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Cropping Systems for Stokes Aster*

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Stokes aster (*Stokesia laevis* L., Compositae) has the potential to become an industrial oilseed crop for epoxy acid, a compound widely used in the chemical industry. Its achenes contain vernolic acid (12, 13-epoxy-*cis*-9-octadecenoic acid), which is easily converted to epoxy acid (Campbell 1981). One obstacle to the development of Stokes aster into a crop is the fact that the perennial does not flower during its first year of growth (Campbell 1981, 1984). Spring seeded plants will not flower that summer and fall seeded plants will not flower the following summer. To overcome this economically unproductive first season, Stokes aster could be intercropped with a summer annual such as soybean [*Glycine max* (L.) Merr., Fabaceae]. Balasbramanian and Sekayange (1990) indicated that intercropping prolongs the exploitation of resources due to longer combined leaf area duration. Thus, intercropping can make better use of land area by overlapping the time needed in the field by the two crops. The main benefit of a soybean–Stokes aster intercrop would be the initial soybean yield during the first year of Stokes aster growth. Soybean would be the overstory crop in this system, substantially reducing the amount of light available for Stokes aster seedling growth. Larcher (1983) has indicated that plants do adapt to changes in light intensity over time as new tissue and organs form. In growth chamber and greenhouse studies, we have found that Stokes aster growth can be reduced by low light intensity, but adjustments in photosynthesis occurred and plants began recovering after shade was removed (Callan and Kennedy 1995a, 1996). Once recovered, Stokes aster should grow and produce normally through the length of the production cycle although no field research has been conducted to corroborate this. Moreover, the length of the production cycle is somewhat vague, but estimated at 3–5 years (Campbell 1981).

Because of this lack of extensive field data, our objectives were twofold. The first was to determine vegetative growth and seed yield of Stokes aster under three cropping systems (a spring-planted monocrop, a fall-planted monocrop, and a spring-planted intercrop with soybean). The second was to determine the change in yield over a several year period to identify a viable production cycle.

METHODOLOGY

Plantings were initiated in 1992 through 1994 at Baton Rouge, Louisiana (30°N Lat.) on a Mhoon silty clay loam (fine-silty, mixed, nonacid, thermic, typic Fluvaquent). ‘Pioneer 9501’ soybean was planted May 1, 1992, April 13, 1993, and April 23, 1994 on a 76.2 cm row spacing. Due to a limited seed supply coupled with variability in germination and emergence of the seed, Stokes aster seed of USDA accession BSLE2 and an unknown parent (BSLE2, BSLE1, BSLL1, or BSLL2) were initially germinated in germination paper, transferred to 5 cm-wide peat pots filled with Jiffy mix and transplanted to the field about 1 month later. The entire process was initiated at the time of soybean planting so the growth of Stokes aster would be on the same time frame as soybean, i.e., it simulated a field planting of Stokes aster. Each intercrop plot consisted of 4 soybean rows. Three 19 cm-wide rows of Stokes aster were planted in each of the 3 middles between each row of soybean. The spring-planted monocrop contained 5 rows of Stokes aster. Row width was 19 cm. The fall-planted monocrop of Stokes aster used the same procedures as the spring monocrop but was initiated in early October each year. All Stokes aster plots were 2.1 m long. Plot widths were 0.95 m for spring- and fall-planted monocrops and 2.28 m for the intercrop. Nutrient fertilization consisted of 2.9 mM N, 0.06 mM P, 0.86 mM K, 1 mM Ca, 1mM Mg, 1 mg/L Fe, and 1 ml/L stock micronutrients used to wet the Jiffy mix during seedling transfer. For 1992, a field application of 67 kg N/ha was applied to all spring-planted Stokes aster plots in the late summer and again in May of 1993. The late summer application was repeated for the 1993 planting, but the spring application occurred in late March and was 224 kg N/ha. Thereafter, only an early spring application of this amount of nitrogen was done for each cropping system. Soybean harvest occurred in late September of each year 1992–1994. Stokes aster harvest, beginning in 1993, occurred in mid August of each year.

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Weed control was a combination of the herbicides vernolate (s-propyl dipropylcarbamothioate) and trifluralin (2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine) along with hand weeding. The use of benomyl (methyl-1-[(butylamino)carbonyl]-H-benzimidazol-2-ylcarbamate) was used for *Phomopsis* blight control. Two to three applications of 1.12 kg/ha usually provided adequate control. Plants per m^2 and leaf number per m^2 were determined for each cropping system during the first year of growth. Light interception by Stokes aster under the soybean canopy was determined with a Li-Cor 1-m line quantum sensor. The sensor was placed parallel to the soybean row and light intensity was averaged over 9 equidistant positions across the row middle at the aster leaf level. This was done 3 times at about 30 day intervals during the growing season beginning about 70 days after planting. Monocropped and intercropped soybean yields were determined on 2, 2-m lengths of row (3.05 m^2). Stokes aster yield was determined from a 1 m^2 harvested area in the center part of each plot. The experimental design was a randomized complete block with 4 replications in 1992 and 1993 and 3 replications in 1994. Statistical analysis was conducted using the general linear model technique and mean separation used the least square means method (SAS 1985).

