for safflower, since safflower grown in other fields of AREC yielded 1400 – 2500 kg ha^{-1} in the last seven years. In 2001, which was a dry year with <400 mm annual rainfall, a demonstration plot in a farmer's field with deep fertile soil yielded 5 t ha^{-1} under rainfed conditions. Thus, we are considering setting up a similar trial in another field.

Conclusion

The results of this study showed clearly the advantage of practising a vetch-barley rotation in a semi-arid, high-elevation Mediterranean site. Farmers in the Bekaa Valley of Lebanon should consider adopting the vetch-barley rotation. Cumin and safflower may be useful crops to break the barley monoculture, but further evaluation is needed.

References

Kearney T, Klonsky KM and De Moura RL (2000). Sample Cost to Produce Safflower – Irigated, Sacramental Valley, Yolo County, 2000. (University of California Cooperative Extension, Davis).

ICARDA (1999). ICARDA Annual Report 1998. (International Center for Agricultural Research in the Dry Areas, Aleppo).

Jones MJ and Singh M (2000a). Long-term yield patterns in barley-based cropping systems in Northern Syria, 2. The role of feed legumes. Journal of Agricultural Science, Cambridge 135, 237-249.

Jones MJ and Singh M (2000b). Long-term yield patterns in barley-based cropping systems in Northern Syria, 3. The case of continuous barley. Journal of Agricultural Science, Cambridge 135, 251-259.

McIntosh MS (1983). Analysis of combined experiments. Agronomy Journal 75, 153-155.

Pala M, Armstrong E. and Johansen C. (2000). The role of legumes in sustainable cereal production in rainfed areas. Proceedings of the Third International Food Legumes Research Conference, Adelaide, South Australia (Kluwer Academic Publishers).

Yau SK (2004). Yield, agronomic performance and economics of safflower in comparison with other rainfed crops in a semi-arid, high-elevation Mediterranean environment. Experimental Agriculture 40, (in press).

Yau SK, Bounejmate M, Ryan J, Nassar A, Baalbaki R and Maacaroun R (2003). Barley-legumes rotations for semi-arid areas of Lebanon. European Journal of Agronomy 19, 599-610.

Yau SK, Pala M and Nassar A (1999). Safflower (*Carthamus tinctorius*) production and research in Lebanon. *Sesame and Safflower Newsletter* 14, 97-102.