Cover Crops for Weed Management

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Cover crops are an important component of integrated weed management programs in annual and perennial cropping systems because of their weed suppressive abilities. They influence weed populations using different mechanisms of plant interaction which can be facilitative or suppressive. However, the question often arises if cover crops can be solely relied upon for weed management or not. The most common methods of weed suppression by an actively growing cover crop include competition for limited plant growth resources that result in reduced weed biomass, seed production, and hence reductions in the addition of seeds to the soil seedbank. Cover crop mulches suppress weeds by reducing weed seedling emergence through allelopathic effects or physical effects of shading. However, there is a great degree of variability in the success or failure of cover crops in suppressing weeds that are influenced by the cover crop species, time of planting, cover crop densities and biomass, time of cover crop termination, the cash crop following in the rotation, and the season associated with several climatic variables.

Keywords: allelopathy ; cover crop termination ; roller-crimper

1. Timing of Cover Crop Planting and Termination

As mentioned above, cover crops are usually planted in the fall, early or late winter, or summer depending on the type of cash crop to be planted after cover crop termination in annual cropping systems [1][2][3][4]. In orchards and vineyards, cover crops are usually planted in fall or early winter [5][6][7]. The cover crops are generally terminated before the planting of the cash crop in annual cropping systems or before the orchard crops or grapevines resume active growth after dormancy [7] because the termination date can negatively affect the emergence of cash crops [8] and result in crop yield losses [9][10]. As a general rule, under north American conditions, specifically in the southeast, it was suggested that cover crops should be terminated two to four weeks prior to cash crop planting [11]. Such research-based recommendations generated from studies on the effect of cover crop termination time on trees or grapevines in orchards and vineyards does not seem to exist.

Timing of cover crop planting can have direct implications for the growth rate and amount of biomass accumulation by the cover crop because of a longer growing season, amount of nitrogen fixed in the case of legumes [12], and amount of weed suppression [4][7][13]. For example, it was reported that cover crops produced 40% less biomass, and less nitrogen production by the legumes, when they were planted in mid-October compared to early-September [12]. Haring and Hanson [7] attributed some suppression of weed biomass by cover crops to early planting compared to late planting. However, a longer growing season may also mean more biomass accumulation in both the cover crop and the weeds [3][4]. Studies have also reported that cover crop planting density can also be a factor in weed suppression. For example, Brennan and Smith [13] documented a positive correlation between the amount of weed suppression and cover crop plant density and stated that early-season canopy development by cover crops was important in weed suppression. However, in a study in Australia, it was observed that there was no relationship between cover crop density and weed suppression [14]. Most of the published reports, globally, seem to indicate that suppression of weeds is more in terms of biomass accumulation of the weeds than the density of the weed per se [7][10][15][16][17][18].

A study conducted in central Spain concluded that the termination method for cover crops can be critical in optimizing cover crop benefits because it can impact cash crop productivity in annual cropping systems and the ecosystem services from cover crop usage [19]. However, this may not be the case for crop productivity in perennial cropping systems but there are very few studies showing the effect of the cover crop termination method on crop productivity. For example, in an annual crop system in central Italy, a study compared the termination of cover crops at different times with a roller-crimper and glyphosate applications and observed that the sunflower (*Helianthus annuus*) yield was similar between the two systems when the cover crop was rolled late but not when it was rolled at an earlier stage of the cover crop and hence, the authors suggested that early termination of cover crops with a roller-crimper may have to be combined with glyphosate applications [20]. A study compared the chemical, mechanical, and chemical + mechanical termination methods of cover crop termination and their effect on cotton (*Gossypium hirsutum*) emergence and yield, and reported some differences in the crop emergence but no effect on yield [21]. Another study compared two different mechanical methods of cover crop termination on mulch, weed cover and nitrogen but not on crop yield [22]. Kornecki and Kichler [23] compared different cover crop terminations with different roller-crimper types and their effect on the cantaloupe (*Cucumis melo*) yield, but no comparison was made with other cover crop termination methods. However, it can be argued that regrowth of cover crops by an inappropriate termination method could be an issue for crop productivity, especially if the cover crop is still growing actively during the bud break of grapevines in vineyards or the onset of active growth after dormancy in orchards.

