SUBTERRANEAN CLOVERS

Trifolium subterraneum,
T. yanninicum,
T. brachycalcycinum

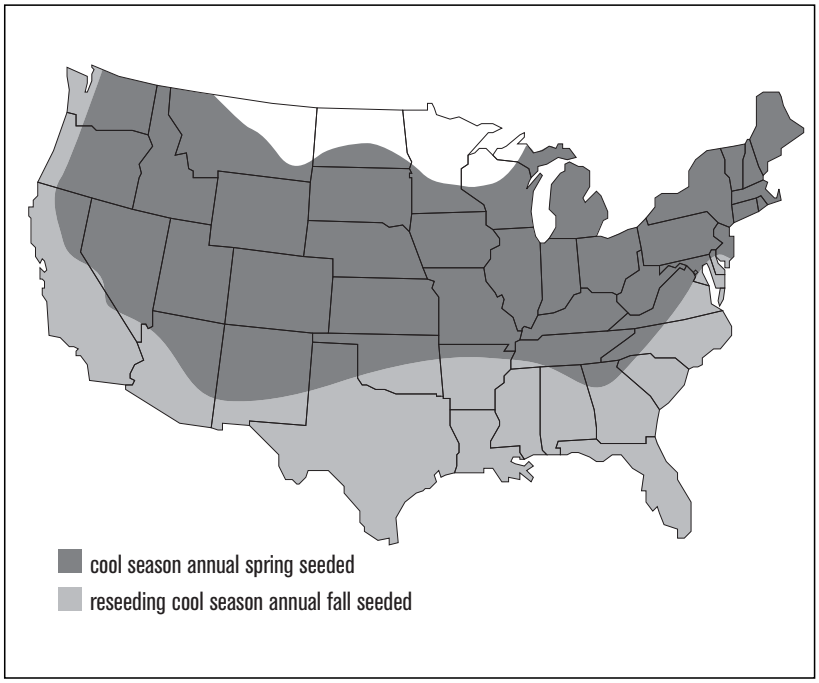
Also called: Subclover

Type: reseeding cool season annual legume

Roles: weed and erosion suppressor, N source, living or dying mulch, continuous orchard floor cover, forage

Mix with: other clovers and subclovers

See charts, p. 66 to 72, for ranking and management summary.



Subterranean clovers offer a range of low-growing, self-reseeding legumes with high N contribution, excellent weed suppression and strong persistence in orchards and pastures. Fall-planted subclovers thrive in Mediterranean conditions of mild, moist winters and dry summers on soils of low to moderate fertility, and from moderately acidic to slightly alkaline pH.

Subclover mixtures are used on thousands of acres of California almond orchards. It holds promise in the coastal mid-Atlantic and Southeast (Hardiness Zone 7 and warmer) as a killed or living mulch for summer or fall crops.

Most cultivars require at least 12 inches of growing-season rainfall per year. A summer dry period limits vegetative growth, but increases hard seed tendency that leads to self-reseeding for fall reestablishment (131).

Subclovers generally grow close to the ground, piling up their biomass in a compact layer. A Mississippi test showed that subclover stolons were about 6, 10 and 17 inches long when the canopy was 5, 7 and 9 inches tall, respectively (105).

Diversity of Types, Cultivars

Select among the many subclover cultivars that fit your climate and your cover crop goals. Identify your need for biomass (for mulch or green manure), time of natural dying to fit your spring-planting schedule and prominence of seed set for a persistent stand.

Subclovers comprise three *Trifolium* species:

- *T. subterraneum*. The most common cultivars that thrive in acid to neutral soils (pH=5.5-7.5) and a Mediterranean climate
- *T. yanninicum*. Cultivars best adapted to water-logged soils
- *T. brachycalcycinum*. Cultivars adapted to alkaline soils and milder winters

Primary differences between these species are their moisture requirements, seed production and days to maturity (21). Other variables include:

- Overall dry matter yield
- Dry matter yield at low moisture or low fertility
- Season of best growth (fall, winter or spring)
- Hard-seeding tendency
- Grazing tolerance

Subclover cultivars often are described by their days to maturity. Seed production is dependent on maturity and weather. The wetter it is during seed set, the lower the percentage of hard seed – important for reseeding systems (131).

