Suitability of Sunn Hemp as an Alternative Legume Cover Crop

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Abstract: The tropical legume sunn hemp *(Crotalaria* juncea L.) may have potential as an alternative legume cover crop for southeastern cropping systems. The objective of this study was to determine dry-matter production and N accumulation and release from sunn hemp under conventional tillage and no-tillage systems as might be used in a corn *(Zea mays* L.) production system. 'Tropic Sun' sunn hemp was sown in mid August and mowed in early December (after killing freeze) in 1991 and 1992 on a Norfolk sandy loam (fine-loamy, siliceous, thermic. Typic Kandiudults) in east-central AL and in 1992 on a Lucedale tine sandy loam (tine-loamy. siliceous. thermic Rhodic Paleudults) in southwestern AL. Mesh bags were used to determine residue decomposition and N release. Average dry-matter production was 5.9 Mg ha.' 9-12 wk (dependent on killing freeze date) after planting. Nitrogen content of residue averaged 126 kg N ha.' at this time. Residue was left on the soil surface (over-wintered) until early April when corn would normally be planted. Approximately 75 to 80 kg N ha^{-1} was released from the residue during winter. In April, (16 wk after sunn hemp was mowed). N remaining in over-wintered residue was 38% (45 kg N ha^{-1}) of that after fall mowing. Nitrogen release from over-wintered residue during the subsequent corn growing season was 13% in no-tillage and 43% in conventional tillage. Sunn hemp produced sufficient dry-matter to cover and protect soil from erosion and provided N to benefit a succeeding summer crop. Sunn hemp thus has potential as an alternative to winter legume cover crops in southeastern cropping systems.

Introduction

The practical use of winter legume cover crops is often limited by asynchronization of cover crop planting windows and biomass accumulation with planting/harvesting windows for summer cash crops like corn and cotton *(Gossypium hirsutum* L.). An alternative to winter annual legume cover crops may be adapted tropical legumes that quickly produce biomass to provide soil cover and accumulate N. One tropical legume that may be adapted to residue management systems in the Southeast is sunn hemp. This legume has been used extensively for soil improvement or green manuring in the tropics (Lales and Mabbayad, 1983). This *Crotalaria* species is nontoxic and can be used as a forage as well as a green manure (Rotar and Joy, 1983). Although not winter hardy, sunn hemp may produce sufficient biomass during fall (until killing freeze) to provide ground cover and N to a following summer cash crop in southern temperate regions.

This study was conducted to determine the suitability of late-summer planted 'Tropic Sun' sunn hemp [released by USDA-NRCS and the University of Hawaii, Hawaii Institute of Tropical Agricultural and Human Resources (Rotar and Joy, 1983)] as a green manure and cover crop for summer grain production systems in the Southeast. Specific objectives were to: (i) determine total biomass production and N accumulation of sunn hemp during a period extending from corn harvest until the first killing freeze (September through November); and (ii) determine N release from over-wintered (December through March) sunn hemp residue under no-tillage and conventional tillage during the period when a subsequent summer cash crop would be grown.

Materials and Methods

This research consisted of two studies. The first study determined biomass and N accumulation of sunn hemp used as a cover crop. It was conducted at the E.V. Smith Research Center (EVS) of the Alabama Agricultural Experiment Station, Shorter, Alabama, on a Norfolk fine sandy loam in fall of 1991 and at both EVS and the Monroeville Experimental Field (MEF), Monroeville, Alabama., on a Lucedale fine sandy loam in fall of 1992. On 16 August 1991, sunn hemp was sown following conventional tillage (moldboard plowing, disking and leveling) at EVS. In 1992, sunn hemp was sown using conventional tillage at EVS on 2 September and at MEF on 18 August. These dates corresponded to a feasible sowing time for cover crops following summer corn harvest. Sunn hemp seed was inoculated with cowpea *(Vignu unguiculata* (L.) Walp.] type rhizobium and drilled at *56* kg ha^{-1}, 2 to 4-cm deep. The experimental design was a randomized complete block with eight replications. Above ground sunn hemp herbage was harvested (two- 0.25 m^2 areas) at 3, 6, 9, and 12 wk after planting (WAP) or until fall-freeze killed the plants. Whole plants were separated into a fraction containing leaves and flowers (leaves) and a fraction containing stems and petioles (stems) and oven-dried at 55 °C for 72 h. After weighing, plant fractions were ground to pass a I-mm screen and analyzed for total N using a LECO CHN-600 C-H-N analyzer

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(Leco Corporation, 3000 Lakeview Ave., St. Joseph, MI).

