Broccoli Production in Forage Soybean and Foxtail Millet Cover Crop Mulches

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Abstract. 'Emperor' broccoli (*Brassica oleracea* L. Botrytis Group) was grown in Fall 1995 at the Beltsville Agricultural Research Center (BARC), Md., and at the Kentland Agricultural Research Farm (KARF), Virginia Polytechnic Institute and State Univ., Blacksburg. The objectives were to determine the effects of cover crop mulches in no-tillage production systems on marketable broccoli yield and weed suppression. The mulch treatments included cover crops of forage soybean (*Glycine max* L.), foxtail millet (*Setaria italica* L.P. Beauv.), and a combination of soybean and millet. Broccoli marketable yield from all three mulch treatments was equal to that from a conventional clean cultivation system, except for the millet treatment at BARC, which produced a lower yield. All treatments maintained weeds below levels that reduced yield. Cover crop biomass ranged from 4.6 to 9.6 t·ha⁻¹ and N content from 10 g·kg⁻¹ for millet to 28 g·kg⁻¹ for soybean.

Broccoli consumption in the United States increased 8-fold in the last 20 years and is still on the rise (Cook et al., 1983; Fahey and Talalay, 1995). The conventional method for commercial production of broccoli in the western states is direct seeding in bare soil followed by thinning and cultivation (Jett et al., 1995; Univ. of California Integrated Pest Management Project, 1987).

In the mid-Atlantic states, broccoli is generally grown in the fall using transplants and clean cultivation. Fall production from direct seeding in July leads to poor stems and non-uniform plant densities that result from poor seed germination at temperatures exceeding 30 °C (Elson et al., 1992; Sterrett et al., 1991). Since the average daily maximum in August along the mid-Atlantic Eastern Shore production area is 29.5 °C (National Oceanic and Atmospheric Administration, 1985–89), poor plant establishment commonly occurs and is attributed to soil temperatures approaching

the lethal germination temperature for broccoli (Elson et al., 1992). In contrast, transplants result in uniform plants and a full stand (Sterrett et al., 1991). Furthermore, the development and widespread use of multi-row transplanters have reduced transplanting cost and enhanced large-scale production from transplants.

Cultivation and herbicide applications are standard practices in conventional broccoli production (Jett et al., 1995; Vandre, 1991). Coolman and Hoyt (1989) proposed a broccoli production system consisting of a winter annual cover crop killed with herbicide in late spring, followed by incorporating with a summer annual legume in a reduced tillage system. In their system, organic matter and N are provided by legume cover crops, and weeds are controlled by the cover crop mulch without a reduction in yield. Castello (1994) proposed intercropping broccoli with a legume living mulch of white clover (*Trifolium praetense* L.), noting that size and yield of single-head broccoli in this system were similar to those in clean cultivation. Cover crops have been reported to reduce soil erosion, add organic matter to the soil, reduce weeds, prevent N leaching, and increase yields of vegetables (Abdul-Baki et al., 1996; Hembry and Davies, 1994).

Our objective was to develop a no-tillage production system that uses summer cover crops as mulches for growing broccoli from transplants in the fall, and compare it with the conventional production system.

Materials and Methods

Field experiments were conducted in 1995 on the North Farm at the Beltsville Agricultural Research Center (BARC), Md., and at the Virginia Polytechnic Institute and State Univ. Kentland Agricultural Research Farm (KARF), Blacksburg. The soil at BARC was Keyport fine sandy loam (clayey, mesic Aquic Hapludult), pH 6.5. Soil at KARF was Hayter loam (fine-loamy, mixed, mesic, Ultic Hapludaf), pH 6.4. Neither site had been planted into crucifers for at least 3 years. Plots in both locations were seeded into cereal rye (*Secale cereale* L.) in Fall 1994. The rye was mowed and residues were removed around mid-May 1995. The site was disk-plowed at BARC and left untilled at KARF.

The statistical design was a split-block design with four replications at BARC and three replications at KARF. Main plots (1.5 × 32 m) included forage soybean with preemergence herbicides, soybean without preemergence herbicides, foxtail millet, and soybean plus millet as cover crops, and tillage following no cover crop (conventional system). Before transplanting broccoli, a herbicide treatment was applied to half of each cover crop plot in a swath traversing each block perpendicular to cover crop plots.