• Short season subclovers tend to set seed quickly. They need only 8 to 10 inches of growing-season rainfall and set seed about 85 days after planting. Early subclovers tend to be less winter hardy (103).

• Intermediate types thrive with 14 to 20 inches of rain and set mature seed in about 100 days.

• Long-season cultivars perform best with 18 to 26 inches of rainfall, setting seed in about 130 days.

BENEFITS

Weed suppressor. Subclover can produce 3,000 to 8,500 lb. dry matter/A in a thick mat of stems, petioles (structures connecting leaves to stems) and leaves. Denser and less viny than hairy vetch, it also persists longer as a weed-controlling mulch.

Subclover mixtures help West Coast orchardists achieve season-long weed management. In Coastal California, fast-growing TRIKKALA, a midseason cultivar with a moderate moisture requirement, jumps out first to suppress weeds and produces about twice as much winter growth during January and February as the other subclovers. It dies back naturally as KOALA, (tall) and KARRIDALE (short) come on strong in March and April. The three cultivars complement each other spatially and temporally for high solar efficiency, similar to the interplanting of peas, purple vetch, bell beans and oats in California vegetable fields where a high-residue, high-N cover is desired.

In legume test plots along the Maryland shore, subclover mulch controlled weeds better than conventional herbicide treatments. The only weed to penetrate the subclover was a fall infestation of yellow nutsedge. The cover crop regrew in fall from hard seed in the second and third years of the experiment (31).

Subclovers thrive in Mediterranean climates of mild, moist winters and dry summers.

Green manure. In east Texas trials, subclover delivered 100 to 200 lb. N/A after spring plowdown. Grain sorghum planted into incorporated subclover or berseem clover with no additional N yielded about the same as sorghum planted into disked and fertilized soil without a cover crop in three out of four years. The fertilized fields had received 54 lb. N/A (243).

Versatile mulch. Subclover provides two opportunities for use as a mulch in vegetable systems. In spring, you can no-till early planted crops after subclover has been mechanically or chemically killed, or plant later, after subclover has set seed and dried down naturally (31). In fall, you can manage new growth from self reseeding to provide a green living mulch for cold-weather crops such as broccoli and cauliflower.

Conventionally tilled corn without a cover crop in a New Jersey test leached up to 150 lb. N/A

Elayne Sears

SUBTERRANEAN CLOVER (Trifolium subterraneum)

over winter while living subclover prevented N loss (128). Mowing was effective in controlling a living mulch of subclover in a two-year California trial with late-spring, direct-seeded sweet corn and lettuce. This held true where subclover stands were dense and weed pressure was low. Planting into the subclover mulch was difficult, but was done without no-till equipment (239).

Soil loosener. In an Australian study in compaction-prone sandy loam soil, lettuce yield doubled following a crop of subclover. Without the clover, lettuce yields were reduced 60 percent on the compacted soil. Soil improvement was credited to macropores left by decomposing clover roots and earthworms feeding on dead mulch (395).

Great grazing. Subclovers are highly palatable and relished by all livestock (120). Seeded with perennial ryegrass, tall fescue or orchardgrass, subclovers add feed value as they improve productivity of the grasses by fixing nitrogen. In California, subclover is used in pasture mixtures on non-irrigated hills. Perennial ryegrass is preferred for pasture through early summer, especially for sheep (309).