The second study was conducted at EVS to determine decomposition of over-wintered sunn hemp residue under no-tillage and conventional tillage during spring and summer 1992, corresponding to the period when corn would normally be grown. On 24 March 1992, at EVS, sunn hemp residue that had been mowed and left in place in the field during winter was collected, cleaned of loose soil particles, and air-dried in a greenhouse. Twenty-gram subsamples of residue were placed in 15 by 30 cm nylon mesh bags, having 1-mm openings and 57% open area. The 20-g residue subsample size was based on the average residue weight for a 15 by 30-cm area, corresponding to the bag size. Mesh bags were placed in the field on 17 April 1992, which is within the normal planting window for corn or cotton.

The experimental design was a split plot with four replications. Main plots were no-tillage and conventional-tillage residue management systems that would have been used for a corn crop following sunn hemp. Over-wintered residue that had been mowed and left on the soil surface from December until April was left in place in no-tillage plots. In conventional tillage plots, residue was disked into the soil (I 5-cm depth). Subplots were sampling dates of 0, I, 2, 4, 8, and 16 wk for bag retrieval. Bags were placed on the surface of no-tillage plots or buried to the plow layer depth (10 to I5 cm) in conventional tillage plots. Glyphosate *[(N-(phosphonomethyl))glycine]* was used to keep the area weed-free during the study.

Collected bags were carefully cleaned to remove soil. Residue material inside each bag was oven-dried at 55 °C for 72 h, and then weighed. Samples were ground to pass a 1-mm screen with a Wiley Mill. Total N was determined on an ash-free basis using a LECO CHN-600 analyzer.

Data were subjected to analysis of variance and regression analyses using the Statistical Analysis System (SAS Institute Inc., 1988; Littell et al., 1991). Nonlinear models were fitted using TableCurve (Jandel Scientific, San Rafael, CA 9490I). Models were selected based on F statistics ($P \leq 0.05$). In all cases the simplest model that best fit the data was used.

Results and Discussion

Dry Matter Production

Dry matter production varied by site-year and sample date ($P \leq 0.01$, data not shown). Sunn hemp biomass 12 WAP averaged 7.3 and 4.8 Mg ha^{-1} at EVS in 1991 and 1992, respectively, and 5.7 Mg ha^{-1} at MEF in 1992. Average sunn hemp biomass production for the three site-years (5.9 Mg ha^{-1}) was comparable to reported values for the two most common cover crops in the Southeast, i.e., hairy vetch *(Vicia villosa* Roth) (4.9 Mg ha^{-1}; Touchton et al., 1984) and crimson clover *(Trifolium incarnatum* L.) (5.0 Mg ha^{-1}; Reeves et al., 1993). For all site-years, after 3 wk, sunn hemp grew rapidly until 9 WAP (late October) and then slowed as temperatures declined.

Nitrogen Accumulation

Nitrogen accumulation was higher in leaves than stems (Fig.1). Nitrogen accumulation ranged from 46 to 50 kg h a' in stems and from 61 to 78 kg ha^{-1} in leaves 9 WAP. Total N accumulation was 136 kg ha^{-1} 12 WAP at EVS in 1991, 120 kg ha^{-1} 9 WAP at EVS in 1992, and 123 kg ha^{-1} 12 WAP at MEF in 1992. Nitrogen accumulation from sunn hemp in our study was similar to the range reported for hairy vetch and crimson clover cover crops (Reeves, 1994).

Decomposition/N release from Over-Wintered Residue

Residue decomposition of over-wintered residue at EVS during spring-summer 1992 (corresponding to corn growing season) depended on tillage system employed (Fig. 2). In conventional-tillage, residue decomposition was best described by a quadratic function. For no-tillage, however, a linear function provided a superior fit. Dry-weights of residue decreased to 36 and 69% of initial values at 16 wk in conventional and no-tillage systems, respectively.

Loss of N from over-wintered residue in both conventional-tillage and no-tillage systems was described by two quadratic models, dependent on the time period (Fig. 3a-c). Net immobilization was shown during 0 to 4 wk (Fig. 3b), and mineralization occurred from 2 to 16 wk (Fig. 3c). Little mineralization occurred in the no-tillage system. As explained before, most plant N was in leaves which decomposed during the winter; remaining over-wintered material was primarily stems. Stem tissue had a high lignin content and C/N ratio (data not shown), which would reduce N mineralization. Nitrogen remaining in residue at 16 wk after corn planting date was 57% and 87% in conventional-tillage and no-tillage, respectively (Fig. 3a,c).

