Screening of stand-alone and mixture of cover crops for ground cover management in a temperate organic peach orchard

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Abstract

Cover crops are alternative strategies for managing weeds within the tree row in organic orchards. The choice of the botanical composition of cover crops is a key issue to propose a reliable alternative. In this study, we investigated the interest of cover crops composed of stand-alone or a mixture of species of the Fabaceae and Poacaea family, respectively chosen for their soil nitrogen release and soil bearing capacity, and mixed according to biological complementarity. Eight cover crops were assessed in an irrigated organic Peach orchard in southeastern France during 3 years. Results highlight the high potential of three species for ground coverage and different patterns of interspecific competition. Cover crop dynamics pointed out the importance of mowing in weed vs. cover crop development and appropriate mowing schemes need to be further tackled.

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Introduction

In temperate commercial organic orchards, ground cover within the row is commonly managed using mechanical methods based on tillage or cover-crop destruction. These methods have some limits e.g. the restriction of superficial root development (Parker and Meyer 1996), increased risk of erosion (Duran Zuazo et al. 2008), modification of soil properties (Oliveira and Merwin, 2001) and the disruption or destruction of habitat for natural enemies of pests (Halley and Hogue, 1989) or earthworms (Parveaud et al., 2012).

The effect of cover crops in organic orchard systems has been assessed (e.g. Hoagland et al. 2008) but implementation in commercial orchards is still rare. As potential nitrogen input, nitrogen-fixing plants used as cover crops are of great interest in organic orchards. In this study, we assessed 8 cover crops during 3 year to (1) identify and quantify the soil covering capacity of stand-alone or mixtures of species and to (2) quantify soil nitrogen dynamics.

Material and methods

The experimental design was located at the INRA Gotheron experimental station in the Rhône Valley production area, in the South-East of France. Peach trees cv. 'Benedicte' grafted on *Prunus* cv. 'Montclar' rootstock were planted in 1999 at 4 x 5 m planting distances in a sandy loam soil. Each treatment was composed of 6 trees x 3 rows, i.e. 18 trees.

Cover-crops species were sowed manually the 8 April 2014 after seed bed preparation. The botanical composition of the 8 treatments was determined according to (1) expected intraspecific

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services (table 1) and (2) interspecific complementarity in time (e.g. soil covering dynamics) and/or in space (height and clumpyness). The cultivars used are *Trifolium repens* 'Klondike' (N°1, 4), *Trifolium pratensis* 'Montana' (N°3, 6), *Medicago sativa* 'Luzelle' (N°7), *Festuca ovina* 'Spartan' (N°4, 5) and *Festuca rubra* 'Maxima' (N°6). The 'Mythopia' commercial species mixture from Camena Company composed of 5 leguminous and 16 companion plant species was assessed (N°8).

Table 1: Botanical composition and agronomic characteristics expected of the 8 cover crops

N°	Species and seed rate (kg/ha)	Agronomic characteristics expected
1	*Trifolium repens* (20)	Fast covering + nitrogen release
2	*Medicago lupulina* (30)	Fast covering + nitrogen release + resowing
3	*Trifolium pratensis* (22)	Nitrogen release + dwarf canopy
4	*Trifolium repens* (10) *Festuca ovina* (30)	Fast covering + nitrogen release Clumpy development
5	*Medicago lupulina* (15) *Festuca ovina* (30)	Fast covering + nitrogen release + resowing Clumpy development
6	*Trifolium pratensis* (11) *Festuca rubra* (18)	Nitrogen release + dwarf canopy Clumpy development
7	*Medicagosativa*(27) *Hordeum vulgare* (100)	Dwarf canopy + low water requirement Fast covering
8	*Medicago lupulina* (8) *Lotus corniculatus* (4) *Trifolium repens* (3) *Anthyllis* sp. (0,06) *Hippocrepis* sp. (0,15) Others (<0,5%)	Fast covering + nitrogen release + resowing Nitrogen release Fast covering + nitrogen release Nitrogen release Nitrogen release Functional biodiversity

In 2014 and 2015 cover crops were mowed at 15 cm height (N°1, 2, 4, 5, 8), at 25 cm height (N° 3, 6) and at 40 cm height (N° 7) with a lawn-mower (model Olivia 'X', Tagliaerba Co.). Cover crops were mowed three times in 2014 (19/05/14, 17/06/14, 28/07/14), twice in 2015 (29/04/15, 25/06/15) and once in 2016 (21/09/16). All cropping practices except cover crops mowing were the same for all treatments.