The forage soybean line we used was bred by Thomas Devine at Beltsville, Md., for exceptionally vigorous growth, plant height, and lodging resistance. It was used in this study with the expectation that its superior growth would provide good competitive ability with weeds and compatibility with millet. Soybean seeds, inoculated with *Bradyrhizobium japonicum*, and millet seeds were sown on 6 June 1995, using a Brillion seeder (Brillion Iron Works, Brillion, Wis.) at BARC and a Haybuster (Haybuster Manufacturing Co., Jamestown, N.D.) no-till drill seeder at KARF. Seeding rates for soybean, millet, and the soybean–millet combination were 60, 40, and 60 plus 27 kg·ha⁻¹, respectively. The soybean–millet combination plots required two passes—one for seeding the soybean and a separate pass for the millet. Conventional plots were fallowed and weeds were periodically mowed until disk-plowed before transplanting. At KARF, granular fertilizer was surface broadcast at (kg·ha⁻¹) 56N–24P–42K over the millet plots and at 0N–24P–42K over the soybean and soybean plus millet plots before seeding of the cover crops. No fertilizer was applied at BARC before seeding the cover crops because soil tests revealed high P and K.

No weed control was used in the cover crop plots, except for the one soybean cover crop treatment. At both sites, this soybean plot received a preemergence application of metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)-acetamide] at 1.68 kg·ha⁻¹. At BARC,

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oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-trifluoro-methyl]benzene] at 0.34 kg·ha⁻¹ was included in that treatment.

On 13 Aug., the cover crops were mowed with a high-speed flail mower (Alamo Group Co., Seguin, Texas) ≈6 cm above soil surface. Before mowing, biomass samples were taken from 1-m² areas of cover crop outside the experimental plots, dried overnight at 70 °C in a forced-air oven and weighed to determine biomass yield and N concentration. Total N was determined by Kjeldahl (Baker et al., 1964). Additional samples of the cover crop residues were taken at KARF 4 and 8 weeks after transplanting of the broccoli to determine decomposition rate and effectiveness in suppressing weeds.

Broccoli planting. On 11 July at BARC, broccoli seeds ('Emperor') were started in a greenhouse in 128-cell flats (cell size 3 × 3 × 6 cm) filled with Jiffy Mix Plus (Jiffy Products, Latavia, Ill.) using a mixture of 50% horticultural grade vermiculite : 50% peat (w/w). Bare root 'Emperor' transplants that had been started in an outdoor nursery were used at KARF. Six-week-old seedlings were transplanted on 22 Aug., using a modified Holland no-till transplanter (Holland Co., Holland, Mich.) at BARC and a no-till subsurface tiller transplanter (Morse et al., 1993) at KARF. In each subplot, 16-m twin rows were spaced 45 cm apart and 1.1 m between twin rows (1.5 m center to center); in-row spacing was 45 cm between plants, resulting in 28,700 plants/ha. Granular fertilizer was surface banded by hand at planting 8 cm from both sides of each row with (kg·ha⁻¹) 100N–40P–84K. All plots were side-dressed with N (50 kg·ha⁻¹) as Ca(NO₃)₂ on 21 Sept. and 10 Oct. Damaged or missing plants were replaced by hand within 1 week after transplanting. The crop was irrigated three times during the growing season using overhead irrigation to avoid moisture stress.

Weeds during the broccoli growing season were chemically controlled in designated plots to assess the need for pretransplant herbicide application. Following mowing of the cover crops on 13 Aug., designated plots were treated with the following herbicide tank mix: napropamide [N,N-diethyl-2-(1-naphthalenyl-oxy)propanamide] at 1.12 kg·ha⁻¹, oxyfluorfen at 0.28 kg·ha⁻¹ plus paraquat (1,1'-dimethyl-4,4'-bipyridinium) at 0.70 kg·ha⁻¹, and 0.25% X-77 surfactant. Conventional plots were disk-plowed before applying the tank-mix herbicides. All plots were irrigated to allow the herbicides to reach the soil under the mulch. Weed pressure in herbicide-treated and non-treated plots was determined by harvesting the

aboveground portions of weed plants from 1-m² areas of each plot at 4 and 8 weeks after transplanting of the broccoli at KARF and at 8 weeks at BARC. The material was dried for biomass determination following the procedure described earlier for determining biomass of cover crops.

