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Surface Cover Provided by Selected Legumes

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ABSTRACT

The use of legumes in conservation tillage systems may yield several benefits including reduced erosion resulting from establishment of surface cover. The effectiveness in furnishing surface cover of 18 plant species seeded on three different dates was evaluated over an 11-month period. For several of the legume species, planting date significantly influenced maximum surface cover and the number of days required to reach maximum cover. For each of the planting dates, hairy vetch achieved maximum cover as rapidly as any other legume and maintained the greatest cover throughout the study period. Relationships for estimating legume surface cover from vegetative mass determinations were also identified. Legumes could serve as important components in well-managed crop production systems.

INTRODUCTION

Legumes may play an important role in soil and crop management systems. Under favorable conditions, legumes will fix nitrogen during periods of active growth. Nitrogen fixation in turn may serve to reduce fertilizer requirements and, thus, the cost of crop production. When legumes remain on the soil surface as a mulch, they can release as much nitrogen as when incorporated into the soil (Martin and Touchton, 1983). Additional benefits which may result from the use of legumes include: improved surface and groundwater quality, increased soil organic matter content, enhanced infiltration and aggregate stability, and decreased erosion (Power et al., 1983).

During the first half of this century, research at a number of locations showed that perennial legumes in the crop rotation usually reduced soil losses (Hargrove, 1982). Legumes were found to decrease runoff because of greater residue cover, increase evapotranspiration, improve water infiltration and enhance hydraulic conductivity. Selected legumes used alone or in combination with non-legumes provided protection from soil erosion (Beale et al., 1955; Bruce et al., 1987; and Hendrickson et al., 1963). Cool season legumes have been utilized to return large quantities of crop residue to the soil, thus helping to restore productivity to previously eroded land (Langdale et al., 1987).

When selecting a legume best suited for a particular crop production system, several factors must be considered including: climatological conditions, surface cover and management requirements, fertilizer needs, insect and disease problems, cropping practices, weed control, soil water conditions and economic benefits. To be satisfactory as a cover crop, a legume should provide a protective vegetative cover when the erosion potential is greatest. For legumes which are to be intereseeded with other crops, competition between plant species and excessive moisture depletion should also be considered. When these various factors have been examined, the most appropriate crop management system can be identified. The objective of this study was to measure surface cover provided by selected legumes planted on varying dates.

PROCEDURE

The study was conducted at the University of Nebraska Agronomy Farm near Lincoln, Nebraska. The soil at the site was a Crete-Butler silty clay loam (fine, montmorillonitic, mesic Pachic Argiustolls-Abruptic Argiaquolls). Total monthly precipitation and mean monthly temperature at the study location are shown in Fig. 1.

Plots 3.1 m (10.2 ft) wide by 12.2 m (40.0 ft) long were planted using inoculated seed at the rates shown in Table 1. A nonlegume (winter rye) was included as a reference species. Different seeding rates were required because of

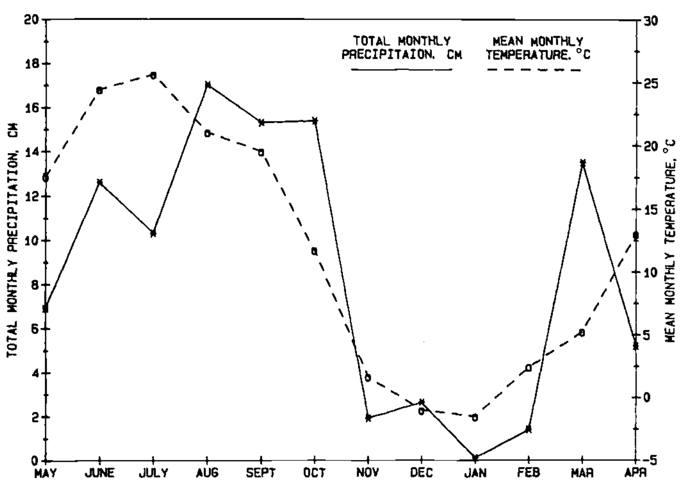

Fig. 1—Total monthly precipitation and mean monthly temperature at the study site.

