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The effect of weeding time on raspberry (*Rubus idaeus* L.) crops yield and weed community in Rio Negro Province, Argentina

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ABSTRACT

Raspberry (*Rubus idaeus* L.) is the most important crop in the (Andean Shire), an area situated at the south of Rio Negro Province in the south of Argentina. Organic berries production in this area increased significantly in the last ten years. Weed management in raspberry organic crops is performed by tillage. Excessive tillage can reduce weed species diversity and increase both soil erosion and production costs. Field experiments were carried out with summer and fall fruiting raspberry varieties within the periods 2005–06 and 2006–07 with the aim of studying the effect of different weeding times on (i) raspberry yield, (ii) fruit quality and (iii) weed community richness and abundance. The fruit harvest was carried out two or three times a week during all harvest period for each variety. In addition, fruit quality was assessed at different harvest times. From spring to the end of harvest weed cover and weed species richness were measured for each treatment. The results showed that the most frequent weed removal did not exceed the yield obtained with three weeding operations carried out during spring and summer. This meant an important reduction in cost production, with the advantage of maintaining weed diversity. The presence of weeds did not affect fruit quality. Summer fruiting variety was more competitive than fall fruiting variety.

1. Introduction

Raspberry (*Rubus idaeus* L.) is the most important crop in the area called Comarca Andina (Andean Shire) situated at the south of Rio Negro Province in Argentina between 42° and 42° 20 ′S. The western border is formed by the Andes mountain range and the eastern by the meridian 71° W. This is the main production area of berries in Argentina. The most frequent crops are raspberry, strawberry (*Fragaria vesca* L.), cherry (*Prunus virginiana* L.), gooseberry (*Ribes* sp.), blackberry (*Rubus* sp. L.), blueberry (*Vaccinium* sp.) and boysenberry (*Rubus loganobaccus* L.) (Martínez et al., 2009). Two kinds of raspberry varieties are planted in the area. On one hand, varieties called summer or floricane fruiting with a harvest period along the summer whose floricanes die after fruiting. On the other hand, raspberry varieties called fall fruit or primocane fruiting have many advantages over traditional summer-fruiting, floricane raspberries. They provide an opportunity to extend the production season from late summer until fall. Whereas the summer raspberry harvest lasts 6 weeks, fall fruiting can add, at least, 6 weeks to the production season (Pritts, 2008). The main raspberry varieties planted in the Comarca Andina are Schoenemann and Autumn Bliss for summer and fall fruiting, respectively (Martínez et al., 2009).

Organic production systems have been significantly expanded in the Comarca Andina. The knowledge of population dynamics of different pests such as weeds, insects or pathogens is essential to design a successful strategy for pest management in production systems with or without reduced use of chemicals. Thus, it is possible to attain a sustainable production maintaining weed population size, which does not reduce significantly crop yield and does not alter the specific role of weeds as ecological services providers in agroecosystems (Radosevich et al., 1997). Competition is a key process regulating the effect of weeds on crop yield. Moreover, there is enough published information regarding the effects of environmental factors or agronomic practices on competition between weeds and crops. Although there are many studies in Argentina concerning weeds effects on extensive crops such as soybean, wheat, corn or sunflower, very few of them focus

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on studying the effect of weeds on intensive crops such as raspberry (Ovalle et al., 2007). In addition, there are no studies comparing the effect of different tillage strategies on crop yield and weed community structure. Interestingly, grass and clover cover crops, rototilling, hand weeding, sawdust mulch, and pre-emergence herbicides were evaluated for their effects on yield, berry weight, and total soluble solids in summer-bearing red raspberries. With the exception of total soluble solids, none of the evaluation criteria were significantly affected by the weed control treatments (Barney and Finnerty, 1994).

Mulching is a common weed management tool and can be very effective in reducing or eliminating most annual weeds from the crop row. However, it is seldom effective for perennial weeds (Bonnano, 2011 www.newenglandvfc.org/pdf_proceedings/Blueberry weed_manage.pdf). In the area of the study it is not usual to use this option in large surfaces because it is not easy to obtain vegetables residues. Hoe-weeding is the main method used in the Comarca Andina in organic raspberry. In addition, many arable weed species support a high diversity of insect species. Thus, excessive soil tillage may cause reduction in abundance of host plants affecting associated insects and other taxa. Weeding in the Comarca Andina is mainly done regardless of the competitive effect of weeds. The average cost of each weeding is 350 kg of raspberry that represents almost 4% of the crop production. Moreover, the costs increase regarding the amount of weeds present in the field. Thus, proper tillage is important in order to keep raspberry labor costs down. During 2005–06 and 2006–07, field experiments were carried out with the aim of studying the effect of different weeding regimes on (i) raspberry yield, (ii) fruit quality (weight, pH and Brix grade) and (iii) weed community richness and abundance in raspberry crops with both floricane and primocane fruiting habit.

