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Cover Crop Potential of White Clover: Morphological Characteristics and Persistence of Thirty-six Varieties

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Introduction

Center of origin for white clover (*Trifolium repens* L.) is thought to be in the Near East (Harlan, 1971). Its distribution throughout Europe and Western Asia has been attributed to caravans and migratory animals (Leffel and Gibson, 1976), and it was first propagated from seed in the Netherlands in the early sixteenth century.

Introduction of white clover into the United States is thought to have been by European settlers. White clover is known to have been in Ohio and Kentucky by the time these areas were settled in the mid-1700's. According to the Federal Extension Service, 12.4 million acres are now planted to white clover cultivars in the United States (Paulling, 1970).

Distribution of white clover throughout the world is limited only by extreme cold, drought, heat, or plant competition. It is found from the Arctic Circle to temperate regions (Leffel and Gibson, 1976). In Colombia, it is found at altitudes from 5,200 to 9,800 feet (Crowder, 1960).

According to Leffel and Gibson (1976), white clover is one of the most important pasture legumes in the world. When grown in association with a grass it improves the nutritional quality of the sward. Animals grazing white clover-grass mixtures have a higher voluntary intake and digestibility than those grazing pure grass pastures. White clover is generally higher in crude protein content than grasses and has a higher percentage of 16 amino acids than birdsfoot trefoil (*Lotus corniculatus* L.), alfalfa (*Medicago sativa* L.), or red clover (*T. pratense* L.) (Loper et al., 1963).

Numerous agronomic and animal studies have been conducted with white clover. However, information is needed on this species used as a cover crop.

Materials and Methods

An assembly of 36 accessions of white clover was received from the National Plant Materials Center, Beltsville, MD. Table 1 lists the varieties and origin.

Seeds of accessions were inoculated and planted in pots in a greenhouse at the Jamie L. Whitten Plant Materials Center, Coffeeville, MS, in mid-October, 1988.

Planting medium was a commercially prepared light weight material composed of shredded peat moss and vermiculite blended with a controlled-release fertilizer (7-17-5, N-P-K).

For transplanting, a seedbed was prepared by broadcast applying 0-13-25 pounds (N-P-K) per acre, disking, chiseling, and harrowing. Soil type was an Oaklimeter silt loam (coarse-silty, mixed thermic Fluvaquentic Dystrochrepts) with a pH of 6.6. Seedlings were transplanted November 21 and 22. Plot size was 3 feet by 10 feet with 6-foot alleys. Each plot contained 30 plants of an assigned accession, planted one foot apart. In March 1990, all plots received an additional 0-13-25 lb (N-P-K) per acre.

Plant vigor was visually rated using a 1-9 scale (1=best, 9=poor). Foliage and flower heights were

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determined by averaging three randomly selected sites within each plot. Forage from one square foot was cut, air dried, and weighed to calculate dry matter (DM) yield. Three leaflets in each plot were measured (length x width) to determine leaf size. Experimental design was a randomized complete block with three replications. Data were subjected to analysis of variance, and means separated using Fisher's Least Significant Difference [LSD ($P > 0.05$)] (Steel and Torrie, 1960).

Results and Discussion

Most of the deviation of white clover persistence occurs during the summer (Albrecht, 1942). In this study, survival counts were taken in March 1989, when individual plants could still be counted. All varieties maintained high survival rates even though significant differences were found (Table 2). Gibson et al. (1963) classified white clover plants into two groups: viney (thin canopy, low number of stolons, and few leaves in the center) and nonviney (uniform dense canopy, frequent stolon branching, and continual production of leaves in the center of the plant). In their study, nonviney type clones had higher survival rates and greater dry matter yields.

Work by Knight (1953a) indicated that persistence and high yield production could be passed from clones to their progenies. In his study, a more even seasonal distribution of forage production was provided by persistent clones than less persistent types.

In the western United States, average seed yield of white clover is 270 lb/acre, which can be up to three times that grown in Louisiana (Gibson and Cope,

Table 1. List of varieties and origination.