The most common methods for cover crop termination include herbicide application, tillage/incorporation, rolling/crimping, burning, mowing [24], and natural winterkill [25]. Generally, broad-spectrum postemergence herbicides, such as glyphosate, paraquat, glufosinate, 2,4-D, etc., are used for the termination of cover crops [25][26], depending on the type of cover crop. For example, it was reported that glyphosate was effective in terminating cereal rye and wheat (*Tricticum aestivum*) cover crops, but not as effective in terminating legumes.

Cover crop residue incorporation with tillage has been shown to be effective in cover crop termination in studies conducted in the US [27] and Denmark [28]; this practice, however, can cause shifts in soil microbial communities and cause damage to the soil structure [29][30][31][32]. Studies from Spain [19] and Italy [33] concluded that cover crop rolling with a roller-crimper was becoming more popular, and this practice enhanced soil health and beneficial biological activity compared to tillage methods. However, rolling methods used alone seem to negatively affect the cash crop yield, as they are less efficient in controlling weed and cover crop populations [27][28]. Studies in Europe have suggested that rolling methods in combination with flaming or herbicide treatments can improve shortcomings of the sole reliance on rolling [19][34].

A study in France reported that frost, as a termination method, had benefits on soil characteristics when compared to rolling and herbicide methods of cover crop termination [35]. However, this method would only be effective in climates characterized by cold winters and when using winter-sensitive cover crop species.

Mowing and tillage are commonly used for cover crop termination in perennial systems [36][37][38]. However, there seems to be less research and publications involving the impacts of different cover crop termination methods in perennial systems likely because cover crop adoption in perennial cropping systems is less common [39][40]. A study reported using flail mowers to terminate cover crops in almond (*Prunus dulcis*) and walnut (*Juglans regia*) orchards in California [7]. Another study reported mowing and allowing the cover crops to senesce as a termination method in vineyards [41]. Perhaps mechanical means of cover crop in orchards and vineyards may be safer than herbicides because the chemicals could drift to the crops and cause phytotoxicity. Usually, as mentioned earlier, cover crops are terminated in spring in orchards and vineyards to avoid competition during the stage when the crops are just resuming active growth after winter dormancy.

2. Mechanisms of Weed Suppression by Cover Crops

One of the main goals of cover cropping is to enhance soil health properties but cover crops can aid in weed suppression because of the interactions between the cover crops and weed species. Such interactions that may result in weed suppression could occur during the actively growing phase of the cover crop or after the cover crop dies or is terminated and left as a surface mulch/residue. The various possible interactions are summarized in a conceptual diagram. Plant interactions that aid in weed suppression include direct competition for plant growth resources, allelopathy, facilitation, and indirect interactions [42]. According to the competitive production principle, a species in a shared niche will influence the environment and cause a negative reaction in the other species [43]. Cover crops and weeds may share specific niches in certain cropping systems, causing competition and the suppression of one group by the other.

Direct competition by manipulation of the seeding rate and method of a rye cover crop was reported to suppress weeds [44]. Biomass and traits, such as plant height, canopy area, and leaf shape also affect the outcome of plant competition [45]. Thus, biomass produced by cover crops can affect light transmittance by creating shaded areas, reduced moisture availability, and reduced soil temperature which in turn can affect the germination of weed seeds [46][47]. Reduced light availability to the weeds in the understory by a taller canopy of subterranean clover (*Trifolium subterranean*) was attributed as a mechanism of weed suppression in a study conducted in the Netherlands [48]. While biomass and leaf area affect competition for light, root length affects nutrient competition [49]. The aboveground plant parts are a direct result of belowground root growth, so plants with rapid root expansion and colonization of root zones are more competitive [50][51]. If cover crops decrease the resource capture of weeds through adjustments to the microclimate, they may out-compete weeds thereby reducing weed pressure in agricultural production systems. Weed suppression by cover crops due to modifications in the soil microclimate has also been reported [52]. Similarly, a study attributed weed suppression in the form of the colonization of weed seeds by bacteria and fungi brought about by soil microbial changes by cover crops [53].