In 2014, 2015 and 2016, total yearly nitrogen supplies were 65, 57 and 15 $kg.ha^{-1}$ respectively. These total nitrogen amounts were fractioned in one (2016) or two applications (2014, 2015). Water within the row was supplied by microjet® and driven by tensiometers with a 50kPa threshold value. In 2014, 2015 and 2016, total water supplies were 271 mm, 275 mm and 297mm, respectively.

The percentage of soil surface coverage by sowed species, weeds and bare soil was visually determined every 1-3 month according to season (11 observations from May 2014 to September 2016). Quadrat samples of $1m^2$ positioned at 1.5m from the trunk were observed. Six repetitions per treatment were realized.

Mean and standard deviation of soil coverage were mentioned as mean±standard deviation in the text. Statistical analyses were performed using R software (R core Team).

Results

Except for the two *Festuca* sp., a pattern of annual ground cover dynamics was observed for all species i.e. an increase of cover crops ground coverage from April to September and a decrease of it from October to March (figure 1a,b,c). Furthermore, a decrease of cover-crop coverage, at the expense of weed development, was observed in 2016 for all the species, except for the two *Festuca* sp. (figure 1b). These results can be explained (1) by the biological characteristics of the species (annual or bi-annual cycle, rate of development) and (2) by cover-crop management. Indeed, in 2016, an important weed development was observed in all the treatment, which could be explained by the absence of mowing from April to September during this year.

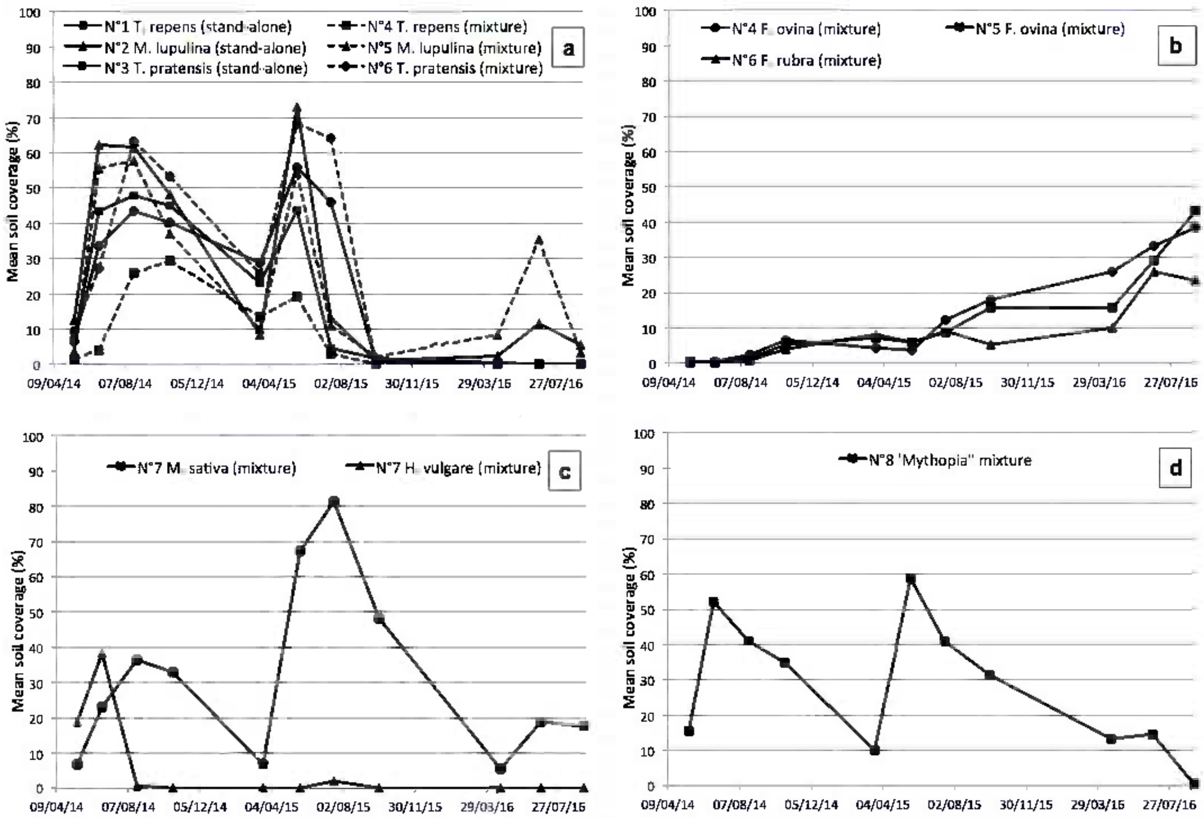

Figure 1. Mean soil coverage of the species tested in the 8 treatments (N°1 to 8) as stand-alone or within species mixtures during 3 years