2. Materials and methods

2.1. Site and experimental design

During 2005/06 and 2006/07 growing seasons, three field experiments were conducted in organic raspberry crops. Experiments were carried out in two different farms near the city of Lago Puelo that have been under organic management systems from more than ten years where soil organic matter is 7% and pH: 6.5. Prevalent soils in the area are Andosols derived from ash volcanic with loamy texture A horizon. They are highly fertile soils with adequate nutrient supply (with the exception of phosphorus). The average bulk density of these soils is 0.5 g/cm^3, N content 4 g kg^{-1} and C 74 g kg^{-1}. The climate is temperate with 75% of the annual rainfall in autumn–winter (between April and September) and both spring and summer (October–March) are generally warm and dry. The mean temperature and annual precipitation are 9.9 °C and 921 mm, respectively (Urretavizcaya, 2010). Temperature and rainfall regimes of the experimental area are shown in Fig. 1.

The crop life in the area is approximately 20 years. Raspberry planting is in lines 3.3 m apart and 0.5 m between plants in each line, in continuous hedgerow with two pair of wires at 1.3 m–0.7 m from the soil. Fertilization is carried out with organic chemical fertilizer incorporated in spring. Drip irrigation is applied regarding 6 mm average demand per day in January. The most serious problems are root diseases which are managed choosing planting site or with soil systematization. The most frequent weeding method is hand hoeing covering 1 m wide along the plant line. The areas between the crop rows are usually maintained with a mowed cover of sod, weeds, or a combination of these. This cover is used primarily for erosion control, to maintain biodiversity and to improve the recollection of fruits by harvesters.

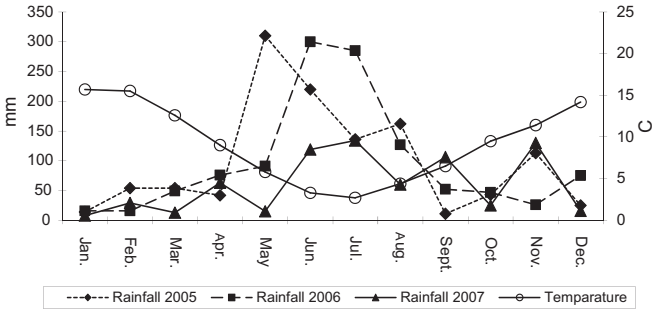

Fig. 1. Air average temperature and rainfall in the experimental area. Temperatures are average of (1997–2007). Rainfall data are from 2005, 2006, 2007.

The experimental design was a randomized complete block with five and four treatments in 2005–06 and 2006–07, respectively. In both years there were three replications for each treatment. The treatments consisted of different frequencies of weeding operations (hand hoeing) during spring (September–December) and summer (December–March) (Table 1). In 2005–06, the experiment was conducted only with the fall fruiting Autumn Bliss variety while in 2006–07, the experiments were carried out with Schoenemann (summer fruiting) and Autumn Bliss varieties. The experimental plots consisted of 5 m of crop line length. Each replication was placed in different lines of the crop. The time of weeding represents the calendar applied in the region and it is related to the weed cover (40–60%). The different hoeing operations were done in the first inches of soil to avoid damaging the roots and shoots of the crops along the plant line in a 1 m wide. The unweedy treatment was without tillage from the beginning of spring and agronomic practices such as irrigation, fertilization, insecticide and fungicide applications were the same in the different experiments as well as in the rest of the crop.

2.2. Data collection

2.2.1. Crop yield and fruit quality

To assess crop yield of Autumn bliss variety each plot was totally harvested by hand two or three times each week, from December (the beginning of summer) to April (mid-autumn). For Schoenemann variety the same harvest method was practiced from December to the end of January. In addition, individual fruit weight, pH and Brix grade (soluble solid contents) of the fruits were also measured. Samples of 50 fruits were taken each week and fresh weight was registered and fruits were preserved at −22 °C until they were analyzed. Brix grade is a measurement of refractometric soluble solids content (RSS) expressed in percentage and is equivalent to the concentration of total sugars in the fruit affecting the proportion of fruit and sugar used in the sweet industry.

2.2.2. Weed community and cover

From September of each year and every fifteen days until April, soil weed cover was visually estimated (0% unweedy – 100% total

Table 1
Different experimental treatments (times of weeding) in experiments (2005–06 and 2006–07). Numbers next to each month is the day of weeding.

2005–06 Autumn bliss	2006–07 Autumn bliss	2006–07 Schoenemann
Sep (11)–Nov (14)	Sep (10)–Feb (15)	Sep (10)–early Nov (10)
Oct (17)–Feb (26)	Sep–Nov (10)–Feb	Sep (10)–late Nov (22)
Sep–Nov–Feb	Weeded biweekly	Weeded biweekly
Weeded biweekly	Weedy	Weedy
Weedy		