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TABLE 1. Plant species for which surface cover measurements were made*

Alfalfa (nitro), *Medicago sativa*, L. "Nitro", (8.41 kg/ha)
Alfalfa (salton), *Medicago sativa*, L. "Salton", (8.41 kg/ha)
Arrowleaf clover, *Trifolium vesiculosum* Savi, "Amelo", (8.41 kg/ha)
Austrian Winter Pea, *Pisum sativum*, L. "Melrose", (67.3 kg/ha)
Black Medic, *Medicago lupulina*, L. (8.41 kg/ha)
Cicer Milkvetch, *Astragalus cicer*, L. "Lutana", (8.41 kg/ha)
Cowpea, *Vigna unguiculata* (L.) Walp. subsp. *unguiculata*, "PI-422155", (67.3 kg/ha)
Crimson Clover, *Trifolium incarnatum*, L. "Tibbee", (33.6 kg/ha)
Crown vetch, *Coronilla varia*, L. 'Emerald", (8.41 kg/ha)
Hairy vetch, *Vicia villosa*, Roth "Madison", (33.6 kg/ha)
Flat Pea (lacto), *Lathyrus sylvestris*, L. "Lacto", (67.3 kg/ha)
Flat Pea (tinga), *Lathyrus tingitanus*, L. "Tinga", (67.3 kg/ha)
Rose Clover, *Trifolium hirtum*, All. "Hycon" (8.41 kg/ha)
Soybean, *Glycine max*, (L.) Merr. "Century", (67.3 kg/ha)
Subterranean Clover, *Trifolium subterraneum*, L. "Wellington", (8.41 kg/ha).
White Clover, *Trifolium repens*, L. "Merit", (8.41 kg/ha)
Winter Rye, *Secale cereale*, L. "Cougar", (33.6 kg/ha)
Yellow Sweetclover, *Melilotus officinalis*, Lgm. "Madrid", (8 41 kg/ha).

*Values listed in parentheses are seeding rates.
(8.41 kg/ha = 7.50 lb/acre; 33.6 kg/ha = 30.0 lb/acre;
67.3 kg/ha = 60.0 lb/acre)

the wide variation in seed size between species. The plots were planted on three dates in 1986: May 7, July 14 and August 26. Three replicate plots were established for each species on each planting date using a split-plot design. Weeds which appeared on the plots were removed by hand.

Surface cover was photographed using 35 mm color slide film. Two slides were obtained per plot on each measurement date for a total of six measurements for each plant species. Photographs were taken at intervals of approximately one week during the summer season to about one month during the winter period. Flags were used to identify the location of the tripod legs so the camera could be positioned in the same location on each date.

Surface cover measurements were made using a photographic grid procedure (Laflen et al., 1978). The slides were projected onto a screen on which a grid had been superimposed. The number of grid intersections over vegetative material was determined visually from the projected slides and the percentage of surface cover was then calculated.

Duncan's multiple range test (SAS Institute, Inc., 1985) was used to evaluate the effect of planting date on surface cover for a given species. The effects, if any, of planting date on maximum cover (greatest surface cover provided by a given species planted on a particular date) or number of days to reach maximum cover (Figs. 2a, 2b and 2c) were determined. Measurements between planting dates were considered to be significantly different if they exceeded the 5% confidence level.

Surface cover as affected by species for a given planting date was also evaluated. For a particular planting date, Duncan's multiple range test (SAS Institute, Inc., 1985) was utilized to determine significant differences in maximum cover or number of days to reach maximum cover among plant species (Table 2). Again, the 5% confidence level was used to identify significant differences in measurements between plant species.

Information presented in Table 2 concerns two principal variables, maximum cover and days to reach maximum cover. However, as shown in Figs. 2a, 2b and 2c, several surface cover measurements were made for each plant species on each planting date. A statistical test was therefore needed which allowed comparison in surface cover measurements between plant species during the entire study period. The paired student's t-test (SAS Institute, Inc., 1985), shown in Table 3, was used to make these comparisons.