Insect pest protection. In the Netherlands, subclover and white clover in cabbage suppressed pest insect egg laying and larval populations enough to improve cabbage quality and profit compared with monocropped control plots. Eliminating pesticide costs offset the reduced weight of the cabbages in the undersown plots. Primary pests were *Mamestra brassicae, Brevicoryne brassicae* and *Delia brassicae*. Undersowing leeks with subclover in the Netherlands greatly reduced thrips that cannot be controlled by labeled insecticides, and slightly reduced leek rust, a disease that is difficult to control. While leek quality improved, the quantity of leeks produced was reduced considerably (415).

When tarnished plant bug (*Lygus lineolaris*) is a potential pest, subclover may be the legume cover crop of choice, based on a Georgia comparison among subclovers, hybrid vetches and crimson clover. MT. BARKER had particularly low levels, and nine other subclover cultivars had lower levels than the crimson (56).

Home for beneficial insects. In tests of eight cover crops or mixtures intercropped with cantalope in Georgia, MT. BARKER subclover had the highest population of big-eyed bugs (*Geocorus punctipes*), a pest predator. Subclover had significantly higher numbers of egg masses of the predator than rye, crimson clover and a polyculture of six other cover crops, but not significantly higher than for VANTAGE vetch or weedy fallow. While the covers made a significant difference in the predator level, they did not make a significant difference in control of the target pest, fall armyworm (*Spodoptera frugiperda*) (56).

Erosion fighter. Subclover's soil-hugging, dense, matted canopy is excellent for holding soil.

Disease-free. No major diseases restrict subclover acreage in the U.S. (21).

MANAGEMENT

Establishment

Subclovers grow best when they are planted in late summer or early autumn and grow until early winter. They go dormant over winter and resume

growth in early spring. In late spring, plants flower and seeds mature in a bur at or below the soil surface (hence the name subterranean clover) as the plant dries up and dies. A dense mulch of dead clover leaves and long petioles covers the seeds, which germinate in late summer to establish the next winter's stand (127). Their persistence over many seasons justifies the investment in seed and careful establishment.

In California, sow in September or early October to get plants well established before cool weather (309). Planting continues through November in the most protected areas.

In marginally mild areas, establish with grasses for winter protection. Subclover stimulates the grasses by improving soil fertility. You can overseed pasture or range land without tillage, but you can improve germination by having livestock trample in the seed. Subclover often is aerially applied to burned or cleared land. Initial growth will be a little slower than that of crimson, but a little faster than white clover (120).

Broadcast at 20-30 lb./A in a firm, weed-free seedbed. Cover seed with a light, trailing harrow or with other light surface tillage to a depth of less than one-half inch. Add lime if soil is highly acid—below pH 5.5 (309). Soils low in pH may require supplemental molybdenum for proper growth, and phosphorus and sulfur may also be limiting nutrients. Only the *T. yanninicum* cultivars will tolerate standing water or seepage areas (21, 309).

Subclover often is planted with rose clover and crimson clover in California orchard mixes. Crimson and subclover usually dominate, but hard-seeded rose clover persists when dry weather knocks out the other two (447).

In the East, central Mississippi plantings are recommended Sept. 1 to Oct. 15, although earlier plantings produce the earliest foliage in spring (120). In coastal Maryland where Mt. Barker plants were tallest and most lush, winterkill (caused when the temperature dropped to 15° F or below) has been most severe. Planting in this area of Zone 7 should be delayed until the first two weeks of October. Plant at about 22 lb./A for cover crop use in the mid-Atlantic (31) and Southeast (103). This is about double the usual recommended rate for pastures in the warmer soils of the Southeast.

Small plants of ground-hugging subclover benefit more from heat radiating from the soil than larger plants, but are more vulnerable during times of freezing and thawing. Where frost heaving is expected, earlier planting and well-established plants usually survive better than smaller ones (103).

Killing

Subclover dies naturally in early summer after blooming and seed set. It is relatively difficult to kill without deep tillage *before* mid-bloom stage. After stems get long and seed sets, you can kill plants with a grain drill or a knife roller (95).