While competition is a major mechanism of plant interaction, the physiological properties of cover crops can also influence weed population dynamics; non-competitive interference, such as the chemical interaction of plants, i.e., allelopathy, can cause harm between plant species [54]. It has been reported that allelochemicals produced by certain cover crop species can have a suppressive effect on weeds, and the study documented a linear relationship between allelochemicals produced by a rye cover crop and percent weed inhibition [55]. Several other studies conducted in North America have reported allelopathic weed suppression by a rye cover crop [56][57][58][59][60]. Other cover crop species, such as sunn hemp (*Crotalaria juncea*), cowpea (*Vigna unguiculata*), and velvet bean (*Mucuna deeringiana*) have also been reported to suppress weed germination and growth by allelopathic processes [61]. Similarly, there are several reports of allelopathic weed suppression by sorghum (*Sorghum bicolor*), barley, and wheat [62][63]. Some studies have reported allelopathic effects of the cover crops on the following cash crop [64]. Koehler-Cole et al. [65] published a review on the allelopathic effect of winter cover crops on several row cash crops. Legumes, such as velvet bean (*Mucuna pruriens*), have also been reported to have suppressive effects on weeds in a field experiment in Mexico with corn [66], which perhaps is an example of physical rather than allelopathic suppression. A study in Spain evaluated the allelopathic effects of aqueous extracts from several plant species to explore their potential as a cover crop. Species included *Bromus hordeaceus, B. rubens*, *Festuca arundinacea*, *Hordeum murinum*, *H. vulgare*, *Vulpia ciliata*, *Medicago rugosa*, *M. sativa*, *Trifolium subterraneum*, *T. incarnatum*, *Phacelia tanacetifolia*, *Sinapis alba*, and *Pinus sylvestris* on three weed species *Conyza bonariensis*, *Aster squamatus*, and *Bassia scoparia*. Their results showed differential effects of the extracts in the suppression of the three weed species and concluded that aqueous extracts of some of these species demonstrated that they had potential to be used as cover crops for weed suppression [67].

Indirect interaction between cover crops and weeds includes the cover crop mulch acting as a physical barrier for weed seedling emergence [58] and can also cause shifts in weed populations when cover crops impact the presence of other biocontrol agents, such as omnivorous predators. For example, it was reported that red clover (*Trifolium pratense* L.) cover crops increased seed predation through the increase of predator activity, density, and frequency; the impact of cover crops in this experiment resulted in weed seed removal [68].

Depending on the species of cover crop, different plant interactions may occur, affecting different species portions in the weed populations. For instance, crimson clover reduced the eastern black nightshade emergence due to physical suppression, while rye reduced yellow foxtail possibly due to allelochemicals produced by the cover crop [69].

3. Success and Failure of Cover Crops in Suppressing Weeds

The effects of cover crops on weed suppression is highly variable and influenced by many different factors and their interactions. Mainly, in cases where cover crops have been successful in weed suppression, they have been reported to either reduce weed seedling emergence, reduce weed biomass by competing with them, reduce weed seed production, or reduce soil weed seedbanks. The effects could also be a combination of these processes. Although there are more reports of successful weed suppression by cover crops, few studies have reported no effect of cover crops on weeds.

For example, in a study in an orchard in Turkey, it was reported that living cover crops suppressed weed biomass whereas, mowed and incorporated cover crops reduced weed density [70]. There are several reports of correlation of cover crop mulches with a decrease in weed emergence; however, the species used as mulch influenced the rate of weed emergence [58][71]. A field study that was conducted to assess the effect of residues of rye, crimson clover (*Trifolium incarnatum*), hairy vetch (*Vicia vollosa*), and barley alone and as mixture of all four observed that they reduced the emergence of eastern black nightshade (*Solanum ptycanthum*), while the emergence of yellow foxtail (*Setaria glauca*) was reduced only by rye and barley; hence, suggesting that suppression of emergence not only depended on the cover crop species but also the weed species [69]. Another study compared weed seedling emergence between rye, wheat, and clover residues and observed that while the grain crops suppressed, the clovers stimulated weed seedling emergence [72]. This finding can be explained by a conclusion from a study that cover crop species that contribute to soil nitrogen, such as legumes, may actually stimulate weed seed germination and growth [73]. It has been stated that, during its growth, cover crops reduce both light quantity and quality (red to far red ratio) which in turn will reduce weed seed germination [74]. Therefore, the architecture of the cover crops and the changes it brings about in light quality and quantity may be a factor affecting weed seedling emergence in the case of actively growing cover crops, but there are very few reports of effects of mulch on light quantity and quality, and thereby influence on weed seedling emergence.