At mowing in fall 1992, sunn hemp residue contained approximately 120 kg N ha^{-1} at both locations (Fig. I). During the 16 wk over-wintering period, approximately 75 kg h a' of this N was released. At corn planting the next spring, approximately 45 kg N ha-'was left in the residue.

Conclusions

As an alternative to winter cover crops, sunn hemp produced a large quantity of dry matter during the late summer/fall season (average 5.9 Mg ha^{-1} in 9-12 wk). The residue contained approximately 120 kg N ha^{-1}, and when mowed provided excellent soil coverage. Approximately 75 kg N ha-I was released from residue to the soil during the winter. Nitrogen release from the 45 kg N ha^{-1} in the over-wintered residue during a subsequent corn growing season averaged 13% under no-tillage and 43% under conventional tillage. The ability to rapidly accumulate biomass and N during such a short period after normal harvesting windows for summer cash crops shows that sunn hemp has potential to be managed as an alternative to winter legume cover crops in Southeastern cropping systems.

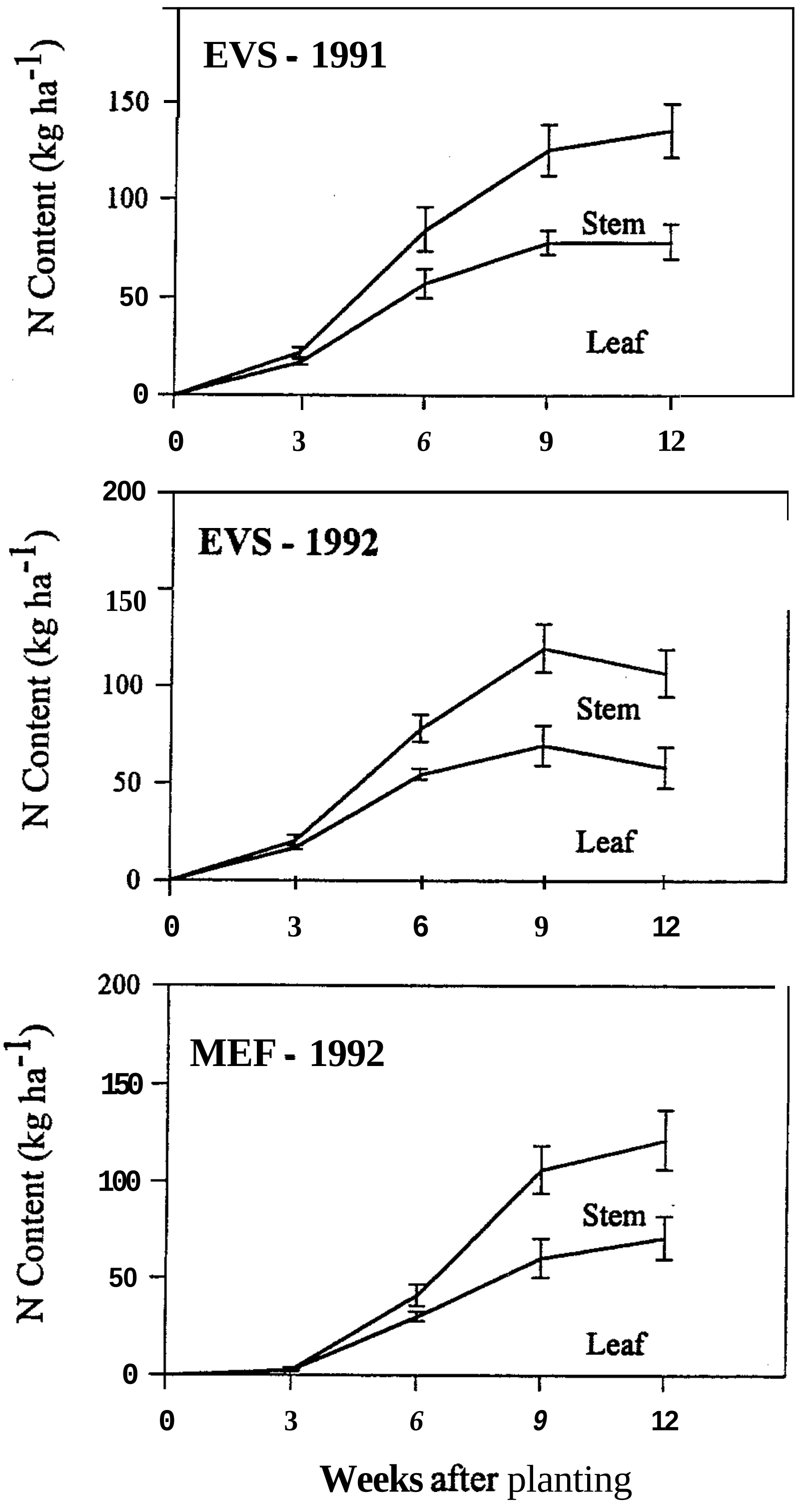

Fig. 1. Nitrogen accumulation in sunn hemp at EVS in 1991 and 1992, and MEF in 1992. Vertical bars are standard errors.

