HIGH-RESIDUE, NO-TILL SYSTEMS FOR PRODUCTION OF ORGANIC BROCCOLI

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INTERPRETIVE SUMMARY

RESEARCH QUESTION

Per capita consumption of organic vegetables is increasing among consumers in the United States and other countries. Vegetables grown without applying synthetic fertilizers or pesticides (organic vegetables) command higher prices than conventionally grown vegetables. Weed control is the greatest production problem among organic growers, according to a recent survey conducted by the Organic Fanning Research Foundation. Without access to modem herbicides, organic growers resort to Integrated Weed Management (IWM) strategies, consisting mainly of mechanical and cultural methods. While mechanical cultivation is an effective weed control strategy, soil organic matter declines in cultivated fields. Organic mulches suppress weeds; however, growing, harvesting, and spreading cover crop mulches are both costly and labor intensive. Using legume cover crops as green manures will provide organic nitrogen (N); however, weeds flourish after leaving the soil surface uncovered when cover crops are incorporated. This study explores an alternative use of cover crops—i.e., using high-residue, no-till production systems to suppress weed growth and provide N for organically grown broccoli.

LITERATURE SUMMARY

Monoculture of leguminous cover crops and biculture grass-legume mixes can produce high biomass and N levels and have been successfully used in no-till systems to produce high yields of many vegetables. In most cases, however, either synthetic (chemical) herbicides and/or synthetic fertilizers have been needed to maximize yield. Whether high-residue, no-till systems require supplemental methods other than the organic residue mulches to suppress weeds and supply needed N is highly dependent on the vegetable crop grown. For example, broccoli has a rapid-spreading, over-lapping leaf canopy, which favors weed suppression; however, the associated sparse, confined root system combined with the rapidly developing, relatively large top growth of broccoli plants require high rates of band-applied N to obtain high broccoli yield. Conversely, in tomato, the slow developing, more open canopy favors early weed growth and the associated profuse, well-developed root systems effectively forage the soil profile for nutrients, necessitating only low rates of applied N to achieve high marketable yield. In no-till studies using white clover in California, alfalfa in Minnesota, and soybean and cowpea in Maryland and Virginia, broccoli required supplemental synthetic N to achieve high yields, comparable with conventionally grown broccoli that received recommended synthetic N rates.

STUDY DESCRIPTION

A factorial experiment was conducted in 1998 at the Kentland Agricultural Research Farm, assessing the effects of six no-till cover crop mulch treatments (no cover, foxtail millet, soybean, soybean and foxtail millet mix, cowpea, and cowpea and foxtail millet mix), each grown at three N rates (zero, 100 lb N/A from blood meal, and 100 lb N/A from ammonium nitrate). Both N sources were side-banded on the soil surface around each plant—1/3 at transplanting, 1/3 at 3 weeks and 1/3 at 5 weeks after transplanting. Blood meal, composed of 12% N, is commonly used by organic growers. Ammonium nitrate, composed of 34% N, is a standard synthetic N source used by conventional vegetable growers. Ammonium nitrate is readily available while blood meal is only moderately available to plant roots. All cover crops studied were seeded with a no-till drill on 25 June. Seed germination was excellent, but plant growth was slightly below normal. Above ground biomass (in tons *dry* wieght/A was 2.6, 2.5, 1.8, 1.6, and 1.8 for foxtail millet, soybean, soybean/foxtail millet mix, cowpea, and cowpea/foxtail millet mix, respectively. On August 19, all plots were subdivided into three sections----control subplots in which cover crops were rolled and broccoli received no fertilizer; organic subplots in which cover crops were flail mowed and broccoli received 100 lb N/A from blood meal; and chemical plots in which cover crops were rolled and broccoli received 100 lb N/acre from ammonium nitrate. A combination of Gramoxone (paraquat) and Goal (oxyflourfen) herbicides was applied immediately after rolling the control and chemical subplots. The organic subplots received no herbicides. Broccoli transplants were set in twin rows on August 25, using a no-till transplanter. All broccoli plots were sprayed with recommended insecticides and fungicides.

APPLIED QUESTIONS

Did no-till cover crops influence broccoli yield?

All cover crop mulches increased broccoli head yield from 6 to 37% (Table 1). Significant yield increases probably resulted from a combination of enhanced soil moisture content in all mulched plots and increased plant-available N, especially in soybean- and cowpea-containing plots. Although all plots were drip irrigated to supplement rainfall, the organic mulches undoubtedly would have increased water infiltration rate following rainfall events and reduced soil moisture evaporation throughout the growing season. Soybean alone (monoculture) or used as a biculture mix with foxtail millet outyielded all other cover crop mulches (Table 1).