Reductions in weed seedbank sizes are also reported as a weed suppressive effect of cover crops. For example, a study in Italy reported that hairy vetch cover crops reduced weed seedling density, while brown mustard (*Brassica juncea*) showed no effect; the variation in suppressive effects between the cover crop species was not explained by differences in cover crop biomass [75]. A study in Iowa, US reported that winter rye cover crops decreased weed seedbank densities in a maize-soybean farming system.

Moreover, reports exist of either actively growing cover crops or mulches having no effect on weed suppression, weed seedling emergence [6][76][77], or decreases in the weed seedbank [78]. The study [76] used rye as a cover crop in a continental climate of Ontario Canada, characterized by hot humid summers and very cold winters and reported that there was no effect on weed density or species composition. Reddy [77] studied the effect of several crops in a humid environment in Stoneville, MS and reported no suppression of barnyard grass (*Echinochloa crus-galli*), prickly sida (*Sida pinosa*), and yellow nutsedge (*Cyperus esculentus*), but some suppression of browntop millet (*Brachiaria ramosa*) densities by Italian ryegrass (*Lolium multiforum*), rye, wheat, hairy vetch, crimson clover (*Trifolium incarnatum*), or subterranean clover cover crops. Baumgartner et al. [6] observed no significant effects of both perennial and annual cover crops on weed populations in a vineyard study that took place in the dry Mediterranean climate with dry summers and mild, wet winters. Other studies also found similar results. For example, in a study in Ontario, Canada, no effect of rye, triticale, and wheat mulches was observed on the emergence patterns of redroot pigweed (*Amaranthus retroflexus*) and common lambsquarters (*Chenopodium album*) [79]. In Oregon, US a study comparing tillage systems with cover crops either lying on the surface or incorporated concluded that tillage type was more important than cover crop mulches in regulating weed seed emergence [80]. Another study in Japan concluded that it was more important to have higher ground coverage at the early stage of the cover crop than using a higher seeding rate of the cover crop for weed suppression [81].

References

1. Mitchell, J.P.; Shrestha, A.; Irmak, S. Trade-offs between winter cover crop production and soil water depletion in the San Joaquin Valley, California. J. Soil Water Conserv. 2015, 70, 430–440.
2. Mirsky, S.B.; Curran, W.S.; Mortenseny, D.M.; Ryany, M.R.; Shumway, D.L. Timing of cover-crop management effects on weed uppression in no-till planted soybean using a roller-crimper. Weed Sci. 2011, 59, 380–389.
3. Murrell, E.; Schipanski, M.E.; Finney, D.M.; Hunter, M.C.; Burgess, M.; LaChance, J.C.; Baraibar, B.; White, C.M.; Mortensen, D.A.; Kaye, J.P. Achieving diverse cover crop mixtures: Effects of planting date and seeding rate. Agron. J. 2017, 109, 259–271.
4. Baraibar, B.; Mortensen, D.A.; Hunter, M.C.; Barbercheck, M.E.; Kayne, J.P.; Finney, D.M.; Curran, W.S.; Bunchek, J.; White, C.M. Growing degree days and cover crop type explain weed biomass in winter cover crops. Agron. Sustain. Dev. 2018, 38, 65.
5. DeVincentis, A.; Solis, S.S.; Rice, S.; Zaccaria, D.; Snyder, R.; Maskey, M.; Gomes, A.; Gaudin, A.; Mitchell, J. Impacts of winter cover cropping on soil moisture and evapotranspiration in California’s specialty crop fields may be minimal during winter months. Calif. Agric. 2022, 76, 37–45.
6. Baumgartner, K.; Steenwerth, K.L.; Veilleux, L. Cover-crop systems affect weed communities in a California vineyard. Weed Sci. 2008, 56, 596–605.
7. Haring, S.C.; Hanson, B.D. Agronomic cover crop management supports weed suppression and competition in California orchards. Weed Sci. 2022, 70, 595–602.
8. Balkcom, K.S.; Duzy, L.M.; Kornecki, T.S.; Price, A.J. Timing of cover crop termination: Management considerations for the southeast. Crop Forage Turfgrass Manag. 2015, 1, 1–7.
9. Rosa, A.T.; Creech, C.F.; Elmore, R.W.; Rudnick, D.R.; Lindquist, J.L.; Butts, L.; Pinho de Faria, I.K.; Werle, R. Contributions of individual cover crop species to rainfed maize production in semi-arid cropping systems. Field Crops Res. 2021, 271, 108245.
10. McKenzie-Gopsill, A.; Mills, A.; MacDonald, A.N.; Wyand, S. The importance of species selection in cover crop mixture design. Weed Sci. 2022, 70, 436–447.
11. Balkcom, K.; Schomberg, D.; Lee, R.D. Cover crop management. In Conservation Tillage Systems in the Southeast: Production, Profitability, and Stewardship; SARE Handbook Series 15; Bergtold, J., Sailus, M., Eds.; SARE: College Park, MD, USA, 2020; pp. 54–76. Available online: https://www.sare.org/wp-content/uploads/Conservation-Tillage-Systems-in-the-Southeast_compressed.pdf (accessed on 6 February 2023).
12. Akbari, P.; Herbert, S.J.; Hashemi, M.; Barker, A.V.; Zandvakili, O.R. Role of cover crops and planting dates for improved weed suppression and nitrogen recovery in no till systems. Commun. Soil Sci. Plant Anal. 2019, 50, 1722–1731.

