Control of bluegrass in lawns and large turf areas continues to be a daunting weed problem for turf managers, but ongoing research on control through breeding offers hope for the future.

Covering a wide range of weeds, UC Davis weed specialists are creating a quick-access computerized database to provide advice and options for agricultural and landscape managers in the use of available chemical and nonchemical weed control products and methods.

Landscapers should be aware of recent research which indicates that planting highway ice plant may be a mistake where soil quality and the success of other plantings are concerned.

***Carpobrotus edulis* L. (Bolus), a member of the Aizoaceae, introduced into the western United States from South Africa in the early 1900s.**

Potential Adverse Effects of the Ice Plant, *Carpobrotus Edulis* L., on the Soil Environment

Carla M. D'Antonio and Bruce E. Mahall

The ice plant, *Carpobrotus edulis*, also known as Hottentot fig or highway ice plant, is used extensively as an ornamental throughout coastal California. Problems can result when it spreads away from planted areas and invades many native plant communities. In cultivation and in nature, it overgrows other species and tends to form dense monospecific stands. In addition to its detrimental effect on the growth of other species, ice plant may eventually kill itself. Large stands often contain extensive patches of dead ice plant material, and the California Department of Transportation has described these stands as "difficult to maintain."

In a large-scale ecological study of ice plant invasion into coastal plant communities in central California, we found that the root systems of ice plant overlapped greatly with those of native species and that they were very effective at getting water that would otherwise have been available to the natives. We also measured a substantial decline in soil pH underneath ice plant mats. Because pH has an important effect on the solubility of nutritive ions in the soil solution, we hypothesized that *C. edulis* could also be having a negative effect on soil fertility.

Our study examined the potential effect of *C. edulis* on soil pH, cations, cation exchange capacity, nitrogen and total phosphorus. Our intentions were to: document the effect of ice plant on these soil fertility factors at a variety of sites; look for site characteristics which might correlate with the magnitude of the ice plant effect; and look at recovery of soil chemistry after the removal of ice plant.

Sampling Ice Plant from Differing Sites

To document the effect of ice plant on the soil environment, we took 4-centimeters-wide-by-20-centimeters deep soil cores under and away from ice plant at nine different sites. The sites were chosen to represent a range of different communities where ice plant has been planted or is naturally invading. Two were in grassland, two in partially stabilized dunes, two in coastal sage scrub, two

***Carpobrotus edulis* invading a coastal community dominated by the native composite *Coreopsis gigantea*.**

in chaparral and one near an estuary. All were on sandy or sandy loam soils in northern Santa Barbara County.

Six ice plant individuals were sampled at each site. Samples were taken from near the center of each *C. edulis* plant and from more than one meter beyond the branch edges in the vicinity of each plant. To control for plant age, all *Carpobrotus* plants sampled were between 4 and 7 meters in diameter. In the laboratory, all samples were analyzed for sand, silt and clay content, pH, calcium, magnesium, sodium, potassium, and cation exchange capacity. A subset of the samples were analyzed for nitrate, ammonium, total nitrogen, total phosphorus and mineralizable nitrogen.

To look at long-term effects of *Carpobrotus edulis* on the soil environment, ice plant removal was initiated at two of the sites. Soil pH, cations and nitrogen were then monitored over the next two years. Litter taken from the removal areas was added to soil that had never contained ice plant to test for the potential acidifying effects of ice plant litter in the absence of live ice plant.

Adverse Effects of C. Edulis

Carpobrotus edulis was found to have a depressant effect on soil pH at seven of the nine sites studied. In most sites, the average pH of soils away from ice plant was 6.0, but underneath ice plant pH values averaged 4.0.

The two sites where no acidification was evident were very different from each other and from the rest of the sites. One was the site near the estuary, where the average soil pH was near 8.0 and the soils were extremely high in exchangeable calcium. The percent saturation of soil exchange sites by cations was quite high (greater than 90 percent) as a result of calcium availability, suggesting that the soil at this site was well-buffered from the effects of *C. edulis*. The other unacidified sampling area, one of the dune sites, contained the least vegetation and the highest percentage of sand of all sites. There calcium levels were very low, as were the number of soil exchange sites, suggesting that the soil itself was not well-buffered. *C. edulis* does not grow well at this site, and the lack of acidification may be the result of slow rates of acid input as a result of the slow growth and decomposition of adult plants.

Calcium was significantly lower underneath *C. edulis* compared to areas away from it at the sites where acidification was evident. Magnesium was also lower at four of those sites, but the effects were not as dramatic as for calcium. There were no consistent effects on sodium or potassium, although there was a tendency for sodium to be higher under C. *edulis* compared to away from it. Total nitrogen and total phosphorus also appeared to be unaffected by the presence of the ice plant, but available nitrogen, particularly nitrate, was lower in its presence. Ammonium concentrations were similar under and away from C. *edulis*, but nitrate levels were reduced to near zero under it. This was particularly true in the acidified sites, and incubation studies suggested that no nitrification was occurring underneath ice plant. This is not surprising since it is widely known that the bacteria responsible for the conversion of ammonium to nitrate are pH sensitive.

The effects of C. *edulis* on soil pH, calcium and nitrate could be induced solely by the addition of C. *edulis* litter to "normal" soil. Within 16 months after litter additions, soil pH values dropped from 5.9 to 5.2, calcium levels dropped by 28 percent and nitrate levels declined by 50 percent. In contrast, sodium levels tripled, suggesting that sodium is stored in ice plant tissue and is released during decomposition. Removal of ice plant did not lead to measurable changes in soil fertility. More than two years after removal, pH values were unchanged (4.0), and the concentration of all other cations remained low.

Recommendations for Landscapers

Our results suggest that the planting of this species of ice plant into landscapes should be done with great caution. C. *edulis* appears to have the potential to cause major changes in soil chemistry particularly in pH. High pH soils may not be as affected because of their generally higher base saturation, as was seen in our estuarine site. Like the sites that we studied, however, many soils in coastal California are acidic. They have the potential to be altered by ice plant, and successful maintenance of ice plant stands may require the addition of calcium, magnesium and nitrate. Regular monitoring of soil pH may provide useful information for landscapers who continue to use this species.

Our litter addition experiments suggest that if ice plant dies or is no longer desired, all plant material should be removed from the site. The litter appears to contain salts which are readily leached into the soil and may be detrimental to the growth of other more desirable species.

In addition, decomposition of ice plant litter can cause a reduction in pH and calcium. Once C. *edulis* is removed from a site, the soil in the area should be supplemented with minerals to bring up the pH. Nitrate levels should also be monitored to determine whether or not this nutrient is now being manufactured by soil microbes or is still lacking. We do not recommend adding ammonium fertilizer to sites containing or which had contained ice plant. Ammonium levels were not depleted beneath ice plant and may in fact build up because of the lack of conversion of ammonium into nitrate.

In gardens and landscape settings it may be possible to regulate the potentially damaging effects of C. *edulis* on the soil environment by carefully monitoring soil chemistry and selectively adding depleted elements. However, we do not recommend using this species in revegetation projects that are within or near natural settings. C. *edulis* seeds are easily disseminated by rabbits and deer, and once established in natural communities, ice plant is difficult to control. Our results suggest that it will deplete soil nutrients and that these effects may be long lasting and may influence the survival of native species.

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