Pest management. The integrated pest management (IPM) systems at the Univ. of Maryland, College Park, and Virginia Polytechnic Institute and State Univ., Blacksburg, were implemented for pest control. *Bacillus thuringiensis* var. Kurstaki (bacteria base insecticide) was applied at 1.1 kg·ha⁻¹ on 8 Sept. to control larvae of the cabbage looper [*Trichoplusia* (Hubner)], malathion [0,0-dimethyls-(1,2-dicarbethoxyethyl)phosphorodithioate] at 0.32 kg·ha⁻¹ was applied on 14 Sept., and diazinon [0,0-Diethyl O-(2-isopropyl-4-methyl-4-methyl-6-pyrimidinyl) phosphorothioate] was applied at 0.48 L·ha⁻¹ on 21 Sept. to control aphids.

Broccoli leaf analysis. Broccoli leaf N was determined on plants grown at KARF at head initiation stage (4 weeks after transplanting). Young mature broccoli leaves were removed in each subplot, dried at 70 °C for 2 weeks, ground with a cyclone mill to pass 0.6-mm mesh, and analyzed for N concentration by Kjeldahl (Baker et al., 1964).

Broccoli harvest. Marketable yield and average head mass were determined on plants from a 6.3-m double row for each replication following U.S. Dept. of Agriculture (USDA) grading standards for head broccoli (USDA, 1943). The length of the flower and stem from the uppermost tip of the dome to the cut stem was 20 cm. Heads that were deformed or weighed <200 g were not considered marketable. Five harvests were made, starting 18 Oct. and ending 10 Nov.

Statistical analysis. Data were tested by analysis of variance with whole-plot effects, for the cover crops and herbicides, by their respective whole-plot error term. Weed biomass data were log transformed before analysis because of heterogeneity of variance. Since there were no significant interactions between cover crops and herbicide for yield data at either location and for weed biomass at KARF, only main effects are presented. An LSD test was used to separate main effect means when the F test was significant.

Results and Discussion

Cover crop biomass production and decomposition. Total biomass of each treatment at BARC was separated into its cover crop(s)

and weed components to elucidate the effectiveness of the cover crop in controlling weeds with and without herbicide application, and to determine the dilution of the N content of the soybean component by millet and weeds (Table 1). Total biomass from the millet, untreated soybean, and soybean plus millet plots was similar and significantly higher than that from the herbicide-treated soybean plots. The reduction in total biomass of the herbicide-treated soybean plot at BARC was due to the application of oxyfluorfen, which eliminated weeds completely, but also reduced soybean seed emergence by 42%, damaged the cotyledons of seedlings, and retarded plant growth during the first 3 weeks. However, the surviving seedlings made full recovery and compensated for reduced emergence by exhibiting more aboveground growth per plant than those in the other treatments. As a result of this growth compensation, soybean biomass in the herbicide-treated plot did not differ significantly from that in the other nontreated soybean plots. Biomass production by these cover crops was significantly higher than that reported for winter annual cover crops (Abdul-Baki et al., 1996; Hoyt and Hargrove, 1986).

Soybean plus millet reduced weed biomass compared to the soybean treatment without preemergence herbicide. Millet and soybean singly were significantly less effective in controlling weeds than herbicide-treated soybean. Millet and weeds diluted the N content of the total biomass from 34 g·kg⁻¹ in the herbicide-treated soybean plot to 19 g·kg⁻¹ in the soybean plus millet plot (Table 1). Concomitantly, the C : N ratio in the herbicide-treated soybean plot, which was weed-free, was only ≈30% of that in the millet plot. Nitrogen content of the cover crops ranged from 83 kg·ha⁻¹ in the millet plot to 190 kg·ha⁻¹ for the soybeans. These results are similar to those published on N concentration in other cover crop species (Abdul-Baki et al., 1996; Hoyt and Hargrove, 1986).