The highest rate of ground coverage was observed on *M. sativa*(81±22%), *M. lupulina* (73±21%), *T. pratensis* (68±23%) and *T. repens* (48±22%). Weed development started quickly after sowing. In 2014, dominant weed species were *Ambrosia artemisifolia*, *Cirsium sp*. and *Polygonum aviculare*. *Elymus repens* and *Rumex* species were located in patches. In 2015 and 2016, annual weed species were mainly replaced by grasses (*Dactylus glomerata*, *Poa* sp.) and others species (*Fragaria vesca, Verbena vulgare*). No effect of the botanical composition of cover crops on weed composition was observed (result not shown).

During spring and summer seasons in 2014 and 2015, the mean ground coverage of *T. pratensis* was higher when it was grown in a mixture (N°6) than as stand-alone (N°3) despite a lower sowing density in the mixture (figure 1a). Conversely, the mean ground coverage of *T. repens* was significantly higher when it was grown as stand-alone (N°1) than in the mixture (N°4) (Wilcoxon test, $p<0.05$).

The two *Festuca* sp. showed a low but constant ground covering capacity during 2014, 2015 and 2016 (figure 1b). Both species were characterized by a very clumpy development and no weed development was observed in *Festuca* sp. clusters. The mixture of *Festuca rubra* and *Trifolium pratensis* (N°6) reached 64±19% and 74±18% in 2014 and 2015, respectively.

H. vulgare (annual cycle) and *M. sativa* (perennial cycle) contributed equally to ground coverage in 2014 (figure 1c). In 2015, an increase of *M. sativa* was observed and *H. vulgare* near had disappeared. The ground coverage of the 'Mythopia' mixture reached 52±33% and 59±32% respectively in 2014 and 2015 (figure 1d).

Discussion

Despite the effect of the biological cycle of each species (annual/bi-annual/perennial), interpretation of cover-crops dynamics highlights the influence of cover crop management. The mowing scheme (height, rhythm) of cover crops and weeds during spring and summer needs to be sufficiently regular to control weed development satisfactorily. The two *Trifolium* sp. and *M. sativa* presented two contrasted patterns of interspecific competition ability, which could be implemented in further studies.

Soil nitrogen dynamic demonstrated that nitrogen availability increased in May-July and tended to be higher under *T. pratensis* and *M. sativa* than under *T. repens* and *Medicago lupulina* (result not shown). Nitrogen release under leguminous cover crops in the tree row was likely to largely contribute to peach trees nitrogen requirements.

References

Duran Zuazo V.H., Rodriguez Pleguezuelo C.R., Francia Martinez J.R., Martinez Raya A., Arroyo Panadero L., Carceles Rodriguez B. & Navarro Moll M.R. (2008): Benefits of plants strips for sustainable mountain agriculture. Agron. Sustain. Dev. 28:497-505.

Halley S. & Hogue E.J. (1989): Ground cover influence on apple aphid, *Aphis pomi* DeGeer (Homoptera : Aphididae), and its predators in a young apple orchard. Crop Protection 9 :225-230.

Hoagland L., Carpenter-Boggs L., Granatstein D., Mazzola M., Smith J., Peryea F. & Reganold J.P. (2008): Orchard floor management effects on nitrogen fertility and soil biological activity in a newly established organic apple orchard. Biol. Fertil. Soils 45: 11- 18.

Oliveira M.T. & Merwin I.A. (2001): Soil physical conditions in a New York orchard after eight years under different groundcover management systems. Plant and Soil 234 :233-237.

Parker M.L. and Meyer J.R. (1996): Peach tree vegetative and root growth respond to Orchard floor management. American Society for Horticultural Science Western Region Annual Meeting, Vancouver, Canada. HortScience 3:322-325.

Parveaud C-E., Gomez C., Bussi C., Capowiez Y. (2012): Effect of White clover (Trifolium repens cv. Huia) cover crop on agronomic properties and soil biology in an organic peach orchard. Acta Horticulturae 933(1): 373-380.

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.