13. Brennan, E.B.; Smith, R.F. Winter cover crop growth and weed suppression on the Central Coast of California. Weed Technol. 2015, 19, 1017–1024.
14. Matloob, A.; Chauhan, B.S. Utilization of the neighborhood design to evaluate suitable cover crops and their density for Echinochloa colona management. PLoS ONE 2021, 16, e0254584.
15. Fisk, J.W.; Hesterman, O.B.; Shrestha, A.; Kells, J.J.; Harwood, R.R.; Squire, J.M.; Sheaffer, C.C. Weed suppression by annual legume cover crops in no-tillage corn. Agron. J. 2001, 93, 319–325.
16. Björkman, T.; Lowry, C.; Shail, J.W., Jr.; Brainard, D.C.; Anderson, D.S.; Masiunas, J.B. Mustard cover crops for biomass production and weed suppression in the Great Lakes region. Agron. J. 2015, 107, 1235.
17. Dorn, B.; Jossi, W.; Van der Heijden, M.G.A. Weed suppression by cover crops: Comparative on-farm experiments under integrated and organic conservation tillage. Weed Res. 2015, 55, 586–597.
18. Hayden, Z.D.; Brainard, D.C.; Henshaw, B.; Ngouajio, M. Winter annual weed suppression in rye–vetch cover crop mixtures. Weed Technol. 2012, 26, 818–825.
19. Alonso-Ayuso, M.; Gabriel, J.L.; Hontoria, C.; Ibáñez, M.A.; Quemada, M. The cover crop termination choice to designing sustainable cropping systems. Eur. J. Agron. 2020, 114, 126000.
20. Antichi, D.; Carlesi, S.; Mazzoncini, M.; Bàrberi, P. Targeted timing of hairy vetch cover crop termination with roller crimper can eliminate glyphosate requirements in no-till sunflower. Agron. Sustain. Dev. 2022, 42, 87.
21. Denton, S.; Raper, T.; Stewart, S.; Dodds, D. Cover crop termination timings and methods effect on cotton (Gossypium hirsutum L.) development and yield. Crop Forage Turfgrass Manag. 2022, e20206.
22. Wayman, S.; Cogger, C.; Benedict, C.; Burke, I.; Collins, D.; Bary, A. The influence of cover crop variety, termination timing and termination method on mulch, weed cover and soil nitrate in reduced-tillage organic systems. Renew. Agric. Food Syst. 2015, 30, 450–460.
23. Kornecki, T.S.; Kichler, C.M. Effectiveness of cover crop termination methods on no-till cantaloupe. Agriculture 2022, 12, 66.
24. Kornecki, T.S.; Balkcom, K. Planting in cover crop residue. In Conservation Tillage Systems in the Southeast: Production, Profitability, and Stewardship; SARE Handbook Series 15; Bergtold, J., Sailus, M., Eds.; SARE: College Park, MD, USA, 2020; pp. 119–132. Available online: https://www.sare.org/wp-content/uploads/Conservation-Tillage-Systems-in-the-Southeast_compressed.pdf (accessed on 6 February 2023).
25. Legleiter, T.; Johnson, B.; Jordan, T.; Gibson, K. Terminating Cover Crops. Successful Cover Crop Termination with Herbicides. Purdue Extension WS-50-W. 2012. Available online: https://www.extension.purdue.edu/extmedia/ws/ws-50-w.pdf (accessed on 29 December 2022).
26. Cornelius, C.D.; Bradley, K.W. Herbicide programs for the termination of various cover crop species. Weed Technol. 2017, 31, 514–522.
27. Bavougian, C.M.; Sarno, E.; Knezevic, A.; Shapiro, C.A. Cover crop species and termination method effects on organic maize and soybean. Biol. Agric. Hortic. 2018, 35, 1–20.
28. Hefner, M.; Gebremikael, M.T.; Canali, S.; Serra, X.F.S.; Petersen, K.K.; Sorensen, J.N.; De Neve, S.; Labouriau, R.; Kristensen, H.L. Cover crop composition mediates the constraints and benefits of roller-crimping and incorporation in organic white cabbage production. Agric. Ecosyst. Environ. 2020, 296, 106908.
29. Doran, J.W. Soil microbial and biochemical changes associated with reduced tillage. Soil Sci. Soc. Am. J. 1980, 44, 765–771.
30. Linn, D.M.; Doran, J.W. Aerobic and anaerobic microbial populations in no-till and ploughed soils. Soil Sci. Soc. Am. J. 1984, 48, 794–799.
31. Frey, S.D.; Elliott, E.T.; Paustian, K. Bacterial and fungal abundance and biomass in conventional and no-tillage agroecosystems along two climatic gradients. Soil Biol. Biochem. 1999, 31, 573–585.
32. Stine, M.A. The relationship between soil quality and crop productivity across three tillage systems in South Central Honduras. Soil Use Manag. 2002, 17, 2–8.
33. Depalo, L.; Burgio, G.; Magagnoli, S.; Sommaggio, D.; Montemurro, F.; Canali, S.; Masetti, A. Influence of cover crop termination on ground dwelling arthropods in organic vegetable systems. Insects 2020, 11, 445.
34. Frasconi, C.; Martelloni, L.; Antichi, D.; Rafaelli, M.; Fontanelli, M.; Peruzzi, A.; Benincasa, P.; Tosti, G. Combining roller crimpers and flaming for the termination of cover crops in herbicide-free no-till cropping systems. PLoS ONE 2019, 14, e0211573.
35. Romdhane, S.; Spor, A.; Busset, H.; Falchetto, H.; Martin, J.; Bizouard, F.; Bru, D.; Breuil, M.; Philippot, L.; Cordeau, S. Cover crop management practices rather than composition of cover crop mixtures affect bacterial communities in no-till