Vegetative samples were collected on July 3, August 13 and October 2 to determine the relationship between surface cover and vegetative mass. Samples from two 76.2 cm (11.8 in.) square areas were obtained on each of the harvest dates for the plots seeded on May 7. Vegetative samples were only collected on the October 2 sampling date for those plots planted on July 14 and August 26.

RESULTS AND DISCUSSION

The effect of planting date on surface cover for a given species is shown below. In addition, surface cover as affected by species for a given planting date is also described. Finally, legume surface cover — vegetative mass relationships are presented.

Effect of Planting Date on Surface Cover for a Given Species

Legumes may be used as a cover or strip crop, for forage production, seed generation, or a source of nitrogen. The purpose for which the legume is intended will dictate the appropriate planting date. The planting date in turn will influence the amount of surface cover provided by the particular legume.

When a legume is interseeded into another crop, planting date may be especially important. The legume should become well established and provide an effective surface cover prior to the first killing frost. However, if planted too early in the season, it may furnish undesired competition and significantly reduce the yield of the crop with which it is interseeded.

Climate is an important factor in determining seeding date for many species. Some species grow best at cooler temperatures while others prefer warmer weather (Zachariassen and Power, 1987). In many regions, extended periods without precipitation are not uncommon, such as occurred in this experiment following the July 14 seeding date.

No significant precipitation occurred for about three weeks following the July 14 planting date. Average daily temperature during this period was approximately 25°C. As a result of the hot, dry weather, there was very little emergence of vegetation until rainfall was received in early August.

Maximum surface cover provided by plant species evaluated in the present study is shown in Figs. 2a, 2b and 2c. No significant difference in maximum cover was found among planting dates for Austrian winter pea, hairy vetch, subterranean clover or winter rye. In contrast, black medic, cicer milkvetch, flat pea (lacto),