Did N rate and source influence broccoli yield?

Nitrogen was a yield-limiting factor in this study (Table 1). Applied N derived from ammonium nitrate was more efficient in enhancing broccoli yield than N from blood meal. Leaf N content was increased by sidedress applications of both N sources; however, leaf N was significantly higher in plants receiving ammonium nitrate (5.6%) than in plants receiving blood meal (4.4%). Based on these data, N-use efficiency for broccoli is greater with the more soluble ammonium nitrate than the less soluble blood meal. Since broccoli yield was significantly less from plants receiving blood meal, either higher blood meal rates or using more soluble N sources should be considered. Perhaps, using organic foliar N sprays or incorporation or injection of the blood meal sidedressing, as well as preplant incorporation of other N-containing organic materials such as manure and sludge, would further enhance organic broccoli yield.

Did weed growth limit broccoli yield in organic (no-herbicide) plots?

Although weed biomass was not measured in this study, visual observations indicated that weed growth was more extensive in organic plots, especially those not containing foxtail millet residues, than in chemical plots. To minimize any deleterious effects of weeds on broccoli growth and yield, weeds were removed by hand on September 22 in all organic plots. Weeds were adequately controlled by herbicides and cover crop mulches in control (zero N) and chemical plots. Data from this study confirm the conclusions derived from other weed experiments that maintaining organic mulches at or above 2 tons/A throughout the crop's early canopy development (approximately 1/3 of the crop cycle) period will normally minimize weed growth, resulting in no reduction in crop yield. Establishing and maintaining high residue levels at or above 2 tons/A during the minimum weed-free period (length of time a crop must be free of weeds after planting in order to prevent yield losses) are therefore major steps toward successful production of organic no-till systems for producing vegetable crops.

CONCLUSION

1. No tillage is a viable option for producing organic broccoli provided that cover crop residues are maintained at levels sufficient to suppress weeds and soil N is not seriously limiting.

2. When weed levels become excessive, one critical hand weeding or mechanical weeding, especially in twin-row production systems, will lower weed populations below yield-limiting threshold levels.

3. When potential weed growth is high and weed removal by hand or mechanical methods is not feasible, maintaining no-till cover crop mulches at or above 2 tons/A during the first 3 weeks after transplanting will normally suppress weed populations below yield-limiting levels for production of fall broccoli. A biculture grass-legume mix, such as soybean and foxtail millet, is recommended to achieve adequate weed suppression and provide a source of plant-available N.

4. Nitrogen availability in no-till systems varies with the N content of the cover crops, level of biomass produced, soil environmental factors affecting rate of organic matter mineralization, and vegetable crop grown. Since broccoli has a high N requirement and possesses a sparse root system, normally supplemental organic N in addition to that derived from the legume cover crops is required to maximize broccoli yield. Future research is needed to assess the effectiveness of (a) manure and sludge either applied prior to establishing cover crops or as soil injections prior to transplanting broccoli and (b) postplant, soil applied sidedressings or injections, and/or foliar sprays.

Table 1. Influence of no-tillage mulch and nitrogen rate and source on yield and leaf nitrogen content of broccoli, 1998.

Treatment	Yield (ton/acre)	Relative yield[z]	Leaf N (%)	Relative leaf N[z]
No-tillage mulch (NTM)				
None (bare)	3.5d[y]	100	4.1b	100
Foxtail millet (FM)	4.0c	114	4.1b	100
Soybean (SB)	4.8a	137	4.9a	120
Mixture(SB/FM)	4.4b	126	4.7ab	115
Cowpea (CP)	4.0c	114	4.7ab	115
Mixture (CP/FM)	3.7cd	106	4.3ab	105
N rate and source (NRS) (lb N/acre)				
0	3.3c	100	3.4c	100
100 (blood meal)	3.9b	118	4.4b	129
100 (ammonium nitrate)	5.0a	152	5.6a	165
Interaction (NTM x NRS) (5%)	NS		NS	

[z]Relative broccoli yield and leaf N content compared with no-mulch (100).

[y]Mean separation among mulch and nitrogen treatments for yield and leaf N by LSD. Means followed by same letter within column do not differ at the 5% level.
NS = Non-significant at 5% level.