ABSTRACT

Safflower (Carthamus tinctorius L.), which has deep roots, can be grown as an economical oil crop in semiarid, rain-fed areas of West Asia and North Africa, where barley (Hordeum vulgare L.) monoculture is a common practice. In this study, we sought to: (i) evaluate the effect of safflower on the yield of the following barley crop and (ii) compare such effect with other crops to determine the potential of rotating safflower with barley. Two series of experiments were conducted under rain-fed conditions in Lebanon’s Bekaa Valley (2002–2003 to 2003–2004 and 2005–2006 to 2010–2011). In Series 1, there were 12 2-yr rotation systems, whereas in Series 2, 3 rotation systems were studied. Results from the two and three rotation cycles were reported from the first and second series of experiments, respectively. Rotation effects were significant (P ≤ 0.05) for barley grain yield, straw yield, and harvest index, but rotation × year interaction was not significant. In Series 1, barley after safflower gave the highest harvest index (0.40 kg kg⁻¹) and mean grain yield (1400 kg ha⁻¹), that is, 28 to 72% higher grain yield than after the other crops, except after cumin (Cuminum cyminum L.) and common vetch (Vicia sativa L.) for grazing. In Series 2, grain yield and harvest index of barley after safflower (4090 kg ha⁻¹, 0.36 kg kg⁻¹) were higher than that after barley (3010 kg ha⁻¹, 0.32 kg kg⁻¹). Thus, growing safflower before barley increased rather than decreased barley yields, and was comparable to or better than after some legumes. Barley/safflower therefore appears to be a viable rotation in semiarid, rain-fed Mediterranean areas.

Does Growing Safflower before Barley Reduce Barley Yields under Mediterranean Conditions?
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In the semiarid northern Bekaa Valley of Lebanon, barley cropping and sheep (Ovis aries) husbandry are the two most important agricultural activities. Barley grain, straw, and stubble are the traditional and predominant feed for sheep and goats (Capra hircus L.) in such areas. Due to population and income increases, sheep and goat numbers have rapidly increased as well. Consequently, a feed shortage has arisen in the region (Hamadeh et al., 1996). The increase in feed demand has led many farmers to grow barley continuously as a monoculture system. However, monoculture is not a sustainable cropping system, because it may deplete soil nutrients and increase disease, pest, and weed populations (Jones and Singh, 2000a; Yau et al., 2003), leading to reduced yields and farmers’ profit.

Legumes in rotation with cereals are beneficial in many semiarid areas (Krupinsky et al., 2006; Yau et al., 2003). In addition to enhancing soil N status and suppression of cereal diseases and pests, there is an N-sparing effect (Chalk, 1998), and growth-promoting substances released from decaying legume residues give healthier wheat roots (Stevenson and van Kessel, 1996). In the Mediterranean region, moisture not taken up by shorter and earlier-maturing legumes enhances the yield of the subsequent cereal crops (Jones and Arous, 1999; Jones and Singh, 2000b). However, few new crops have been introduced to increase diversity or sustainability in West Asia and North Africa, and little research on crop rotations using these new crops has been conducted.

Safflower, mainly an oil-seed crop that originated in the eastern Mediterranean region, is relatively drought-tolerant because of its deep roots (Merrill et al., 2002). Under rain-fed conditions in Lebanon’s Bekaa Valley, safflower gives similar grain yield as barley but much higher straw yield (Yau, 2004). Since safflower is not a monocot, it may be a good break crop for the cereal monoculture. Yau et al. (1999) gave other reasons: safflower oil usually fetches a high price, the high-protein meal is a valued feed, petals (about 100 kg/ha) can also be collected for sale, adaptation is not a problem as it originated from the Middle East, can be grown just like winter cereals in rain-fed fields with no need of additional implement or machinery, and cultivars with high-oleic fatty acid are available to support its re-introduction into Lebanon and the Mediterranean region in general. Although safflower is adapted to the region, it cannot be assumed that it is a suitable crop for rotation with barley. In fact, conflicting reports on effects of safflower on subsequent crops have been obtained outside the region, as presented below.

The fact that safflower has deep roots raised concerns that it may exhaust water reserve in the soil and thus deleteriously affect the following crop (Pala and Beg, 1997). In a semiarid area of the northern Great Plains of the United States, Aase and Pikul (2000) showed that safflower and sunflower (Helianthus annuus L.) used more water than many other crops and warned farmers of possible reductions in grain yield following deep-rooted crops. Lower yield of barley and wheat (Triticum aestivum L.) after safflower and yellow mustard (Brassica hirta Moench) occurred under dryland conditions in Washington State, as safflower and mustard left less water in...