RESULTS AND DISCUSSION

Vegetative Growth

In a perennial-annual intercrop, the goal is an acceptable growth rate for the perennial and a good yield for the annual (Vandermeer 1989). Initial Stokes aster growth varied between planting year and cropping system. In 1992, seedling mortality was a factor in growth per unit land area as measured by leaf production. The soybean provided a shaded understory that undoubtedly reduced soil evaporation and surface temperatures as well as light intensity. This condition resulted in better aster seedling survival than in exposed monocrop plots (Fig. 1) which kept leaf production per m^2 higher in the intercropping system (Fig. 2). However, leaf development per plant was lower under the intercropped soybean canopy (data not shown). In 1993 and 1994, the negative effects of being the understory component of an intercrop was apparent for Stokes aster. Seedling mortality was less of a problem in the monocrop but tended to decline in the intercrop as did leaf production (Fig. 1, 2). Previous work (Callan and Kennedy 1995a) has shown that Stokes aster can tolerate low light intensity of at least 160 µmol/m^2/s photosynthetic photon flux density (PPFD) and continue to grow, although slowly. At PPFD less than 40 µmol/m^2/s Stokes aster leaf development becomes static and recovery is slow (Callan and Kennedy 1996). Although average mid-day PPFD reaching Stokes aster was usually at or above about 160 µmol/m^2/s in the field (Fig. 3), the distribution of light would vary with location of Stokes aster plants relative to the soybean row and also time of day. Thus, the total amount of light received was probably lower than the average would indicate. Moreover, the greatest decline in growth of Stokes aster during the intercropping period in 1993 was late in soybean development and corresponded to the time of soybean leaf drop. These senesced leaves covered the Stokes aster resulting in increased mor-

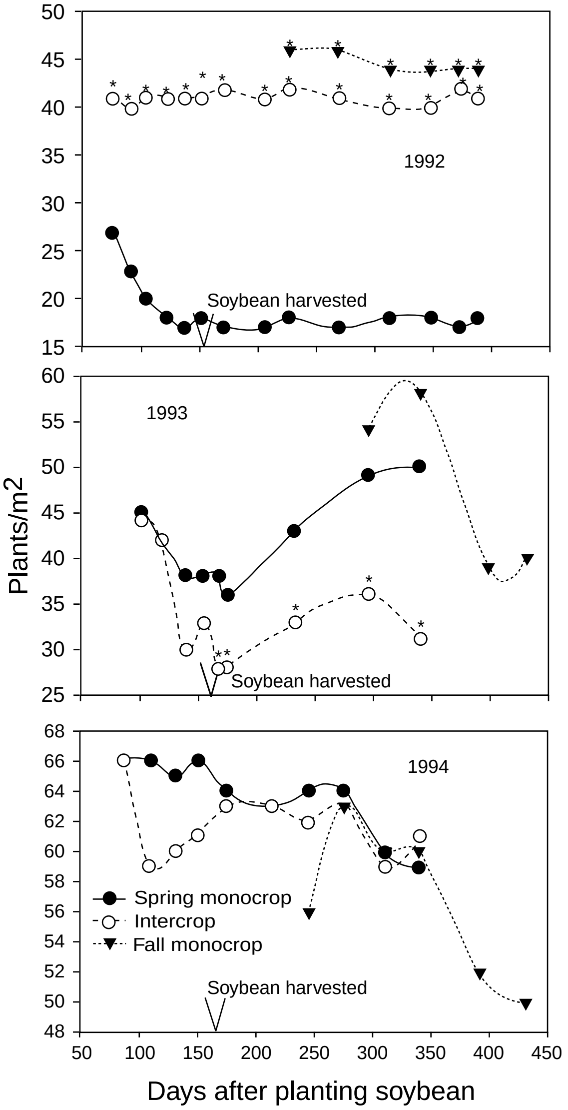

Fig. 1. Plant population of Stokes aster under different cropping systems. Symbols subtended by "*" at a given time are significantly different from the spring monocrop.