Total biomass of the cover crop (weeds included) at mowing time (0 week) at KARF was higher for the soybeans than for the millet (Table 2). Cover crop residue samples taken from the plots 4 and 8 weeks after mowing showed less biomass for the two pure soybean treatments than for millet alone. Cover crop total biomass of the two pure soybean plots after 4 weeks was reduced relative to the amount at 0 week. Millet was not significantly reduced during 8 weeks. The soybean plus millet combination had more biomass than the two soybean plots at 4 weeks, but was not significantly different at 8 weeks. Similar dif-

Table 1. Cover crop biomass and N content at the time of mowing at Beltsville, Md.

Cover crop	Biomass (t·ha ⁻¹)					N in total biomass (g·kg ⁻¹)	C : N ratio in biomass	Total N (kg·ha ⁻¹)
	Millet	Soybean	Weed ²	Total	Weeds (%)			
Millet	7.0 a	---	1.1 ab ^y	8.1 a	14	10 d	43.0 a	83
Soybean + millet	3.7 a	3.7 a	0.7 bc	8.1 a	8	19 c	22.6 b	155
Soybean	---	4.7 a	2.0 a	6.7 a	30	28 b	15.2 c	190
Soybean + herbicide	---	4.5 a	0 c	4.5 b	0	34 a	12.6 c	154

¹Large crabgrass was the dominant weed species.

²Mean separation within columns by protected least significant difference test at $P \leq 0.05$.

ferences in persistence of soybean and millet residues were reported by Morse (1995).

Broccoli yield and nitrogen content. Marketable yields and head mass of broccoli at BARC were lowest when grown following millet (Table 3). Although not significant, a similar trend was noted at KARF. Marketable yields in both sites were in the range that makes broccoli production in Maryland and Virginia economically feasible (Sterrett et al., 1990). Sterrett et al. (1990) concluded that broccoli production in the mid-Atlantic states becomes economical when yields are ≥ 8.3 t·ha⁻¹. Broccoli yields under the alternative production system were similar to those under clean cultivation and yielded ≈ 10.5 t·ha⁻¹ at BARC and ≈ 15 t·ha⁻¹ at KARF. Further refinement of the proposed alternative system may further improve yields and reduce production cost.

Nitrogen concentration of young mature broccoli leaves at the head formation stage, determined only at KARF, was lowest without cover crop, but it was similar to that obtained with soybean plus millet (Table 3). Nonetheless, leaf N in all treatments fell within the sufficient range of 3.2% to 5.5% (Jones et al., 1991).

Weed biomass. High levels of residue biomass would be expected to suppress annual weeds (Teasdale and Mohler, 1993), but there were few annual weeds emerging from seed at either site. The major weed problem at BARC was large crabgrass [*Digitaria sanguinalis* (L.) Scop.] that became established during cover crop growth and regrew after mowing. This weed became most abundant in broccoli planted into millet or soybean cover crops (Table 4). The use of a preemergence herbicide with soybean or the combination of soybean plus millet reduced this weed equally compared to either grown alone. Two perennials, broadleaf dock (*Rumex obtusifolius* L.) and red sorrel (*Rumex acetosella* L.), were established in the field at KARF. Here, cover crop treatments including millet suppressed these weeds (Table 4).

Application of herbicide before broccoli transplanting reduced weed biomass at both locations (Table 4). However, pretransplant herbicide had no effect on broccoli yield, head mass or leaf N concentration. Although there were differences in weed biomass among treatments, weed biomass never exceeded a level sufficient to reduce broccoli yield in any treatment. Infante and Morse (1996) showed that weed biomass levels exceeding 100 g·m⁻² were needed to reduce broccoli yield. In our experiments, weed biomass did not exceed 50 g·m⁻² (Table 4). We attribute the capacity to maintain weeds below yield-reducing threshold levels to 1) use of large, vigorous transplants; 2) arrangement of broccoli plants in high-density twin rows (Infante and Morse, 1996), and 3) lower weed density during the fall season. No-tillage mulches potentially suppress weeds better than conventional clean tillage systems when herbicides are not used (Infante and Morse, 1996; Teasdale et al., 1991).