Accession	Origin
Aberstwyth	England
Alice	England
Angel Gallardo	Argentina
Aran	Ireland
Blanca	Belgium
California Ladino	USA
Crau	France
Donna	England
El Lucero May	Argentina
Grassland Kopu	Australia
Huia	New Zealand
Irrigation	Australia
Jiwan	
Karina	Germany
Kitaooha	Japan
Lena	Sweden
Lipera	Germany
Louisiana S-1	USA
Lune De Mai	France
Makibashiro	Japan
Menna	England
Merwl	Belgium
N.F.G. Gigant	Germany
Nesta	England
Nora	Sweden
Olwen	England
Pertina	Netherlands
PG8	New Zealand
Pitau	New Zealand
Retor	Netherlands
Ross	Ireland
Sandra	Sweden
Sonja	Sweden
Steinacher	Germany
Tahora	New Zealand
Vilkla	Netherlands

Table 2. Survival, flower number, flower height, and dry matter yield of 36 white clover varieties, Coffeeville, MS, 1989.

Variety	Survival*	Flower**		DMyield**
		number	height	
	%	No/ft²	in.	lb/acre
Aberstwyth	97	36	10	3,934
Alice	97	37	15	5,920
Angel Gallardo	100	55	15	4,893
Aran	100	22	15	4,797
Blanca	100	24	14	4,001
California Ladino	100	24	16	4,481
Crau	100	20	13	4,481
Donna	100	23	13	4,510
El Lucero May	100	64	16	4,577
Grassland Kopu	100	20	16	4,673
Huia	100	40	12	4,155
Irrigation	97	53	14	4,634
Jiwan	100	32	12	3,838
Karina	100	30	13	4,385
Kitaooha	100	10	16	4,414
Lena	100	57	11	4,250
Lipera	100	68	13	5,248
Louisiana S-1	100	46	17	5,536
Lune De Mai	100	27	14	3,425
Makibashiro	100	38	13	4,989
Menna	100	30	12	4,538
Merwl	97	34	13	4,155
N.F.G. Gigant	100	24	15	4,634
Nesta	97	12	12	3,742
Nora	100	76	11	3,838
Olwen	100	24	15	3,675
Pertina	100	36	13	4,951
PG8	100	60	11	4,193
Pitau	100	49	12	4,414
Retor	100	31	12	3,934
Ross	100	18	14	4,414
Sandra	100	35	13	4,730
Sonja	100	49	13	4,769
Steinacher	100	67	15	4,538
Tahora	100	102	11	4,222
Wilkla	100	34	11	4,250
LSD (0.05)	1	24	2	1,669

* Rated April 6.
** Determined May 24.

1976). Environmental conditions for growth, flower production, pollination, and harvesting are more ideal in the West than in the Southeast. Of the factors affecting seed yield, seed head number per area is the greatest. Any factor that reduces seed head number reduces seed yield. Rincker and Rampton (1985) reported that 'Kitaooha' produced a seed yield of 350 lb/acre from 44 seed heads per square foot. In this study, 'Tahora' produced the highest number of seed heads with 102 heads per square foot (Table 2). Although not evaluated in this experiment, time of flowering may be comparable with flower height. Smith (1909), in working with corn (*Zea mays* L.), associated ear height with time of flowering, with early flowering types having lower ear heights. However, persistence, vigor, and disease resistance of white clover has been correlated to lateness of flowering (Knight, 1953b). Flower heights of the white clover varieties are given in Table 2.

Nitrogen fixation levels of white clover are dependent upon stand density, plant growth, growing season length and nature, soil fertility, inoculation efficiency, and variety. Knight and Watson (1973) estimated that ladino white clover could fix up to 180 lb N/acre. When grown in a legume-grass mixture, white clover may supply more than 50 percent of the total forage produced (Woodhouse and Chamblee, 1958). In this study, DM yield ranged from 3,425 to 5,920 lb/acre for 'Lune De Mai' and 'Alice,' respectively (Table 2). Kitaooha was continuously selected and grazed by deer (*Odocoileus virginianus*).

Strong, upright petioles are essential to prevent leaf contact with the soil, which may contain pathogens. Kitaooha was one of the tallest varieties while Tahora was one of the shortest (Table 3).

Gibson and Cope (1985) stated the failure of white clover to persist in legume-grass swards as its main limiting factor. Geneticists have selected for characteristics such as disease and insect resistance, increased N fixation, and physiological traits that will improve white clover's adaptation to certain areas. 'Aran,' 'Grassland Kopu,' Kitaooha, and 'Ross' were the four varieties that ranked consistently among the top for plant vigor at all rating dates (Table 4). Knight (1953b) found a correlation between vigor after flowering and persistence.