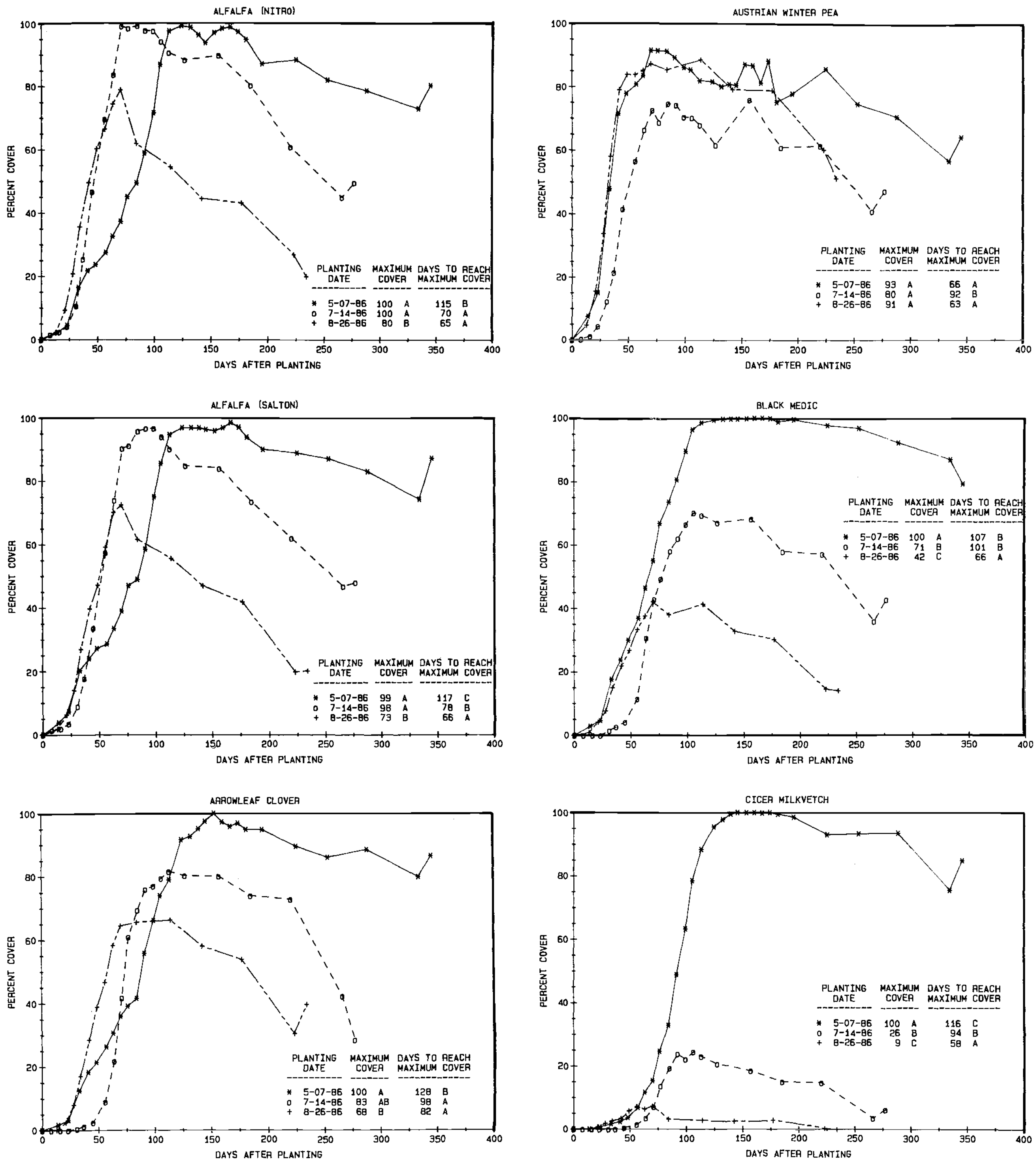

Fig. 2a—Surface cover provided by alfalfa (nitro), alfalfa (salton), arrowleaf clover, Austrian winter pea, black medic and cicer milkvetch planted at three different dates. Differences in maximum cover and days to reach maximum cover are significant at the 5% level (Duncan's multiple range test) if the same letter does not appear.

rose clover, soybean and yellow sweet clover all produced significantly different amounts of maximum cover for the three planting dates. With the exception of subterranean clover and winter rye, the greatest maximum cover was obtained for the earliest planting date. For many of the legumes seeded on July 14, the July drought resulted in an initial delay in surface cover production of about 20 days (Figs. 2a, 2b and 2c).

The number of days required for rose clover to reach maximum cover was similar between planting dates. In comparison, alfalfa (salton), cicer milkvetch, cow pea, crimson clover, crown vetch, flat pea (lacto), flat pea (tinga), hairy vetch, white clover and winter rye showed significant differences between planting dates in the number of days required to reach the greatest surface cover. In many cases, the length of time needed to reach maximum cover progressively decreased as the growing season became shorter.

The first freezing temperatures of the season occurred on October 13 when air temperatures fell to $-1°C$.