In northern Mississippi, subclover was the least controlled of four legumes in a mechanical kill test. The cover crops were rolled with coulters spaced 4 inches apart when the plants had at least 10 inches of prostrate growth. While hairy vetch and crimson clover were 80 to 100 percent controlled, berseem control was 53 percent and subclover was controlled only 26 to 61 percent (105).

Subclover mixes help keep weeds in check all season long in West Coast orchards.

Researchers in Ohio had no trouble killing post-bloom subclover with a custom-built undercutter. The specialized tool is made to slice 1 to 2 inches below the surface of raised beds. The undercutter consisted of two blades that are mounted on upright standards on either side of the bed and slant backward at 45 degrees toward the center of the bed. A mounted rolling harrow was attached to lay the cover crop flat on the surface after being cut (96). The tool severs stalks from roots while above-ground residue is undamaged, greatly slowing residue decomposition (95).

Subclover tolerance to herbicides varies with cultivar and growth stage. Generally, subclover is easier to kill after it has set some seed (104, 165).

Reseeding Management

The "over-summering" fate of reseeding subclover plantings is as critical to their success as is the over-wintering of winter-annual legumes. The thick mat of vegetation formed by dead residue can keep subclover seeds dormant if it is not disturbed by grazing, tillage, burning or seed harvest. Where cover crop subclover is to be grazed before another year's growth is turned under, intensive grazing management works best to reduce residue but to avoid excess seed bur consumption (309). Grazing or mowing in late spring or early summer helps control weeds that grow through the mulch (292).

You can improve volunteer regrowth of subclover in warm-season grass mixes by limiting N fertilization during summer, and by grazing the grass shorter until cold temperatures limit grass growth. This helps even though subclover seedlings may emerge earlier (21). Subclover flowers are inconspicuous and will go unnoticed without careful, eye-to-the-ground inspection (103).

After plants mature, livestock will eagerly eat seed heads (120). In dry years when you want to maintain the stand, limit grazing over summer to avoid over-consumption of seed heads and depletion of the seed bank. Close mowing or grazing can be done any time.

Management Challenges

Possible crop seedling suppression. The allelopathic compounds that help subclover suppress weeds also can hurt germination of some crops. To avoid problems with these crops, delay planting or remove subclover residue. No-till planters equipped with tine-wheel row cleaners can reduce the recommended 21-day waiting period that allows allelopathic compounds to drop to levels that won't harm crops (101). Kill subclover at least a year before planting peach trees to avoid a negative effect on seedling vigor. It's best to wait until August of the trees' second summer to plant subclover in row middles, an Arkansas study found (61).

The degree to which a cover crop mulch hinders vegetable seedlings is crop specific. Plant-toxic compounds from subclover mulch suppressed lettuce, broccoli and tomato seedlings for eight weeks, but not as severely or as long as did compounds from ryegrass (*Lolium rigidum* cv. WIMMERA) mulch. An alfalfa mulch showed no such allelopathic effect in an Australian study (395).

Guard against moisture competition from subclover at planting. Without irrigation to ensure crop seeds will have enough soil moisture to germinate in a dry year, be sure that the subclover is killed seven to 14 days prior to planting to allow rainfall to replenish soil moisture naturally (31).

Soil-borne crop seedling disease. In north Mississippi tests, residue and leachate from legume cover crops (including subclover) caused greater harm to grain sorghum seedlings, compared to nonlegumes. *Rhizoctonia solani*, a soil-borne fungus, infected more than half the sorghum seedlings for more than a month, but disappeared seven to 13 days after legume residues were removed (101).

N-leaching. The early and profuse nodulation of subclovers that helps grass pastures also has a downside—excess N in the form of nitrate can contaminate water supplies. Topgrowth of subclover, black medic and white clover leached 12 to 26 lb. N/A over winter, a rate far higher than red clover and berseem clover, which leached only 2 to 4 lb. N/A in a Swedish test (227).