agroecosystems. Front. Microbiol. 2019, 10, 1618.

36. Costello, M.J. Growth and yield of cultivated grape with native perennial grasses nodding needlegrass or California barl ey as cover crops. HortScience 2010, 45, 154–156.
37. Belmonte, S.A.; Celi, L.; Stahel, R.J.; Bonifacio, E.; Novello, E.; Zanini, E.; Steenwerth, K.L. Effect of long-term soil ma nagement on the mutual interaction among soil organic matter, microbial activity and aggregate stability in a vineyard. Pedosphere 2018, 28, 288–298.
38. Rudolph, R.E.; DeVetter, L.W.; Zasada, I.; Hesse, C. Effects of annual and perennial alleyway cover crops on physical, chemical, and biological properties of soil quality in Pacific Northwest red raspberry. HortScience 2020, 55, 344–352.
39. LaRose, J.; Meyers, R. Soil Health Institute Releases Progress Report on Adoption of Soil Health Practices. Soil Health Institute. 2019. Available online: https://soilhealthinstitute.org/soil-health-institute-releases-progress-report-on-adoption-of-soil-health-practices (accessed on 29 December 2022).
40. Crézé, C.M.; Horwath, W.R. Cover cropping: A malleable solution for sustainable agriculture? Meta-analysis of ecosyst em service frameworks in perennial systems. Agronomy 2021, 11, 862.
41. Smith, R.; Bettiga, L.J.; Cahn, M.D.; Baumgartner, K.; Jackson, L.E.; Bensen, T. Vineyard floor management affects soi l, plant nutrition, and grape yield. Calif. Agric. 2008, 62, 184–190.
42. Callaway, R.M.; Walker, L.R. Competition and facilitation: A synthetic approach to interactions in plant communities. Ec ology 1997, 78, 1958–1965.
43. Vandermeer, J.H. The Ecology of Intercropping; The competitive production principle; Cambridge University Press: Ca mbridge, UK, 1989.
44. Mirsky, S.; Ryan, M.; Teasdale, J.; Curran, W.; Reberg-Horton, C.; Spargo, J.; Scott Wells, M.; Keene, C.L.; Moyer, J.W. Overcoming weed management challenges in cover crop–based organic rotational no-till soybean production in the ea stern United States. Weed Technol. 2013, 27, 193–203.
45. Gaudet, C.L.; Keddy, P.A. A comparative approach to predicting competitive ability from plant traits. Nature 1988, 334, 6179.
46. Teasdale, J.R.; Mohler, C.L. Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and ry e. Agron. J. 1993, 85, 673–680.
47. Teasdale, J.R. Interaction of light, soil moisture, and temperature with weed suppression by hairy vetch residue. Weed Sci. 1993, 41, 46–51.