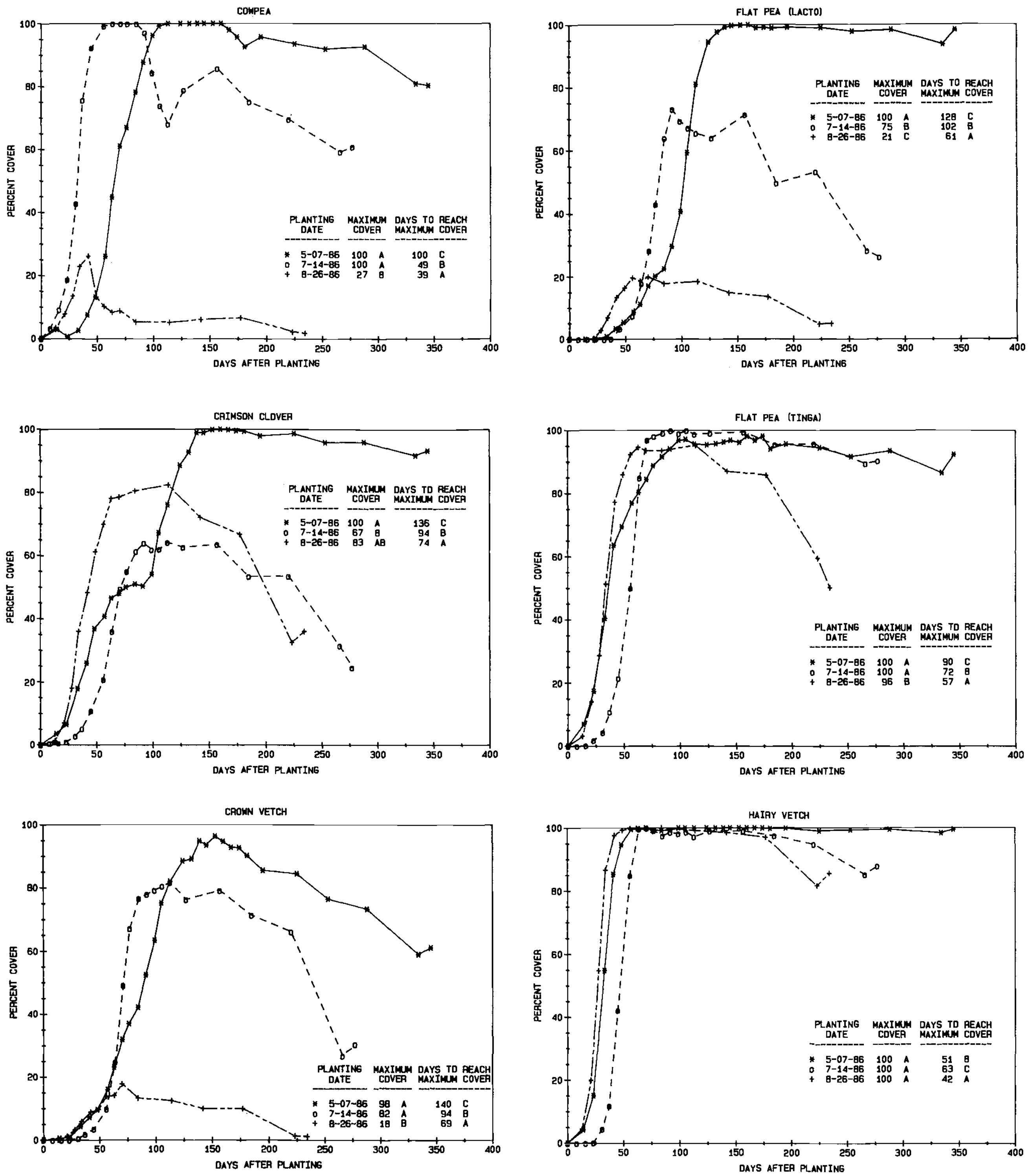

Fig. 2b—Surface cover provided by cow pea, crimson clover, crown vetch, flat pea (lacto), flat pea (tinga) and hairy vetch planted at three different dates. Differences in maximum cover and days to reach maximum cover are significant at the 5% level (Duncan's multiple range test) if the same letter does not appear.

These temperatures occurred 159, 91 and 48 days after the May 7, July 14 and August 26 planting dates, respectively. Only the cow pea and soybean plants appeared to have been seriously affected by the first frost. The weather remained mild until November 10 when air temperatures plunged to −17°C. These freezing temperatures occurred 187, 119 and 76 days after the May 7, July 14 and August 26 planting dates, respectively. For most of the plant species, surface cover decreased after this date.

The final series of surface cover measurements were obtained on April 17, 1987. For several of the plant species, surface cover increased from previous observations. New plant growth was occurring for many of the species as a result of warmer spring temperatures. On some of the plots, residue which had previously been standing had fallen onto the soil surface which also resulted in increased cover measurements.

