SUBTERRANEAN CLOVER

Trifolium subterraneum L.

Plant Symbol = TRSU3

Common Names: Subclover, sub clover
Scientific Names: *Trifolium subterraneum* ssp. *brachycalycinum* Katzn. & Morley, *Trifolium brachycalycinum* (Katzn. & Morley) Katzn., *Trifolium subterraneum* var. *yanninicum* (Katzn. & Morley) Zohary

Photo by Steve Matson, 2008 on Feedipedia.org

Description
General: Legume family (Fabaceae). Subterranean clover is a cool-season annual legume. Seeds germinate in the fall after the first rains and growth is rapid through the winter months. It grows in densely matted clumps that are 6-15 inches tall and spread through rootless runners reaching up to 3 feet in length (Sattell et al., 1998). The leaves are alternate and sometimes clustered from lack of stem elongation (McGuire, 1998). The stipules are wide and tapered. The petioles of subterranean clover are longer than the leaf blades. The leaflets are obovate to obcordate and usually borne in threes. The flowers of subterranean clover are borne below the leaves and thus the inflorescences are generally inconspicuous (Sattell et al., 1998). A flower cluster may contain up to seven florets, but three or four is more common. The florets are white or white with pink veins (McGuire, 1985). Subterranean clover is self-fertilizing, so there is no need for insect pollination. After fertilization, the peduncle elongates and turns downward as a burr forms around the developing seed. The burr is eventually pushed under the soil surface to a depth dependent on soil conditions and cultivar. This process, known as geocarpy, is what makes this species unique among clovers and lends the common name. The seed is dull purplish-black to black, except for the white-seeded cultivars of *T. yanninicum* (McGuire, 1985). The seed is relatively large compared to other clovers at approximately 70,000 seeds/lb (Sattell et al., 1998). Subclover forms a taproot with many fibrous branching roots. The root system of subterranean clover is generally larger than other clovers, with around 40% of the nitrogen in the plant below ground (Sattell et al., 1998). Like other legumes, subterranean clover produces N-fixing nodules on its root system in the presence of specific *Rhizobium* bacteria.

Subterranean clover burr seedhead that will eventually bury itself underground. Photo by Keir Morse, ©2018.

Distribution: Subterranean clover is native to Europe, Northern Africa, and temperate Asian countries. It was introduced into Australia and cultivation there began around 1889. Introductions were made to the United States by the Department of Agriculture in about 1921 (McGuire, 1985). It is now widely used and naturalized on the west coast from British Columbia to southern California, as well as on the East Coast and in the Southeast (Clark, 2007).

Habitat: Subterranean clover thrives in USDA plant hardiness zone 7 or warmer, in Mediterranean climates characterized by hot, dry summers and cool, wet winters. It can be grown in a wide range of soil types and at a pH range of 5.5-7.5; optimum pH is 6.5. Subclover grows best in full sun, but is tolerant of up to 50% shade (Clark, 2007).

Adaptation
Temperature and rainfall are the two main considerations for choosing subclover varieties since, as a species, it is adaptable to most soil types. Boundaries for subclover production have been defined as arid, warm, and cold (McGuire, 1985). Arid winter boundaries occur when the winter rainfall is so low or erratic that the lifecycle from germination to seed set cannot be completed. The arid boundaries in the US occur in southern and inland areas of California and possibly in southwestern areas of Texas, necessitating earlier maturing cultivars.

The warm temperature boundary is determined by the low temperature requirement for vernalization. The cold boundary is defined as the effect of prolonged low temperatures and frost on flowering and on delayed seed setting. It primarily applies to higher elevations in summer dry areas. Most cultivars require at least 12 inches of growing season rainfall per year. Dry summers limit vegetative growth, but increase subclover's hard seed tendency that leads to self-reseeding for fall reestablishment (McGuire, 1985).

Uses

Weed suppression: Given its size and spread, subclover offers very strong weed control. Its active late summer to mid-spring life cycle makes it very good at preventing spring weeds from establishing. Subclover has been seen to control weeds better than conventional herbicide treatments in legume test plots along the Maryland shore (Clark, 2007). In the same trial, the only weed seen to penetrate the subclover in the fall was an infestation of yellow nutsedge (*Cyperus esculentus* L.).

Green manure: Subclover is capable of producing 100 to 200 lb N/ac at spring plow down (Clark, 2007). Sorghum planted into incorporated subclover without added N yielded close to the same as sorghum planted into disked ground fertilized with 54 lb N/ac three of the four years of a trial in east Texas.

Mulch: There are two main ways that subclover is used as a mulch in vegetable cropping systems (Clark, 2007). In spring, crop planting can be done after subclover has been chemically or mechanically killed or after it has dried down and set seed in late spring. In fall, it can be managed to provide a living mulch for cold weather crops such as members of the Brassica family. Close mowing provides this management.