48. den Hollander, N.G.; Bastiaans, L.; Kropff, M.J. Clover as a cover crop for weed suppression in an intercropping desig n: II. Competitive ability of several clover species. Eur. J. Agron. 2007, 26, 104–112.
49. Craine, J.M. Reconciling plant strategy theories of Grime and Tilman. J. Ecol. 2005, 93, 1041–1052.
50. Pavlychenko, T.K.; Harrington, J.B. Competitive efficiency of weeds and cereal crops. Can. J. Res. 1934, 10, 77–94.
51. Pavlychenko, T.K. Quantitative study of the entire root systems of weed and crop plant under field conditions. Ecology 1937, 18, 62–79.
52. Stigter, C.J. Traditional use of shade: A method of microclimate manipulation. Arch. Meteorol. Geophys. Bioclimatol. 19 84, 34, 203–210.
53. Ngouajio, M.; McGiffen, M.E. Going organic changes weed population dynamics. HortTechnology 2002, 12, 590–596.
54. Kong, C.; Xuan, T.D.; Khanh, T.D.; Tran, H.; Trung, N.T. Allelochemicals and signaling chemicals in plants. Molecules 2 019, 24, 2737.
55. Gavazzi, C.; Schulz, M.; Marocco, A.; Tabaglio, V. Sustainable weed control by allelochemicals from rye cover crops: Fr om the greenhouse to field evidence. Allelopath. J. 2010, 25, 259–274.
56. Teasdale, J.R. Contribution of cover crops to weed management in sustainable agricultural systems. J. Prod. Agric. 199 6, 9, 475–479.
57. Weston, L.A. Utilization of allelopathy for weed management in agroecosystems. Agron. J. 1996, 88, 860–866.
58. Teasdale, J.R.; Mohler, C.L. The quantitative relationship between weed emergence and the physical properties of mul ches. Weed Sci. 2000, 48, 385–392.
59. Mirsky, S.; Curran, W.; Mortensen, D.A.; Ryan, M.R.; Shumway, D.L. Control of cereal rye with a roller/crimper as influe nced by cover crop phenology. Agron. J. 2009, 101, 1589–1596.
60. Flood, H.E.; Entz, M.H. Effects of a fall rye cover crop on weeds and productivity of Phaseolus beans. Can. J. Plant Sc i. 2018, 99, 22–33.

61. Adler, M.J.; Chase, C.A. Comparison of the allelopathic potential of leguminous summer cover crops: Cowpea, sunn hemp, and velvetbean. HortScience 2007, 42, 289–293.

62. Putnam, A.R.; DeFrank, J. Use of phytotoxic plant residues for selective weed control. Crop Prot. 1983, 2, 173–181.

63. Putnam, A.R.; DeFrank, J.; Barnes, J.P. Exploitation of allelopathy for weed control in annual and perennial cropping systems. J. Chem. Ecol. 1983, 9, 1001–1010.

64. Shekoofa, A.; Safikhan, S.; Raper, T.B.; Butler, S.A. Allelopathic impacts of cover crop species and termination timing on cotton germination and seedling growth. Agronomy 2020, 10, 638.