The alternative no-tillage system uses a forage soybean cover crop alone or combined

Table 2. Cover crop biomass at mowing and degradation during the cropping season at Kentland Agricultural Research Farm, Blacksburg, Va.

Cover crop	Biomass (t·ha ⁻¹) at selected weeks after mowing		
	0	4	8
Millet	6.3 bA ^z	5.1 bA	5.1 aA
Soybean + millet	8.8 aA	6.7 aB	4.6 abC
Soybean	9.6 aA	4.8 bB	3.6 bB
Soybean + herbicide	9.5 aA	4.6 bB	3.5 bB

^zMean separation by lowercase letter within columns by protected least significant difference test at $P \leq 0.05$. Mean separation by uppercase letter within rows by protected least significant difference test at $P \leq 0.05$.

Table 3. Influence of cover crop on broccoli yield, head mass, and leaf N content at Beltsville (BARC) and Kentland Agricultural Research Farm (KARF).

Cover crop	Broccoli characteristic				
	Yield (t·ha ⁻¹)		Head mass (g)		Leaf N (%)
	BARC	KARF	BARC	KARF	KARF
None	11.3 a ^z	14.5 a	408 a	505 a	4.3 b
Millet	8.4 b	13.8 a	344 b	485 a	5.4 a
Soybean + millet	10.5 a	15.8 a	408 a	550 a	5.0 ab
Soybean	11.2 a	14.6 a	410 a	510 a	5.4 a
Soybean + herbicide ^y	11.3 a	14.5 a	415 a	507 a	---

^zMean separation within columns by least significant difference test at $P \leq 0.05$.

^yHerbicide applied preemergence to soybeans.

Table 4. Main effects of cover crop and pretransplant herbicide on weed biomass in broccoli at 8 weeks after transplanting.

Cover crop	Weed biomass (g·m ⁻²)	
	BARC	KARF
None	7 bc ^z	36 a
Millet	49 a	9 b
Soybean + millet	4 c	12 b
Soybean	25 ab	48 a
Soybean + herbicide ^y	5 c	52 a
Broccoli pretransplant herbicide		
With	2 b	18 b
Without	45 a	36 a

^zData were transformed to $\ln(X+1)$ before analysis. Mean separation within columns by least significant difference test at $P \leq 0.05$. Means were backtransformed for presentation.

^yHerbicide applied preemergence to soybeans.

with millet. The forage soybean line we used is highly efficient in N fixation and biomass production. Soybean, used alone or combined with millet, fixes N required by the broccoli crop and produces enough biomass to form a mulch that suppresses weed growth, improves soil fertility, and stops soil erosion. These benefits are generally derived from no-tillage systems that incorporate cover crops into the production rotation (Hoyt and Hargrove, 1986). The alternative no-tillage system further extends broccoli production to highly erodible areas where cooler weather favors broccoli production. Many vegetables growing areas in the mid-Atlantic states fall into this category of steep slopes and erodible soils.

Soil covered by cover crop mulches can be expected to be several degrees cooler than bare soil in July (Teasdale and Abdul-Baki, 1995). This characteristic offers an advantage at transplanting time (early August) when soil temperatures may be detrimental to transplant establishment and growth. However, cover crop mulches may delay crop maturity compared to clean cultivation. They also may permit earlier transplanting and allow a longer period for crop growth.

In summary, broccoli yield in the alternative production method was similar to that with the conventional method. The alternative method, which includes soybeans, offers the

advantages of adding fixed N, enriching the soil with organic matter, reducing cultural operations that contribute to soil compaction, and providing a cover that eliminates soil erosion.