Pest Management

Subclovers showed little resistance to root-knot nematodes in Florida tests on 134 subclover lines in three years of testing the most promising varieties (233).

Lygus species, important pests of field, row and orchard crops in California and parts of the Southeast, were notably scarce on subclover plants in a south Georgia comparison. Other legumes harboring more of the pests were, in descending order, CAHABA and VANTAGE vetch, hairy vetch, turnip and monoculture crimson clover (56).

Most cultivars imported to the U.S. are low in estrogen, which is present in sufficient levels in

some Australian cultivars to reduce fertility in ewes, but not in goats or cattle. Confirm estrogen status of a cultivar if you plan to graze sheep on it (309).

Crop Systems

Interseeded with wheat. NANGEELA subclover provided 59 lb. N/A when it was grown as an interseeded legume in soft red winter wheat in eastern Texas. That extra N helped boost the wheat yield 283 percent from the previous year's yield when four subclover cultivars were first established and actually decreased yield, compared with a control plot. NANGEELA, MT. BARKER, WOOLGENELLUP and NUNGARIN cultivars boosted wheat yield by 24, 18, 18, and 11 bu./A, respectively, in the second year of the study. Over all three years, the four cultivars added 59, 51, 38 and 24 lb. N/A, respectively (44).

Plant breeder Gerald Ray Smith of Texas A&M University worked with several subclovers in eastern Texas. While the subclovers grew well the first year, he concluded that those cultivars need a prolonged dry period at maturity to live up to their reseeding performance in Australia and California. Surface moisture at seed set reduces seed hardening and increases seed decay. Midsummer rains cause premature germination that robs the subclover seed bank, especially in pastures where grasses tend to create moist soil. Most summer-germinating plants die when dry weather returns.

In Mississippi, subclover hard seed development has been quite variable from year to year. In dry years, close to 100 percent hard seed is developed. Dormancy of the seed breaks down more rapidly on bare soil with wider temperature swings than it does on mulched soils (133, 134). To facilitate reseeding or to seed into pastures, the grasses must be mowed back or grazed quite short for the subclover to establish (103).

Mix for persistence. California almond growers need a firm, flat orchard floor from which to pick up almonds. Many growers use a mix of moisture-tolerant TRIKKALA, alkaline-tolerant KOALA, and KARRIDALE, which likes neutral to acid soils. These blended subclovers give an even cover across moist swails and alkaline pockets.

Rice N-source. In Louisiana trials, subclover regrew well in fall when allowed to set seed before spring flooding of rice fields. Compared with planting new seed, this method yields larger seedling populations, and growth usually begins earlier in the fall. The flood period seems to enhance dormancy of both subclover and crimson clover, and germination is robust when the fields are drained (103). Formerly, some Louisiana rice farmers seeded the crop into dry soil then let it develop for 30 days before flooding. Early varieties such as DALKIETH and NORTHAM may make seed prior to the recommended rice planting date. In recent decades, "water planting" has been used to control red rice, a weedy relative of domestic rice. Water seeding into cover crop residues has not been successful (36).

Fertility, weed control for corn. In the humid mid-Atlantic region, grain and silage corn no-tilled into NANGEELA subclover did well in a six-year New Jersey trial. With no additional N, the subclover plots eventually out-yielded comparison plots of rye mulch and bare-soil that were conventionally tilled or minimum-tilled with fertilizer at up to 250 lb. N/A. The subclover contributed up to 370 lb. N/A (128), an N supply requiring careful management after the subclover dies to prevent leaching.

Control of fall panicum was poor in the first year, but much better the next two years. Control of the field's other significant weed, ivyleaf morning glory, was excellent in all years. Even though no herbicide was used in the subclover plots, weed biomass was lowest there (128).