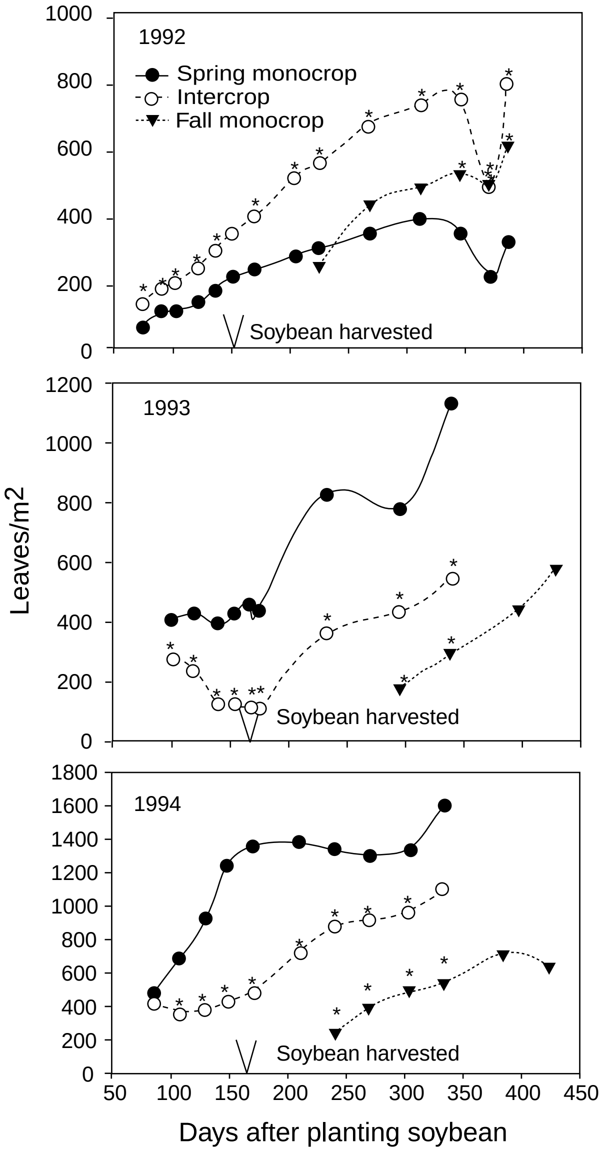

Fig. 2. Effect of cropping system on leaf development of Stokes aster. Symbols subtended by "*" at a given time are significantly different from the spring monocrop.

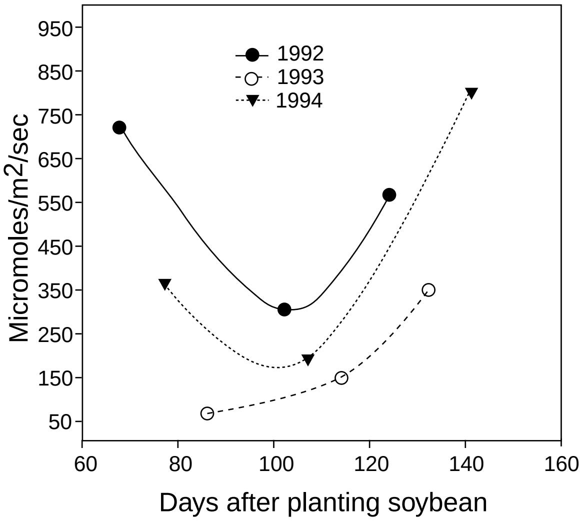

Fig. 3. Photosynthetic photon flux density reaching stokes aster intercropped under a soybean canopy.

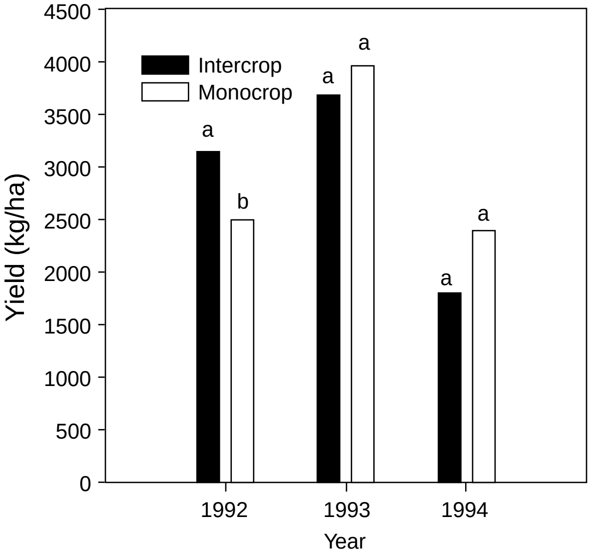

Fig. 4. Yields of monocropped soybean and soybean intercropped with Stokes aster. Bars having the same letter for a given year are not significantly different.

tality and leaf die-back. Because the population rebounded after a decline, the mortality applied only to the above ground portion of the plant; the growing point remained viable in many 'dead' plants. Regardless of performance under the soybean canopy, Stokes aster increased in growth after the canopy was removed (Fig. 2). This growth, coupled with plant age was enough to allow reproductive development the following spring. The fall-planted monocrop grew throughout its first year, but was too young and/or too small to be generally receptive to stimuli that caused a shift to reproductive growth during the first spring subsequent to planting.