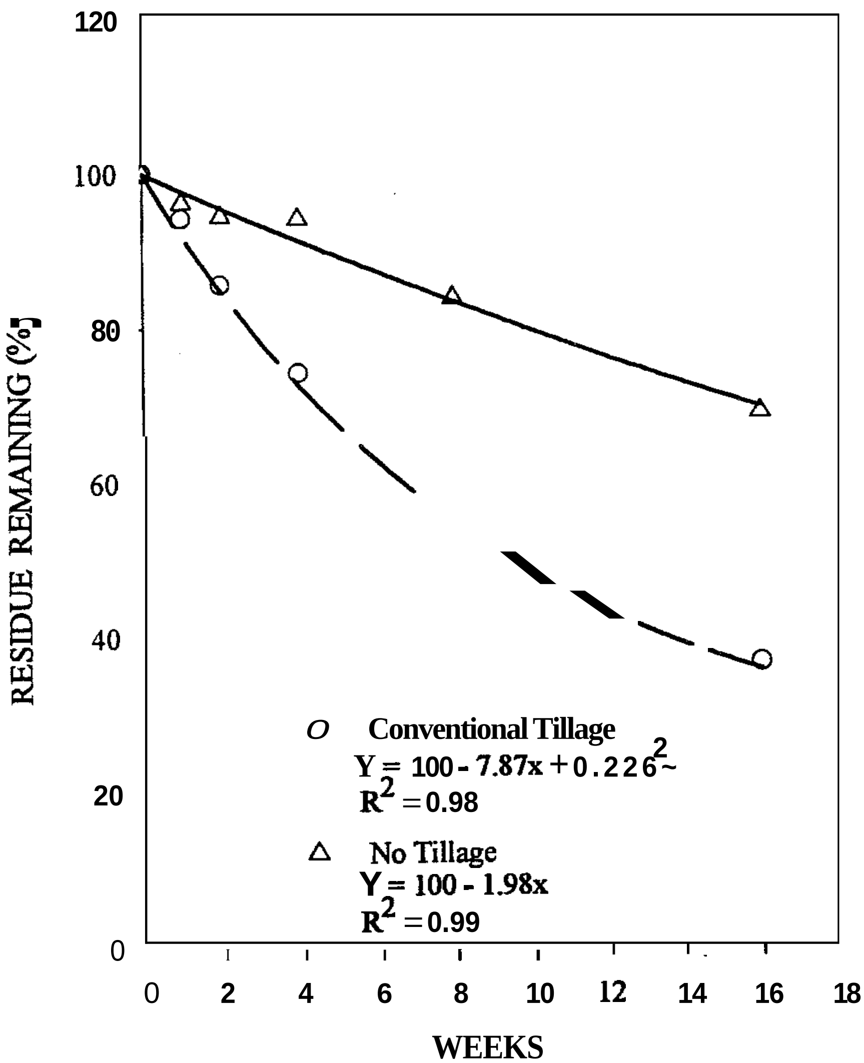

Fig. 2. Decomposition of over-wintered sunn hemp residue from 17 April to 7 August 1992 (normal corn growing season) *at* EVS as affected by tillage system.