65. Koehler-Cole, K.; Everhart, S.E.; Gu, Y.; Proctor, C.A.; Marroquin-Guzman, M.; Redfearn, D.D.; Elmore, R.W. Is allelopathy from winter cover crops affecting row crops? Agric. Environ. Lett. 2020, 5, e20015.

66. Caamal-Maldonado, J.A.; Jiménez-Osornio, J.J.; Torres-Barragán, A.; Anaya, A.L. The use of allelopathic legume cover and mulch species for weed control in cropping systems. Agron. J. 2001, 93, 27–36.

67. Puig, C.G.; Valencia-Gredilla, F.; Pardo-Muras, M.; Souto, X.C.; Recasens, J.; Pedrol, N. Predictive phytotoxic value of water-soluble allelochemicals in plant extracts for choosing a cover crop or mulch for specific weed control. Ital. J. Agron. 2021, 16, 1872.

68. Blubaugh, C.K.; Hagler, J.R.; Machtley, S.A.; Kaplan, I. Cover crops increase foraging activity of omnivorous predators in seed patches and facilitate weed biological control. Agric. Ecosyst. Environ. 2016, 231, 264–270.

69. Creamer, N.G.; Bennett, M.A.; Stinner, B.R.; Cardina, J.; Regnier, E.E. Mechanisms of weed suppression in cover crop-based production systems. HortScience 1996, 31, 410–413.

70. Tursun, N.; Işık, D.; Demir, Z.; Jabran, K. Use of Living, Mowed, and Soil-Incorporated Cover Crops for Weed Control in Apricot Orchards. Agronomy 2018, 8, 150.

71. Sias, C.; Wolters, B.R.; Reiter, M.S.; Flessner, M.L. Cover crops as a weed seed bank management tool: A soil down review. Ital. J. Agron. 2021, 16, 4.

72. Blum, U.; King, L.; Gerig, T.; Lehman, M.; Worsham, A. Effects of clover and small grain cover crops and tillage techniques on seedling emergence of some dicotyledonous weed species. Am. J. Altern. Agric. 1997, 12, 146–161.

73. Hill, E.C.; Renner, K.A.; Sprague, C.L.; Davis, A.S. Cover crop impact on weed dynamics in an organic dry bean system. Weed Sci. 2016, 64, 261–273. Available online: https://www.jstor.org/stable/26420689 (accessed on 6 February 2023).

74. Batlla, D.; Benech-Arnold, R.L. Weed seed germination and the light environment: Implications for weed management: Light control of weed seed germination. Weed Biol. Manag. 2014, 14, 77–87.

75. Adeux, G.; Rodriguez, A.; Penato, C.; Antichi, D.; Carlesi, S.; Sbrana, M.; Bàrberi, P.; Cordeau, S. Long-Term Cover Cropping in Tillage-Based Systems Filters Weed Community Phenology: A Seedbank Analysis. Field Crops Res. 2023, 291, 108769.

76. Swanton, C.J.; Shrestha, A.; Roy, R.C.; Ball-Coehlo, B.R.; Knezevic, S.Z. Effect of tillage systems, N, and cover crop on the composition of weed flora. Weed Sci. 1999, 47, 454–461.

77. Reddy, K.N. Effects of cereal and legume cover crop residues on weeds, yield, and net return in soybean (Glycine)1. Weed Technol. 2001, 15, 660–668.

78. Shrestha, A.; Mitchell, J.P.; Hembree, K.J. Weed seedbank characterization in long-term cotton–tomato rotations in California. Agron. J. 2015, 107, 597–604.

79. Moore, M.J.; Gillespie, T.J.; Swanton, C.J. Effect of cover crop mulches on weed emergence, weed biomass, and soybean (Glycine max) development. Weed Technol. 1994, 8, 512–518. Available online: https://www.jstor.org/stable/3988021 (accessed on 6 February 2023).

80. Peachey, R.; William, R.; Mallory-Smith, C. Effect of no-till or conventional planting and cover crops residues on weed emergence in vegetable row crop. Weed Technol. 2004, 18, 1023–1030.

81. Uchino, H.; Iwama, K.; Jitsuyama, Y.; Ichiyama, K.; Sugiura, E.; Yudate, T. Stable characteristics of cover crops for weed suppression in organic farming systems. Plant Prod. Sci. 2011, 14, 75–85.
