At trials in Davis, California, berseem clover was hand-harvested as many as six times during the winter-spring growing season.

# Berseem clover is getting a second chance

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Legumes were an important source of nitrogen in crop rotations in the United States before World War II, until agriculture came to rely on nitrogen fertilizers produced from oil products. A renewed interest in nitrogen-fixing legumes in recent years, however, has led to a program to reevaluate berseem clover for use as a winter forage (green chop and/or silage) and as a green manure plant.

Berseem, a winter and spring annual, is thought to have originated in the Middle East. Today the country of greatest use is Egypt, where berseem is grown on nearly 4 million acres as a winter forage or green manure crop, usually preceding cotton or summer vegetables. Most modern-day berseem varieties can be traced to one of the Egyptian landraces: Miscawi, Saidi, and Fahl. These represent the three general types of berseem, based on stem branching. Miscawi is a basal or crown branching type that can be cut five or six times during its growing season. Fahl is a stem branching type and can be cut only once. Saidi is both basal and stem branching and can be cut only two to three times during the growing season.

Berseem was introduced into California as early as 1896, into Texas by 1916, and into Florida by 1950. Despite early expectations, however, it performed sporadically in all of these areas. Based on prior work in North Africa by the senior author, we decided that berseem was worthy of a second chance because of its large forage production and nitrogen-fixing ability.

Seed inoculation with the nitrogen-fixing *Rhizobium* bacterium is necessary. Exploration for *Rhizobium* strains in Tunisia by J. C. Burton (former Research Director, Nitragin Company) in 1981 resulted in the development of significantly superior strains that are now available commercially.

Berseem strain and variety introductions were made during the fall of 1981, and since 1982, we have conducted field trials in northern California at the University of California, Davis, in southern California at California Polytechnic Institute, Pomona, and in Mexico at the University of Baja California, Mexicali. Their purpose has been to assess forage production and the nitrogen-fixing potential of some of the multiple-cut varieties under supplemental irrigation.

## Variety trial, Davis, 1982-83

The first Davis trial was established on October 1, 1982. The berseem clover entries Multicut (formerly called Burton), Sacromonte, and Tunisian common were planted after the seeds were pellet-inoculated with Rhizobia. Annual ryegrass was also planted as a check on nitrogen fixation. No fertilizer was used in this or subsequent Davis trials, since they were all conducted on Reiff fine sandy loam, a deep, well-drained, fertile soil with neutral pH.

Supplemental sprinkler irrigation was used in the fall for seedling establishment and again in the spring after the winter rains stopped. Annual rainfall averaged 24 inches at Davis during these experiments; less than 10 percent of the rain occurred during the six-month dry season of April through October.

Plots were harvested when the berseems were 16 to 20 inches high, and dry matter production and nitrogen concentration in the forage measured. Nitrogen fixation was estimated by the difference method; that is, the amount of nitrogen uptake into the harvested tops of the ryegrass was subtracted from that in each berseem entry to give nitrogen fixed.

Five harvests were made, from January 21 to July 13, 1983 (table 1). Multicut significantly outyielded the other entries at 11,000 pounds per acre of dry matter, and it had an average crude protein content of 21 percent (nitrogen percentage times 6.25). Ryegrass produced 6,900 pounds per acre with average protein content of 10 percent.

Nitrogen fixation by the top-yielding variety, Multicut, was estimated at 236 pounds per acre.

***The high yield, protein content, and nitrogen-fixing ability of new varieties make berseem an excellent candidate for forage in some areas of the state. Foundation seed will be available this fall.***

## Berseem clover description

Berseem clover, *Trifolium alexandrinium* L., also called Egyptian clover, is an erect-growing, non-reseeding annual legume with oblong, slightly hairy leaflets lacking a watermark. It has hollow stems and a short taproot. When it reaches a height of 16 to 20 inches, buds from 1 to 2 inches long develop, initially from nodes for the cotyledons and first two leaves, and the crop is ready for harvest. The multiple-cut varieties can be harvested five or six times at four-week intervals from January or February until June or July. The first three cuttings are made in the vegetative stage, the later harvests during bloom, beginning in May.

Flowers are yellowish white, self-sterile, and clustered in dense elliptical heads about 1 inch long. Each floret produces one roughly spherical, yellow seed. Flowering begins in May under the above cutting regime, and seed is ripe by late July. Seed production is abundant. Seed weight averages 200,000 seeds per pound.