Grazing: Subclover is very palatable to livestock and can improve the growth of other pasture species by fixing nitrogen. It actually grows and re-seeds best with moderate to heavy grazing or close mowing. If using subterranean clover for grazing, be sure to select more recently developed cultivars. Older cultivars of subclover may contain the estrogenic isoflavone, formononetin, which has a detrimental effect on the birthing rates of ewes (Nichols, 2017). No such detrimental effects have been seen in goats or cattle. Newer varieties have been selected to eliminate the estrogenic isoflavones so they have no birth rate effects on sheep.

Erosion control: Subclover is an excellent erosion fighter due to its large, dense mat of above ground stems, petioles and leaves and its large fibrous root system. Its full potential for erosion control is usually achieved in the second season after planting when populations are fully established (Clark, 2007).

Status

This plant may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed. Please consult with your local NRCS Field Office, Cooperative Extension Service office, state natural resource, or state agriculture department regarding its status and use. Please consult the PLANTS Web site (http://plants.usda.gov/) and your state's Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Planting Guidelines

Subterranean clover should be planted in the fall before the first rain. If rain is not forecasted, irrigation is recommended to speed up germination and increase fall growth. For best stand establishment, seed should be broadcast or drilled in narrow rows into a smooth, firm seedbed at a depth of no more than ½ inch. Broadcast seed should be covered using a harrow or other surface-scratching implement. The bed should then be rolled if the soil is dry. Getting strong stand establishment in the first season helps to ensure reseeding in subsequent years. Seeding rates vary widely among cultivars. Under the ideal conditions above, good stand establishment is achievable with low seeding rates which are typically between 10 and 20 lb/ac (Steiner and Grabe, 1982). Seeding into steep, unbroken areas by aerial seeding, pasture over-seeding, or seeding into rough ground requires higher seeding rates between 20 and 30 lb/ac. These higher rates are recommended for helicopter over-seeding of pastures in southwestern Oregon according to the Oregon State University regional livestock and forage extension agent (S. Filley, personal communication, 2018).

Lime should be added if the soil pH is below 5.5. Soils with a low pH may also require supplemental molybdenum for proper growth. Sulphur and phosphorous may be other limiting nutrients. Sulphur should be applied at 20–30 lb/ac annually (Shannon and Noble, 1995). Tables 1 and 2 provide guidance on phosphorous and potassium soil amendment rates according to a range of soil test values.

***Table 1**. Recommended pre-planting phosphorus application rates for subterranean clover corresponding to a range of P soil test values, from Steiner and Grabe (1982).*

Soil phosphorus value	Apply this amount of P_2O_5
ppm	lb/acre
0 to 10	60 to 90
10 to 20	40 to 60
20 to 30	30 to 40
over 30	0

***Table 2.** Recommended pre-planting potassium application rates for subterranean clover corresponding to a range of K soil test values, from Steiner and Grabe (1982).*

Soil potassium value	Apply this amount of K_2O
ppm	lb/acre
0 to 75	60 to 100
75 to 150	40 to 60
over 150	none

Management

Flowering is induced by low temperatures. Late-maturing cultivars are prevented from blooming by lack of cold; early-maturing cultivars may be required in warmer areas (McGuire, 1985). Along with temperature, rainfall has the potential to restrict production and must be considered when choosing cultivars. Depending on the cultivar it could require anywhere from 10 to 35 inches of annual rainfall or irrigation (UC SAREP, 1999). Blooming and seed set of subterranean clover takes place in the early spring after which the plant naturally dies out with summer heat and dry conditions. In order for the self-seeded crop to be successful, aboveground plant material must be removed prior to fall rains. This can be achieved through grazing, burning, close mowing, or chemical application. This allows the buried seed to germinate and establish the following year's crop.

Termination: Subclover naturally dies back in early summer after blooming and seed set. It is relatively difficult to kill without deep tillage before mid-bloom stage. After stems elongate and seed sets, you can kill plants with a grain-drill or a knife roller. Subterranean clover herbicide tolerance varies widely with cultivar and growth stage, but it is generally easier to kill after it has set some seed (Clark, 2007).

Pests and Potential Problems

According to Nichols et al. (2014), subterranean clover has relatively few disease and insect problems, but there are a few potential pests and diseases that may cause damage given the right environment.

Foliar fungal pathogens: Clover scorch (*Kabatiella caulivora*) is the most important fungal pathogen for subclover. Extensive breeding efforts have developed subclover varieties that are resistant to clover scorch. Other foliar fungal pathogens that can cause injury to subclover in favorable environmental conditions are rust (*Uromyces trifolii-repentis*), cercospora (*Cercospora zebrine*), powdery mildew (*Oidium* sp.), and common leaf spot (*Pseudopeziza trifolii*).