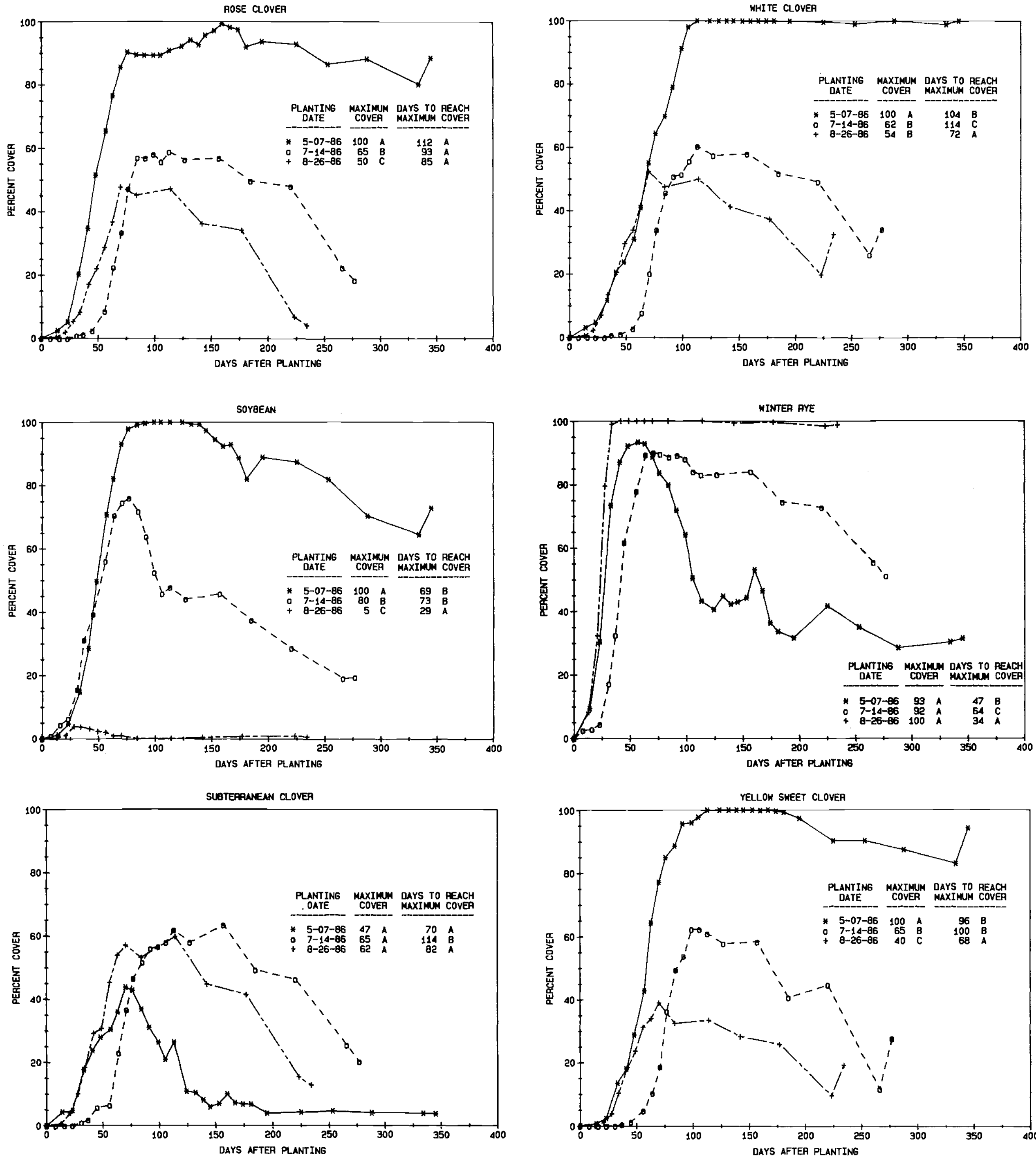

Fig. 2c—Surface cover provided by rose clover, soybean, subterranean clover, white clover, winter rye and yellow sweet clover planted at three different dates. Differences in maximum cover and days to reach maximum cover are significant at the 5% level (Duncan's multiple range test) if the same letter does not appear.

Surface Cover as Affected by Species for a Given Planting Date

Some legumes are better suited for a particular crop production system than are others. The rate of growth for a given legume species may be significantly affected by planting date. When comparing different legumes for soil erosion protection, vegetative growth and the amount of surface cover produced for a given planting date should be considered.