## Production practices

Seed is planted at 15 to 20 pounds per acre in a prepared seedbed in the early fall, in the same way as alfalfa is planted. The irrigation schedule should also follow that of fall-planted alfalfa. The seed should be pellet-inoculated with Rhizobia before plantings; inoculum specific to berseem clover is available commercially. Fertilizer needs are similar to those of alfalfa. Berseem clover tolerates moderate salinity and moderate periods of waterlogging in the soil. It is a fairly strong competitor with winter weeds during establishment, and by the third cutting is often weed-free.

Seed of two varieties is available commercially in California—Multicut (formerly called Burton) and Bigbee. Foundation seed of Multicut is available for fall planting in 1987. Bigbee, a winter-hardy type, is readily available, but it suffered a yield disadvantage of 10 to 50 percent in the trials described here, during which there has been no freeze-out. Multicut has withstood, without damage, temperatures as low as 24°F, the lowest temperature during the five years of testing. Multicut was taller, bloomed about 10 days later, and produced more winter forage than Bigbee in our tests.

NOTE: Details of seed inoculation are given in *Range Legume Inoculation and Nitrogen Fixation by Root Nodule Bacteria*, Bulletin 1842CA. To order, send check or money order for $1.75, payable to UC Regents, to:

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## Planting-date trial, Davis, 1983-84

In the next Davis trial, we studied the effect of three planting dates: September 12, October 7, and October 28, 1983. Multicut and annual ryegrass were used again to assess nitrogen fixation. A mixture of annual ryegrass and Multicut (half and half) was also planted on all three dates. The berseem seeds were pellet-inoculated with the new Tunisian Rhizobium strains in this and all subsequent trials described here.

The first two plantings produced six cuttings, with the earliest harvest on December 21 and the last on July 20. The latest planting produced five harvests, beginning on March 2. Multicut again was a high yielder, at 7 tons per acre, and the total yield was not affected significantly by planting date. The earliest planting date, however, produced 1 ton per acre by December 21, whereas this yield was not attained until March 2 under the latest planting date.

Ryegrass alone yielded slightly more than half as much as the clover did, and nitrogen was a limiting factor from March on. The mixtures yielded about the same as berseem clover alone, with ryegrass dominating in the early cuts, and berseem in the last three harvests.

Total nitrogen fixed by Multicut ranged from 303 to 325 pounds per acre.

## Ryegrass-mixture trial, Davis, 1984-85

The third Davis trial was established to test dry matter production and nitrogen fixation by various proportions of Multicut berseem and annual ryegrass in mixtures and to continue testing berseem variety adaptation to the Sacramento Valley. Multicut berseem and annual ryegrass were planted in monoculture and mixtures of 25, 50, and 75 percent berseem clover (based on viable seed numbers) on October 9, 1984. The other berseem cultivars included were Fahl (single cut), Bigbee, and Miscawi (Egypt).

Five harvests were made, beginning February 26 and ending July 2, 1985. In pure stands, Multicut was the most productive with 13,800 pounds per acre dry matter. Fahl produced only one cutting at 3,500 pounds per acre dry matter. Annual ryegrass alone yielded about half as much forage as Multicut alone. The mixtures of 50 and 75 percent Multicut with annual ryegrass yielded as much forage as Multicut alone.

The amount of nitrogen fixed by Multicut alone totaled 277 pounds per acre and the 50 and 75 percent Multicut with ryegrass mixture did not reduce the amount of nitrogen fixed by very much. Multicut berseem became dominant in all mixtures with ryegrass by the third harvest.

## Variety trial, Davis, 1985-86

We tried Multicut with five other berseems: Bigbee, Gigande de Lage, Khadraoui, Belem, and Miscawi (Egypt). Annual ryegrass and a half-and-half mixture of Multicut and Bigbee berseem were also tested. Bigbee, which was developed for frost tolerance, was included as insurance against a freeze-out, although in five years of testing, no frost damage has occurred on Multicut. Planting was on October 7, 1985, following a crop of sudangrass for hay (three cuttings).

Six harvests were made from February to July 1986. The two top yielders were the Multicut-Bigbee mixture and Multicut alone, with both fixing more than 300 pounds per acre nitrogen. Because of its shorter stature, Bigbee appeared to contribute progressively less to the mixture after the first harvest. Annual ryegrass did poorly throughout and was clearly stressed for nitrogen because of the prior crop of sudangrass and the absence of nitrogen fertilizer. Nitrogen uptake by the top treatment (Multicut-Bigbee mixture) was about 10 times the total uptake of 45 pounds per acre by the ryegrass, showing the tremendous nitrogen-fixing power of berseem clover.