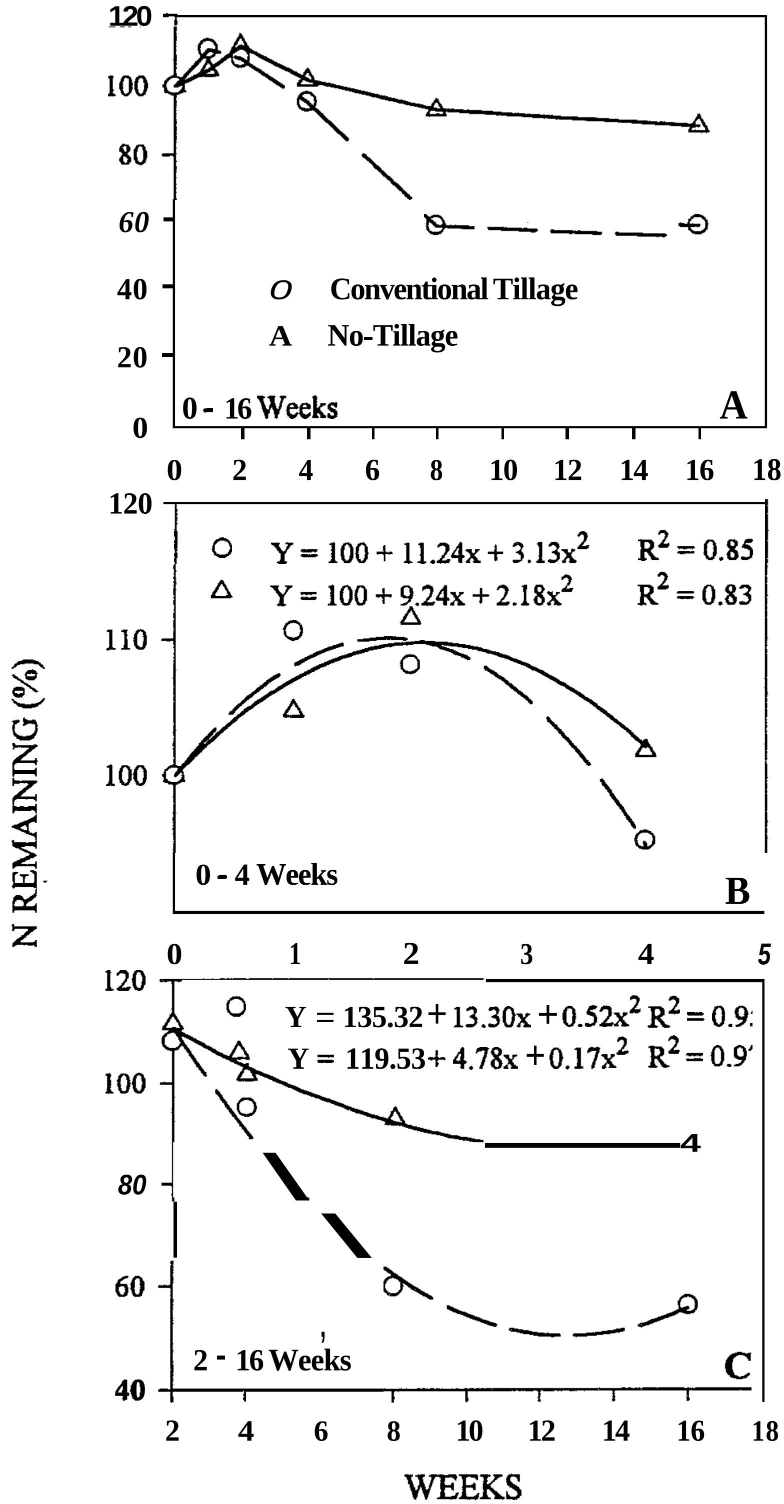

Fig. *3*. **Percentage of initial N remaining** *in* **over-wintered sunn hemp residue from 17 April to 7 August 1992 at EVS as affected by tillage system. A) during entire 16 wk period, B) during 0 to 4 wk period, and C) during 2 to 16 wk period.**

References

Lales, J. C. and B. B. Mabbayad. 1983. The potential and establishment method of *Crotalaria juncea* L. as a green manure for corn *(Zea mays* L.). Phillip. J. Crop Sci. 8: 145-147.

Littell, R. C., R. J. Freund, P. C. Spector. 1991. SAS system for linear models. SAS lnstitue Inc., Cary, NC 275 13 .

Reeves, D. W. 1994. Cover crops and rotations. *In* J. L. Hatfield and B. A. Stewart (eds.) Advances in Soil Science: Crops Residue Management. pp. 125-172. Lewis Publishers, CRC Press Inc., Boca Raton, FL.

Reeves, D.W., C.W. Wood, and J.T. Touchton. 1993. Timing nitrogen applications for corn in a winter legume conservation-tillage system. Agron. J. 85:98-106.

Rotar, P.P. and R.J. Joy. 1983. 'Tropic Sun' sunn hemp *(Crotalaria juncea* L.). Res. Ext. Series 36. Hawaii Inst. Tropical Agr. and Human Resources, Univ. Hawaii, Honolulu. pg 1-7.

SAS Institute Inc. 1988. SAS/STAT User's Guide, Release 6.03 Edition. Cary, NC: SAS Institute

Touchton, J.T., D.H. Rickerl, R.H. Walker, and C.E. Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil Tillage Res. 4:391-401.