Seed Yield

Soybean yields were generally unaffected by Stokes aster as an intercrop (Fig. 4). Since Stokes aster growth was small during the first 6 months, its effect on soybean was negligible. The effect of environment among years was not significant on seed yield of Stokes aster, but years in production from initial establishment did have a significant impact on seed yield. For this reason, data from each establishment (planting) year was pooled across production year for analysis. The effect of intercropping Stokes aster and the vegetative growth decline during the period in which it was under the soybean canopy did tend to depress aster seed yields in the first year following establishment. The second year harvest always had the greatest average seed yield for the Stokes aster originally intercropped (Fig. 5). Differences between spring-planted monocrop and intercropped Stokes aster yields (Fig. 5) may be for the reasons already alluded and also because 25% of the land area was not planted to Stokes aster in the intercrop. On an area-planted basis, the intercropped Stokes aster averaged higher yields than the monocrop (data not shown). Establishing Stokes aster in the fall resulted in an establishment duration of an additional seven months prior to blooming compared to the other cropping systems. This prolonged duration may have attributed to the slightly lower yields of that system (Fig. 5).

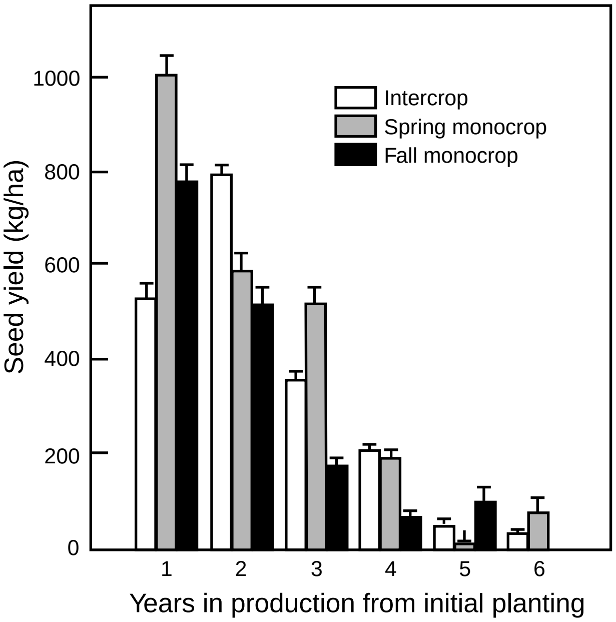

Fig. 5. The effect of cropping system and years in production from the initial planting on seed yield of Stokes aster. Average of three planting years. Error bars represent standard error of the mean. Yields of intercropped Stokes aster reflect the 25% of land not actually planted, i.e., the old soybean rows.

Although seed yield of Stokes aster has been estimated at about 2000 kg/ha and a production cycle of 3 to 5 years, (Campbell 1981), we did not find either to be the case in our study. Maximum yields were generally less than 1000 kg/ha. Moreover, maximum yields did not extend past one year of production (Fig. 5). The yield potential of Stokes aster at this location may have been lower due to soil type or some other limiting unknown factor. The limitation of the production cycle of this perennial crop was primarily a problem of sustained weed control, *Phomopsis* blight, and fire ant mound building. Although some research has been conducted on tolerance of Stokes aster to various herbicides (Campbell 1981; Callan and Kennedy 1995b) the ability to control some weed species, especially perennial clover species (*Trifolium* spp.) within an established Stokes aster planting is lacking. This weed encroachment was probably amplified due to the small plot sizes in this study. *Phomopsis* blight and possibly other diseases reduced the plant stand over time, but these diseases were usually kept in check with fungicide applications. Mound building by fire ants (*Solenopsis saevissima*) smothered established plants. We perceived a greater number of large fire ant mounds in Stokes aster plots than in the surrounding area, but have not substantiated this with data and the use of small plots may have amplified the negative effect. Regardless, application of insecticide can reduce this problem.

CONCLUSIONS

The use of an intercropping system to supplement land productivity during Stokes aster's establishment year appears viable. However, extremely dense overstory canopies and a subsequent large amount of leaf drop might limit the success of intercropped Stokes aster. Maximum yield potential at our location was less than 1000 kg/ha and a viable production cycle could last no more than two years. If Stokes aster is to become a viable industrial oilseed crop, additional efforts in breeding, and herbicide-biotechnology need to be undertaken.

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