## Variety trials, Pomona

In 1984 at Pomona, forage production from four to five cuttings of berseem clover varieties ranged from 8,000 to 11,400 pounds per acre dry matter (table 2) with an average of 24 percent crude protein and 22 percent crude fiber. These trials were performed on a highly fertile soil in rotation with vegetable crops heavily fertilized with nitrogen. The nitrogen fixation by the berseem thus was correspondingly lower. Annual ryegrass yielded 84 percent as much forage as the best berseem variety, Khadraoui, and contained 18 percent crude protein, while the ryegrass at Davis under low nitrogen fertility produced much less and averaged about 10 percent crude protein.

We measured crude fiber, ash, and fat but detected no significant differences among the clover varieties.

In the second year of testing, 1985-86, we expanded the number of berseem varieties and included barley as a grass component in addition to annual ryegrass, Mixtures of Multicut with annual ryegrass and with barley were also included.

Again, the high residual soil nitrogen allowed annual ryegrass to perform well, as indicated by the 193 pounds per acre nitrogen uptake. As measured by the difference method, nitrogen fixed by the berseem varieties varied from 158 to 214 pounds per acre and was consistently lower than that measured at Davis.

Eight of the berseem entries produced significantly more total dry matter than

**TABLE 1. Dry matter produced and nitrogen fixed by various treatments with berseem clover varieties compared with annual ryegrass under supplemental irrigation, Davis**

| Treatment | Planting date | Harvest 1 | 2 | 3 | 4 | 5 | 6 | Total | Nitrogen fixed |
|---|---|---|---|---|---|---|---|---|---|
| | | *Dry matter lb/a* | | | | | | | *lb/a* |
| **1983** | | **1/21** | **4/1** | **5/3** | **6/2** | **7/13** | | | |
| Multicut | 10/1/82 | 1540 | 2370 | 2410 | 2060 | 2610 | | 11000 | 236 |
| Sacromonte | | 1590 | 2840 | 2100 | 1440 | 1360 | | 9300 | 186 |
| Tunisian | | 0 | 2240 | 1960 | 1920 | 2430 | | 8600 | 150 |
| Ryegrass | | 2980 | 2240 | 260 | 520 | 860 | | 6900 | (169)* |
| LSD 5% | | 490 | 590 | 760 | 260 | 700 | | 1700 | |
| **1984** | | **12/21** | **3/2** | **3/28** | **4/24** | **5/22** | **7/20** | | |
| Multicut | 9/12/83 | 2010 | 1940 | 2460 | 2320 | 2500 | 2850 | 14100 | 311 |
| 50:50 mix | | 2940 | 1970 | 1300 | 1480 | 2030 | 2660 | 12300 | 196 |
| Ryegrass | | 2860 | 1630 | 620 | 480 | 1050 | 1150 | 7800 | (163)* |
| | | **1/13** | | | | | | | |
| Multicut | 10/7/83 | 1360 | 1690 | 2210 | 2290 | 2640 | 3680 | 13900 | 303 |
| 50:50 mix | | 2340 | 1540 | 1850 | 1960 | 2620 | 3670 | 14000 | 268 |
| Ryegrass | | 2840 | 1400 | 1120 | 1000 | 1030 | 1240 | 8700 | (182)* |
| Multicut | 10/28/83 | 0 | 1860 | 2600 | 2400 | 2680 | 3800 | 13300 | 325 |
| 50:50 mix | | 0 | 3440 | 2260 | 2120 | 2630 | 4170 | 14600 | 326 |
| Ryegrass | | 0 | 2160 | 1110 | 1200 | 1210 | 1250 | 6900 | (120)* |
| LSD 5% | | 650 | 890 | 420 | 310 | 350 | 690 | 1900 | |
| **1985** | | **2/26** | **3/24** | **4/23** | **5/21** | **7/2** | | | |
| Multicut | 10/9/84 | 3100 | 1940 | 2480 | 2360 | 3940 | | 13800 | 277 |
| 75:25 mix | | 3350 | 2000 | 2220 | 2250 | 4030 | | 13800 | 270 |
| 50:50 mix | | 3640 | 1980 | 2270 | 2120 | 4030 | | 14000 | 268 |
| 25:75 mix | | 3900 | 1510 | 1840 | 1870 | 3550 | | 12700 | 206 |
| Ryegrass | | 3980 | 800 | 930 | 620 | 1060 | | 7400 | (174)* |
| Fahl | | 3530 | 0 | 0 | 0 | 0 | | 3500 | 0 |
| Miscawi-E | | 3150 | 2080 | 2050 | 1760 | 2500 | | 11500 | 210 |
| Bigbee | | 3840 | 480 | 2780 | 1360 | 3430 | | 11900 | 235 |
| LSD 5% | | 470 | 380 | 290 | 210 | 860 | | 1500 | |
| **1986** | | **2/11** | **3/20** | **4/18** | **5/16** | **6/17** | **7/15** | | |
| Multicut | 10/7/85 | 1420 | 1690 | 1820 | 1860 | 3710 | 3390 | 13900 | 358 |
| M&B mix† | | 1530 | 1720 | 1920 | 1970 | 4070 | 3590 | 14800 | 396 |
| Bigbee | | 1500 | 2060 | 1150 | 1400 | 4440 | 530 | 11100 | 311 |
| Gigande | | 830 | 1480 | 1860 | 1840 | 3630 | 2170 | 11800 | 314 |
| Khadraoui | | 1050 | 1310 | 1540 | 1510 | 3630 | 1100 | 10100 | 233 |
| Belem | | 1420 | 1310 | 2250 | 2010 | 3890 | 2220 | 13100 | 353 |
| Miscawi-E | | 1320 | 1110 | 1700 | 1360 | 2410 | 540 | 8400 | 236 |
| Ryegrass | | 1160 | 730 | 50 | 170 | 590 | 370 | 3100 | (45)* |
| LSD 5% | | 260 | 200 | 590 | 530 | 870 | 760 | 1800 | |