Watson (1956) found that leaf area is greater than net assimilation rate in determining DM yield. Beinhart (1962) studied white clover response to temperature and light intensity and found a correlation between leaf area and dry plant weight. Therefore, it is important to study leaf area production among varieties. Leaf size ranged from 2.1 to 7.6 cm^2 for 'Aberstwyth' and Grassland Kopu, respectively (Table 4).

Conclusions

White clover has several characteristics desired of a cover crop. It has a low growth habit, provides rapid cover, fixes nitrogen, is a prolific seed producer, and reseeds well. When grown at a soil temperature of 50 °F for a growth period greater than 60 days, growth rate (Zachariassen and Power, 1991) and N fixation per unit water used (Power and Zachariassen, 1993) were greater for white clover than for crimson clover (*T. incarnatum* L.) or hairy vetch (*Vicia villosa* L.). To determine the potential use of this species in soil conservation, morphological characteristics and persistence of 36 varieties were evaluated.

Aran, Grassland Kopu, and Kitaooha were con-

Table 3. Foliar height of 36 white clover varieties, Coffeeville, MS, 1989-1990.

	Foliar height		
Variety	4/06/89	5/03/89	3/16/90
	inches		
Aberstwyth	3	8	4
Alice	5	13	7
Angel Gallardo	7	13	7
Aran	6	13	9
Blanca	5	11	6
California Ladino	7	13	7
Crau	5	11	9
Donna	4	11	7
El Lucero May	6	13	7
Grassland Kopu	7	14	9
Huia	3	10	8
Irrigation	4	11	7
Jiwan	5	11	7
Karina	5	10	7
Kitaooha	8	14	9
Lena	3	9	5
Lipera	4	10	6
Louisiana S-1	7	14	6
Lune De Mai	6	12	8
Makibashiro	4	11	6
Menna	4	10	7
Merwl	4	11	7
N.F.G. Gigant	7	12	7
Nesta	4	10	8
Nora	4	9	6
Olwen	6	13	8
PG8	6	11	7
Pertina	2	8	6
Pitau	3	9	7
Retor	4	8	7
Ross	6	11	8
Sandra	3	9	6
Sonja	4	11	7
Steinacher	5	11	7
Tahora	2	8	5
Wilkla	3	9	6
LSD (0.05)	2	2	2

sistently ranked favorably in all parameters studied. 'Angel Gallardo,' 'California Ladino,' and 'Louisiana S-1' were highly ranked in most categories.

Additional research is needed to fully determine the potential of white clover as a cover crop. With the recent developments in equipment and herbicide chemistries, white clover could be successfully used as a cover crop or a living mulch for grain crops.

Table 4. Plant vigor and leaf size of 36 white clover varieties, Coffeeville, MS, 1989-90.

	Vigor*			Leaf size
Variety	4/6/89	5/3/89	3/16/90	3/16/90
				cm^2
Aberstwyth	4	4	5	2.1
Alice	3	2	3	4.4
Angel Gallardo	3	2	3	5.2
Aran	2	2	1	6.1
Blanca	3	2	3	4.1
California Ladino	2	2	3	5.2
Crau	3	2	1	7.1
Donna	3	2	2	3.4
El Lucero May	3	2	3	5.9
Grassland Kopu	2	2	2	7.6
Huia	4	3	3	4.5
Irrigation	4	2	3	4.2
Jiwan	3	3	3	5.4
Karina	3	3	3	3.9
Kitaooha	2	2	1	7.4
La. S-1	2	4	4	3.2
Lena	3	2	4	3.5
Lipera	3	2	3	4.6
Lune De Mai	2	2	2	3.2
Makibashiro	3	3	3	3.3
Menna	3	4	3	4.4
Merwl	3	2	3	4.1
N.F.G. Gigant	2	4	3	4.2
Nesta	3	4	2	5.9
Nora	3	2	5	3.7
Olwen	3	2	2	5.6
Pertina	3	4	3	4.0
PG8	2	4	4	2.7
Pitau	4	4	3	5.0
Retor	3	2	3	4.0
Ross	2	3	1	5.6
Sandra	4	3	4	3.9
Sonja	4	2	3	4.6
Steinacher	3	4	3	3.2
Tahora	4	4	4	3.1
Wilkla	4	3	3	3.3
LSD (0.05)	1	1	1	2.6

* Vigor scale: 1=best, 9=poor.

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