Soil-borne fungal diseases: There are five significant soil-borne fungal diseases that affect subclover and are usually lumped together as 'root rot' fungi (*Phytophthora clandestina, Pythium irregular, Aphanomyces trifolii, Rhizoctonia solani,* and *Fusarium avenaceum*).

Viral diseases: The three most important viruses that affect subterranean clover are subterranean clover stunt virus, bean yellow mosaic virus, and subterranean clover red leaf virus (Johnstone and McLean, 1987).

Insect and invertebrate pests: Many aphids are pests on subterranean clover, but blue-green aphid (*Acyrthosiphon kondoi*) and cowpea aphid (*Aphis craccivora*) are reported to cause the most significant direct damage. Many other aphids cause damage by vectoring the previously mentioned viruses. Redlegged earth mite (*Halotydeus destructor*) and blue oat mite (*Penthaleus major*) are also important pests to subclover. Subterranean clover is also susceptible to root-knot nematodes.

Environmental Concerns

Subterranean clover is known to naturalize in some climates and may become a weed in natural areas, outcompeting native vegetation. Also, according to Sattell et al. (1998), subclover can become a serious weed in annual vegetable crops.

Control

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method.

Seeds and Plant Production

According to Steiner and Grabe (1982), subclover seed from all cultivars is ready to harvest when active growth ceases and aboveground plant material has dried. The most efficient way to harvest seed is to clear the field of dried stems and leaves with conventional hay-making equipment first. Once the field is cleared, it is then allowed to dry further and prepared for vacuum by smoothing the surface of the soil as much as possible. The vacuum must make good contact with the surface, so it is important that there are no mounds, ridges, or plant debris. This can be achieved simply by dragging a section of cyclone fence or a spike-toothed harrow that has been flipped upside down. This process also breaks the stems and burs away from the crown of the plant, allowing them to be sucked up.

Another method of harvesting is to use a windrower with conventional guards on the mower bar. The mower bar can be tilted 12 to 15º below horizontal to cut close to the ground. The windrow is then picked up with a combine as with other seed crops. This method is faster and uses more widely available equipment, but picks up less seed than the vacuuming method.

Most harvest methods leave more than 20% of the seed crop in the field. Not all seed will germinate right away, as most of it is dormant, but this is usually enough seed to reestablish the crop for the following year. The remaining seed may be unevenly distributed throughout the field, so it is a good practice to harrow or lightly disc the field sometime before germination in the fall.

Cultivars, Improved, and Selected Materials (and area of origin)

There are three recognized varieties/subspecies of *Trifolium subterraneum*: *T. subterraneum*, *T. subterraneum* L. ssp. *brachycalycinum*, and *T. subterraneum* L. var. *yanninicum* (USDA-NRCS, 2018). The primary differences between these are their moisture requirements and tolerances, seed production, and days to maturity, but there are other variables to consider when choosing the most suitable cultivar. Some of those include dry matter yield under different environmental conditions, season of strongest growth (fall, winter, or spring), hard-seeded tendency, and grazing tolerance. Cultivars derived from *T. subterraneum* thrive in neutral to acidic soils and a Mediterranean climate (Nichols, 2007b). Cultivars of *T. subterraneum* ssp. *brachycalycinum* are best adapted to alkaline, cracking or stony soils and milder winters (Nichols, 2007a). Cultivars derived from T. *subterraneum* var. *yanninicum* are best adapted to water-logged soils (Nichols, 2007c). Mixtures of cultivars are often planted when a self-seeding cover crop is desired. Only the best adapted cultivars for that particular climate will thrive and reseed.

Most current breeding efforts on subterranean clover are being carried out in Australia. According to Nichols et al. (2013) there are six main areas of focus in the breeding and selection efforts of subclover: (*i*) adaptation to deep, acid sands and to soils that are hard-setting or subject to salinity; (*ii*) susceptibility to seed losses from false breaks to the season; (*iii*) insufficient hardseededness to maintain a dense seed bank through cropping phases, particularly from increased cropping frequencies, and in areas with unreliable spring rainfall; (*iv*) susceptibility to a suite of root-rotting pathogens and to redlegged earth mite; (*v*) shallow rootedness, leading to premature senescence after drought periods in spring and increased groundwater recharge, with a resultant increase in the potential for dryland salinity; and (*vi*) soil erosion caused by the need to vacuum-harvest seeds. The Western Australia Department of Primary Industries and Regional Development has an excellent website where the most recent cultivar development information can be found (Nichols, 2017). The hope is that some of the best performing cultivars will eventually make their way to the US market. In the US, breeders at the USDA-Agricultural Research Service are working to develop lines of subclover that have superior growth and vigor in East Coast climates (Devine, 2001).

Cultivars should be selected based on the local climate, resistance to local pests, and their intended use. Consult with your local land grant university, local extension or local USDA NRCS office for recommendations on adapted cultivars for use in your area**.**

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