For the May 7 planting date, no significant difference in maximum cover (Table 2) was found between the various species with the exception of Austrian winter pea, subterranean clover and winter rye. All of the plant species except subterranean clover produced a cover greater than 90%. Crimson clover, flat pea (lacto), hairy vetch, white clover and winter rye maintained a surface cover greater than 90% throughout the study period. Winter rye and hairy vetch required the shortest period of time to reach maximum cover (Table 2), 47 and 51 days, respectively. Hairy vetch maintained the greatest

TABLE 2. Maximum cover and days to reach maximum cover for selected plant species*

Species	Planting Date					
	May 7, 1986		July 14, 1986		August 26, 1986	
	Maximum cover, %	Days to reach maximum cover	Maximum cover, %	Days to reach maximum cover	Maximum cover, %	Days to reach maximum cover
Alfalfa (nitro)	100 a	115 fg	100 a	70 b	80 bc	65 bcd
Alfalfa (salton)	99 a	117 fg	98 a	78 bc	73 cd	66 bcd
Arrowleaf Clover	100 a	128 gh	83 abc	98 d	68 cde	82 ef
Austrian Winter Pea	93 b	66 bc	80 abc	92 cd	91 ab	63 bcd
Black Medic	100 a	107 ef	71 bc	101 de	42 gh	66 bcd
Cicer Milkvetch	100 a	116 fg	26 d	94 d	9 j	58 bc
Cow Pea	100 a	100 def	100 a	49 a	27 hi	39 a
Crimson Clover	100 a	136 h	67 c	94 d	83 bc	74 def
Crown Vetch	98 a	140 h	82 abc	94 d	18 ij	69 bcde
Flat Pea (lacto)	100 a	128 gh	75 abc	102 de	21 ij	61 bcd
Flat Pea (tinga)	100 a	90 d	100 a	72 b	96 ab	57 b
Hairy Vetch	100 a	51 ab	100 a	63 ab	100 a	42 a
Rose Clover	100 a	112 efg	65 c	93 d	50 fg	85 f
Soybean	100 a	69 c	80 abc	73 b	5 j	29 a
Subterranean Clover	47 c	70 c	65 c	114 e	62 def	82 ef
White Clover	100 a	104 def	62 c	114 e	54 efg	72 cdef
Winter Rye	93 b	47 a	92 ab	64 b	100 a	34 a
Yellow Sweet Clover	100 a	96 de	65 c	100 de	40 gh	68 bcd

*Differences in maximum cover and days to reach maximum cover are significant at the 5% level (Duncan's multiple range test) if the same letter does not appear.

surface cover throughout the study period as shown in Table 3.

The plant species producing the greatest maximum cover (Table 2) for the July 14 planting date were: alfalfa (nitro), alfalfa (salton), arrowleaf clover, Austrian winter pea, cow pea, crown vetch, flat pea (lacto), flat pea (tinga) hairy vetch, soybean and winter rye. Cow pea and hairy vetch provided maximum cover most rapidly (Table 2) requiring 49 and 63 days, respectively. Again, hairy vetch maintained the greatest cover throughout the study period as shown in Table 3.

For the August 26 planting date, the plant species producing the greatest maximum cover (Table 2) were Austrian winter pea, flat pea (tinga), hairy vetch and winter rye. Cow pea, hairy vetch, soybean, and winter rye required the shortest period of time to reach maximum cover (Table 2), 39, 42, 29 and 37 days, respectively. The legume species maintaining the greatest surface cover throughout the study period was hairy vetch (Table 3).

The cover crops used in this experiment were established in a prepared seed bed without other plant competition. In many cropping systems, cover crops would be interseeded into a well established cash crop. Competition from other crops would be expected to significantly affect the surface cover provided by a particular legume.

