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Structure of weed communities occurring in monoculture and intercropping of field pea and barley

Santiago L. Poggio *

Cátedra de Producción Vegetal, Departamento de Producción Vegetal, Facultad de Agronomía, Universidad de Buenos Aires, Av. San Martín 4453 (C1417DSE), Ciudad Autónoma de Buenos Aires, Argentina

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Abstract

Weed growth suppression is an explanation of intercropping yield advantage, which can be applied to diminish herbicide use in agriculture. Intercrop effects on weed community structure, nonetheless, have been sparsely studied. The hypothesis that intercrops will produce greater changes in weed community structure than monocultures was therefore postulated. It was concurrently predicted that species diversity of the weed community will be lower in the intercropping than in the monocultures, and that winter- and spring-emerging species in intercrop will be relatively less and more abundant than in monocultures, respectively. Field experiments were carried out at Buenos Aries and Rojas (Argentina) involving monocultures, intercrops of barley and pea, and a control treatment where weeds grew without crops. Effects on weed communities were characterised in terms of growth, species diversity (richness and evenness), and floristic and functional composition. Nitrogen content of plant biomass and interception of solar radiation were also measured. The greater the crop biomass, the higher the weed suppression was. However, barley tended to greatly suppress the growth of weed and pea plants, which could be explained by the greater nitrogen accumulation in barley plants in monocultures and intercrops. Furthermore, there were apparent complementarity in nitrogen uptake between barley and pea when intercropped, since both crops use different sources of soil nitrogen. Intercrops and barley monocultures generally produced similar effects on the companion weed communities, whereas pea effects were less suppressive and more variable. However, intercrops effects appeared to be more stable across experiments. Spring-emerging species generally increased its relative importance in the intercrop weed communities; whereas winter-emerging species were usually less abundant in intercrops. Divergence in the abundance of winter and summer emerging weeds could be attributed to the different canopy dynamics of intercrop and monocultures. This work contributes to improve current understanding of how crop–weed communities are assembled and may help in developing weed management practices that are environmentally sound.

Keywords: Competition; Intercropping; Plant functional traits; Species diversity; Weed suppression

1. Introduction

The increase in agricultural productivity during the 20th century resulted from the use of high levels of external inputs (Evans, 1998). Agricultural intensifi-

* Tel.: +54 11 4524 8025x32; fax: +54 11 4524 8737.
E-mail address: spoggio@agro.uba.ar.

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cation, however, also produced some side effects, such as soil erosion, environmental pollution by agrochemicals and fertilisers misuse, and the appearance of agrochemical resistant populations of weeds and pests (Cox and Atkins, 1979; Jackson and Piper, 1989; Gressel, 1991; Vandermeer et al., 1998). Diversification of cropping systems, for instance, by increasing the number of crop species grown, has been proposed as a solution to some problems of modern agriculture (Vandermeer, 1995; Brummer, 1998; Vandermeer et al., 1998; Altieri, 1999). Intercropping, the practice of growing two (or more) crops simultaneously in the same land area (Willey, 1979a; Vandermeer, 1989), represents an option to diversify cropping systems (Brummer, 1998; Altieri, 1999). The most common reason for the adoption of intercropping is yield advantage, which is explained by the greater resource depletion by intercrops than monocultures, particularly when cereal and legume crops are grown together (Willey, 1979a, 1979b; Vandermeer, 1989; Ofori and Stern, 1987; Fukai and Trenbath, 1993). Weed suppression, the reduction of weed growth by crop interference, has been referred as one determinant of yield advantage of intercropping, being a viable alternative to reduce the reliance of weed management on herbicide use (Liebman, 1988; White and Scott, 1991; Liebman and Dyck, 1993; Midmore, 1993; Liebman and Davis, 2000).

Most weed research is devoted to study particular weed characteristics, mainly crop–weed competition, whereas only few studies are focused on the assemblage of multiple species communities composed of crop and weed species (Martínez-Ghersa et al., 2000). Concordantly, research on the changes in the weed community structure due to intercropping is sparse (Shetty and Rao, 1981; Janiya and Moody, 1984; Mohler and Liebman, 1987). There is some evidence supporting that crop presence modifies the species hierarchy of a weed community (i.e. the distribution of biomass among the species in the community). Mohler and Liebman (1987), in an experiment with barley and field pea, observed that the suppression of dominant weed species was greater as the crop productivity increased, even though changes were more dependent on crop dominance rather than on the number of species in the intercrop. Moreover, adding ferny Azolla (*Azolla pinnata* R. Br.) into rice monoculture selectively suppressed *Monochoria vaginalis* (Burm.f.) Presl. Solms and released *Echinocloa crus-galli* (L.) Beauv. from the competition of the dominant weed species (Janiya and Moody, 1984). Thus, it would be expectable that adding a second crop species to a monoculture will modify the biomass distribution among the species in a weed community.

Furthermore, since plant traits instead of species are actually adapted to a particular environment, arranging weed species into functional groups may give a better understanding of how weed communities are assembled that just using species lists (Ghersa and León, 1999; Booth and Swanton, 2002). For instance, differences in the relative abundance of both winter and spring emerging weeds between pea and wheat monocultures have been recently reported, which could be explained by the differences between crops in their patterns of resource consumption (Poggio et al., 2004). In pea–barley intercrops, it was also observed that the establishment of late-emerging species would have been modulated by the intensity of crop competition (Mohler and Liebman, 1987). Since cereals and legumes use different nitrogen sources (Tofinga et al., 1993; Snaydon, 1996; Hauggaard-Nielsen et al., 2001), and nitrogen and radiation are intimately linked with canopy dynamics (Dreccer et al., 2000), it would also be reasonable to propose that changes in the competition for nitrogen and radiation between crops and weeds grown in mixtures might also be involved in the modification of the weed community structure.

Based on the previous evidence, it can be hypothesised that the use of available resource by barley–pea intercrop is more complete than that of monocultures. Pea–barley intercrops will therefore produce greater changes than monocultures in weed community structure, characterised by its species diversity and its compositions of species and functional traits (life cycle, emergence season). These changes not only will be observed in terms of greater weed growth suppression, affecting as well, species diversity accounted by impoverishment of floristic and functional compositions. Thus, the following predictions were tested: (1) species diversity (i.e. species number and evenness) of the weed community will be lower in the pea–barley intercrop than in the monocultures, and (2) in comparison with monocultures, winter- and spring-emerging species of the intercrop will be relatively less and more abundant, respectively.