Central New Jersey had mild winters during these experiments. Early spring thaws triggered subclover regrowth followed by plunging temperatures that dropped below 15° F. This weakened the plants and thinned the stands. The surviving plants, which formed dense stands at times, were mowed or strip-killed using herbicides or tillage. Mowing often induced strong regrowth, so strips at least 12 inches wide proved to be the best to prevent moisture competition between the subclover and the cabbage and zucchini transplants.

Sustainable sweet corn. On Maryland's Eastern Shore (one USDA hardiness zone warmer than New Jersey), University of Maryland weed specialist Ed Beste reported good reseeding in four consecutive years and no problems with stand loss from premature spring regrowth. Overwintering MT. BARKER plants sent out stolons across the soil surface to quickly re-establish a good stand ahead of sweet corn plantings (31).

Beste believes the sandy loam soil with a sand underlayer at his site is better for subclover than the heavier clay soils at the USDA Beltsville station some 80 miles north, where hairy vetch usually out-performs subclover as a killed organic mulch in transplanted vegetable systems. Winterkill reduced the subclover stand on top of bedded rows one year of the comparison, yet surviving plants between the beds produced nearly as much biomass per square foot as did hairy vetch (2).

Beste has worked with subclover at his Salisbury, Md., site for several years, seeding vegetables in spring, early summer and mid-summer into the killed or naturally dead cover crop mulch. For three years, subclover at Beste's sweet corn system comparison site yielded about 5,400 lb. DM/A. Without added N, the subclover plots yielded as much sweet corn as conventional plots receiving 160 lb. N/A. Weed suppression also was better than in the conventional plots. He sprayed glyphosate on yellow nutsedge in fall to prevent tuber formation by the grassy weed, the only weed that penetrated the subclover mulch (31).

Beste sprays paraquat twice to control subclover ahead of no-till, direct seeded zucchini in the first week of June. His MT. BARKER will set seed and die back naturally at the end of June—still in time to seed pumpkins, fall cucumbers, snap beans or fall zucchini planted without herbicides (31). Such a no-chemical/dying mulch/perpetually reseeding legume system is the goal of cultivar and system trials in California.

Seed production in subclovers normally is triggered by increasing day length in spring after the plant experiences decreasing fall day length. This explains why spring-planted subclover in Montana tests produced profuse vegetative growth, especially when fall rains began, but failed to set any seed (383). Stress from drought and heat also can trigger seed set.

COMPARATIVE NOTES

White and arrowleaf clovers have proved to be better self-reseeding clovers than subclover in the humid South because their seed is held in the air, giving them a better chance to harden. Top reseeding contenders are balansa clover (see *Up-and-Coming Cover Crops*, p. 191) and southern spotted burr medic (see *Southern Spotted Burr Medic Offers Reseeding Persistence*, p. 154).

While mid-season subclovers generally produced more dry matter and N than medics for dryland cereal-legume rotations in Montana (381), they did not set seed when grown as summer annuals in the region. Summer growth continued as long as moisture held up in trials there. Vegetative growth increased until frost, as cool, moist fall weather mimicks the Mediterranean winter conditions where subclover thrives (383).

CLARE is a cultivar of the subclover subspecies *brachycalycinum*. Compared with the more common subspecies subterranean (SEATON PARK and DALIAK), CLARE has vigorous seedlings, robust growth when mowed monthly and is said to tolerate neutral to alkaline soils. However, it appears to be less persistent than other types (61).

Subclover, rye and crimson clover provided grass weed control that was 46 to 61 percent better than a no-cover/no-till system at two North Carolina locations. Subclover topped the other covers in suppressing weeds in plots where no herbicides were used. None of the cover crop treatments eliminated the need for pre-emergent herbicides for economic levels of weed control (454).

Subclover creates a tighter mat of topgrowth than vetch (31) or crimson clover (103).

Cultivars. See *Comparative Notes*, above, and *Diversity of Types, Cultivars* (p. 165).

Seed sources. See *Seed Suppliers* (p. 195).