* Soil nitrogen uptake by annual ryegrass (not fixed). This value has been subtracted from each clover nitrogen uptake to estimate the corresponding nitrogen-fixed value.
† Mixture of Multicut and Bigbee.

**TABLE 2. Dry matter produced and nitrogen fixed by various treatments with berseem clover varieties compared with annual ryegrass and barley under supplemental irrigation, Pomona**

| Treatment | Planting date | Harvest 1 | 2 | 3 | 4 | 5 | Total | Nitrogen fixed |
|---|---|---|---|---|---|---|---|---|
| | | *Dry matter lb/a* | | | | | | *lb/a* |
| **1984** | | **1/10** | **2/24** | **3/28** | **4/27** | **5/23** | | |
| Tunisian | 10/20/83 | 1950 | 2130 | 1880 | 2390 | 1870 | 10200 | 131 |
| Bigbee | | 1040 | —† | 3680 | 1780 | 1480 | 8000 | 39 |
| Khadraoui | | 1430 | 1890 | 2750 | 2940 | 2380 | 11400 | 157 |
| Sacromonte | | 1790 | 1740 | 1820 | 1900 | 1680 | 8900 | 96 |
| Ryegrass | | 1580 | 2480 | 2060 | 2100 | 1330 | 9600 | (266)* |
| LSD 5% | | 430 | 670 | 380 | 1000 | 720 | | |
| **1986** | | **1/9** | **2/24** | **4/3** | **5/10** | | | |
| Ryegrass | 10/15/85 | 2800 | 2220 | 1410 | 1950 | | 8400 | (193)* |
| MS Exp. 1 | | 1910 | 2570 | 2440 | 3280 | | 10200 | 170 |
| MS Exp. 2 | | 2020 | 2200 | 2400 | 3100 | | 9700 | 163 |
| MS Exp. 3 | | 2010 | 2350 | 2250 | 2900 | | 9500 | 158 |
| Bigbee | | 2040 | 2430 | 2260 | 2720 | | 9400 | 157 |
| Belem | | 1810 | 2730 | 2870 | 4240 | | 11600 | 179 |
| Multicut | | 1820 | 2300 | 2820 | 3570 | | 10500 | 166 |
| Gigande | | 1520 | 2460 | 2720 | 3970 | | 10700 | 153 |
| GR 803 | | 2160 | 2880 | 2790 | 3500 | | 11300 | 173 |
| GR 850 | | 2430 | 2850 | 3350 | 3710 | | 12300 | 214 |
| Multicut/ Ryegrass | | 3110 | 2590 | 2520 | 3540 | | 11800 | 162 |
| Multicut/ Barley | | 3480 | 650 | 920 | 1830 | | 6900 | 24 |
| Barley | | 3650 | 390 | 0 | 0 | | 4000 | (121) |
| LSD 5% | | 590 | 410 | 580 | 770 | | 1200 | |

* Soil nitrogen uptake by annual ryegrass (not fixed). This value has been subtracted from each clover nitrogen uptake to estimate the corresponding nitrogen-fixed value.
† No cutting taken at second Bigbee harvest date in 1984 because of this entry's poor recovery.