TABLE 3. Comparison of surface cover measurements between plant species during the entire study period*

Species	Planting Date — 1986		
	May 7	July 14	August 26
Alfalfa (nitro)	gh	c	f
Alfalfa (salton)	g	d	f
Arrowleaf Clover	hi	fg	f
Austrian Winter Pea	de	e	d
Black Medic	d	fg	hi
Cicer Milkvetch	ij	l	l
Cow Pea	e	ab	jk
Crimson Clover	f	gh	e
Crown Vetch	k	f	k
Flat Pea (lacto)	jk	hi	j
Flat Pea (tinga)	b	b	c
Hairy Vetch	a	a	b
Rose Clover	c	jk	h
Soybean	cd	fg	m
Subterranean Clover	l	ij	g
White Clover	d	k	g
Winter Rye	k	c	a
Yellow Sweet Clover	cd	jk	i

*Differences in surface cover measurements within a column are significant at the 5% level (paired student's t-test) if the same letter does not appear.

TABLE 4. Regression relationships used for estimating legume surface cover

Legume Species	Regression coefficient, a*	Coefficient of determination, r^2
Alfalfa (nitro)	0.891	0.72
Alfalfa (salton)	0.810	0.80
Arrowleaf Clover	0.975	0.83
Austrian Winter Pea	0.874	0.51
Black Medic	1.01	0.88
Cicer Milkvetch	1.90	0.90
Cow Pea	0.770	0.96
Crimson Clover	0.480	0.55
Crown Vetch	1.83	0.74
Flat Pea (lacto)	2.25	0.80
Flat Pea (tinga)	1.33	0.66
Hairy Vetch	2.56	0.51
Rose Clover	0.846	0.83
Soybean	1.62	0.74
White Clover	1.21	0.87
Yellow Sweet Clover	0.946	0.88

*Regression coefficient, a, found in the equation:

$$\text{surface cover} = 100\,(1 - e^{-a\ \text{vegetative mass}})$$

where surface cover is given as a percentage and legume vegetative mass is measured in t/ha.

The surface cover measurements were influenced by several factors including soil and climatological conditions existing during the study period. Figures 2a, 2b and 2c are useful in describing general surface cover trends. However, deviations in these surface cover patterns may occur due to different weather and soil conditions. In addition, the experimental results found in southeastern Nebraska may not necessarily be directly applicable to other locations.

Surface Cover - Vegetative Mass Relationships

The two surface cover and vegetative mass measurements obtained on each plot were averaged to obtain values used to identify the regression coefficient, a, shown in the following equation:

$$\text{surface cover} = 100\,(1 - e^{-\,a\ \text{vegetative mass}})$$

where surface cover is given as a percentage and legume vegetative mass is measured in t/ha. Regression coefficients identified for each of the legume species except subterranean clover are shown in Table 4.

Subterranean clover was not well suited for the existing climatological conditions found in southeastern Nebraska. The coefficient of determination identified in the regression analysis for subterranean clover was not large enough to justify reporting the regression coefficient. Winter rye also was not included in Table 4 since it is not a legume species and was used in the experiment only as a reference crop.

It is important to note that the vegetative mass relationships shown in Table 4 cannot be used directly to estimate residue amounts. The dry matter production values obtained in this experiment apply to actively growing vegetative material. Somewhat different surface cover — residue mass relationships would be expected following the growing season after the occurrence of frost.

CONCLUSIONS

Legumes may play an important role in soil and crop management systems. Use of legumes provide several benefits including the potential for reducing erosion. Legumes may serve to decrease soil loss by providing a protective vegetative cover over the soil surface.

For several legume species, significant differences in maximum cover and days to reach maximum cover were found between planting dates. In general, the greatest surface cover was usually found for the earliest planting date. The length of time required for a particular legume species to reach maximum cover generally decreased as the length of the growing season became shorter.

All of the plant species seeded on the initial planting date except subterrean clover provided a surface cover greater than 90%. On each of the three planting dates, hairy vetch maintained the greatest surface cover throughout the study period. Hairy vetch was also found to be one of the species which most rapidly established a substantial vegetative cover on each of the planting dates.

A variety of factors must be considered when selecting a legume best suited for a particular crop production system. The purpose for which the legume is intended will dictate the appropriate planting date. The planting date in turn will influence the amount of vegetative cover provided by a particular species. For the given experimental conditions existing in southeastern Nebraska, hairy vetch was found to be one of the legume species best suited for establishing a substantial surface cover in a relatively short time period, regardless of planting date.

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