Literature Cited

- Abdul-Baki, A., J.R. Teasdale, R. Korkak, D.J. Chitwood, and R.N. Huettel. 1996. Fresh-market tomato production in a low-input alternative system using cover crop mulch. *HortScience* 31:65-69.
- Baker, D.E., G.W. Grosline, C.B. Smith, W.J. Thomas, W.E. Brude, and J.L. Ragland. 1964. Technique for rapid analysis of corn leaves for eleven elements. *Agron. J.* 56:133-136.
- Castello, M.J. 1994. Broccoli growth, yield, and level of applied infestations in leguminous living mulches. *Biol. Agr. & Hort.* 10:207-222.
- Cook, W.P., D.O. Ezell, R.P. Griffin, and S.E. Drye. 1983. Commercial broccoli production in South Carolina. Clemson Univ. Coop. Ext. Serv. Hort Lfl. 52, p. 1-7.
- Coolman, R.M. and G.D. Hoyt. 1989. Conservation tillage, legume intercropping, and broccoli production in Western North Carolina. *Soil Sci. Soc., North Carolina* 32:65-70.
- Elson, M.K., R.D. Morse, D.D. Wolf, and D.H. Vaughn. 1992. High temperature inhibition of seed germination and seedling emergence of broccoli. *HortTechnology* 2:417-419.
- Fahey, J.W. and P. Talalay. 1995. The role of

- crucifers in cancer chemoprotection, p. 87–93. In: D.L. Gustine and H.E. Flores (eds.). *Phytochemicals and health*. Amer. Soc. Plant Physiologists, Rockville, Md.
- Hembry, J.K. and J.S. Davies. 1994. Using mulches for weed control and preventing leaching of nitrogen fertilizer. *Acta Hort.* 371:311–316.
- Hoyt, G.D. and W.L. Hargrove. 1986. Legume cover crops for improving crop and soil management in the Southern United States. *HortScience* 21:397–402.
- Infante, M.L. and R.D. Morse. 1996. Integration of no-tillage and overseeded legume living mulches for transplanted broccoli production. *HortScience* 31:376–379.
- Jett, L.W., R.D. Morse, and C.R. O'Dell. 1995. Plant density effects on simple-head broccoli production. *HortScience* 30:50–52.
- Jones, J.B., Jr., B. Wolf, and H.A. Mills. 1991. *Plant handbook*. Macro-Micro Publishing, Athens, Ga.
- Morse, R.D. 1995. No-till, no-herbicide systems for production of transplanted broccoli, p. 113–116. In: W.L. Kingery and N. Buehring (eds.). *Conservation farming—A focus on water quality*. Proc. Southern Region Conservation Tillage for Sustainable Agriculture. Jackson, Miss., 26–28 June 1995.
- Morse, R.D., D.H. Vaughan, and L.W. Belcher. 1993. Evaluation of conservation tillage systems for transplanting crops—Potential role of the subsurface tillage transplanter, p. 145–151. In: P.K. Bollich (ed.). *The Evolution of conservation tillage systems*. Proc. Southern Conservation Tillage Conference for Sustainable Agriculture. Monroe, Louisiana, 15–17 June.
- National Oceanic and Atmospheric Administration. 1985–89. *Virginia climatic data annual summary* 95–99. 13:2.
- Sterrett, S.B., J.W. Mapp, Jr., and C.W. Coale, Jr. 1990. Feasibility of broccoli as a new enterprise—A systems approach. *HortScience* 25:638–641.
- Sterrett, S.B., C.W. Coale, Jr., and C.P. Savage, Jr. 1991. Comparison of management techniques for broccoli production using a systems approach. *HortScience* 26:599–602.
- Teasdale, J.R. and A. Abdul-Baki. 1995. Soil temperature and tomato growth associated with black polyethylene and hairy vetch mulches. *J. Amer. Soc. Hort. Sci.* 120:848–853.
- Teasdale, J.R., C.E. Beste, and W.E. Potts. 1991. Response of weeds to tillage and cover crop residue. *Weed Sci.* 39:195–199.
- Teasdale, J.R. and C.L. Mohler. 1993. Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. *Agron. J.* 85:673–680.
- U.S. Department of Agriculture, Agricultural Marketing Service. 1943. *United States standards for grades of bunched Italian sprouting broccoli*. U.S. Govt. Printing Office, Washington, D.C. p. 1–5.
- University of California Integrated Pest Management Project. 1987. *Integrated pest management for cole crops and lettuce*. Univ. of California Div. Agr. and Natural Resources. Publ. 3307.
- Vandre, W. 1991. *Weed control in cole crops, carrots, lettuce, and peas for 1991*. Univ. of Alaska, Fairbanks, Coop. Ext. Serv. p. 1–7.