Thought to have originated in the Middle East, berseem clover is now widely grown in Egypt as a winter forage and, because of its nitrogen-fixing ability, as a green manure crop. Improved varieties and importation of more efficient strains of seed-inoculation bacteria from Tunisia have renewed interest in the crop in California.

did annual ryegrass. The barley entry was the poorest dry-matter producer. Bigbee berseem was not a significantly better producer of dry matter than ryegrass, and it was the second lowest nitrogen-fixer. The poor showing of the Multicut/barley mixture resulted from the barley's fast early growth, which reduced the berseem seedling population and thus the potential for production in the later cuttings.

The top dry-matter producer and nitrogen-fixer, GR 850, was collected in Morocco during our 1983 plant exploration trip. Its performance is very encouraging for our plant exploration program, which will continue to add to the germplasm pool in berseem clover.

## Baja California trials

The Baja California trials took place in two locations in the Mexicali Valley. Based on our Davis results, we were most interested in testing Multicut against the only commercial variety available, Bigbee (table 3).

Multicut outproduced Bigbee in dry matter during the 1985-86 season at the Ejido Nuevo Leon site. Winter production (first two cuttings) was about the same, but the late production of Multicut (last two cuttings) was superior to that of Bigbee. This production pattern is similar to our UC-Davis results. Multicut had an average of 18 percent crude fiber compared with 21 percent for Bigbee. Average crude protein was higher in Multicut than in Bigbee (22 versus 19 percent). Multicut thus outperformed Bigbee in both quantity and quality.

Total dry matter yields were higher in the 1985-86 variety trial at Colonia Progreso than at Ejido Nuevo Leon. Multicut again was the top yielder.

In the trial comparing mixtures of annual ryegrass and berseem at Ejido Nuevo Leon, ryegrass dominated during the first two cuttings, but the superior berseem strains dominated in the later cuttings and thus formed a large fraction of the forage total. The Multicut-ryegrass and the Tunisian berseem-ryegrass mixtures both substantially outproduced the Bigbee-ryegrass mixture, with the ryegrass alone being a distant fourth.

**TABLE 3. Dry matter production by berseem clover varieties and berseem/annual ryegrass mixtures under irrigation, Baja California**

| Treatment | Planting date | Harvest 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| | | Dry matter lb/a | | | | | | |
| **Ejido Nuevo Leon:** | | | | | | | | |
| **1985** | | **2/26** | **3/19** | **4/11** | **5/8** | **6/4** | **7/5** | |
| Multicut | 11/12/84 | 1020 | 1750 | 1940 | 2340 | — | 3880 | 10900 |
| Bigbee | | 1280 | 1390 | 1770 | 1770 | 1340 | 0 | 7600 |
| **Colonia Progreso:** | | | | | | | | |
| **1986** | | **1/2** | **2/14** | **3/18** | **4/18** | **5/6** | **5/29** | |
| Multicut | 10/21/85 | 2340 | 2900 | 2820 | 3180 | 2000 | 1590 | 14800 |
| Bigbee | | 1390 | 2470 | 2760 | 3450 | 1260 | 2040 | 13300 |
| Khadraoui | | 2800 | 2940 | 2150 | 3150 | 2190 | 1350 | 14600 |
| Tunisian | | 1210 | 2420 | 2880 | 3110 | 1640 | 920 | 11100 |
| **Ejido Neuvo Leon:** | | | | | | | | |
| **1986** | | **1/6** | **2/24** | **4/1** | **4/28** | **5/27** | | |
| Multicut/ryegrass | 10/22/85 | 2630 | 2840 | 2900 | 2600 | 1970 | | 12900 |
| Bigbee/ryegrass | | 2570 | 2390 | 2420 | 1920 | 1460 | | 10800 |
| Tunisian/ryegrass | | 2320 | 2290 | 3450 | 2410 | 2550 | | 13000 |
| Ryegrass | | 3110 | 1070 | 1610 | 1030 | 790 | | 7600 |

## Conclusions

These results should offer a lot of encouragement to meat and milk producers. In the Mexicali Valley, feed is usually at a premium during the winter and spring. Annual ryegrass is traditionally planted on 25,000 to 30,000 acres annually to provide steer-fattening pasture. The replacement of ryegrass with berseem in these pastures could result in important savings by eliminating the need for nitrogen fertilizer while increasing the meat production potential from the higher quality of the berseem forage.

In California, field-scale plantings of Bigbee berseem last year were reported by dairy operators in San Joaquin and Riverside counties. A 45-acre planting was used for bagged silage, and a 37-acre planting was handled as green chop. Both trials were considered successful by the producers, and they expressed plans to expand the use of berseem clover in their operations.

Our consistently good results with Multicut berseem encouraged us to apply for release of this variety through the California Foundation Seed program at UC Davis. Breeders' seed has been increased, and foundation seed will be available for fall planting in 1987.

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