

# California Turfgrass Culture

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## Irrigation Water Quality and Turfgrass Management

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Irrigation water quality plays a major role in the successful management of turfgrasses. Of prime importance are the effects of irrigation water on turf-soil-water relations and on the soil's chemical and physical properties, particularly as these factors relate to turfgrass quality. Therefore, assuming proper irrigation practices, the concept of irrigation water quality for turfgrass is generally based on interpretations of the chemical analysis of a given water.

All irrigation waters contain appreciable quantities of soluble salts and traces of other materials. These may include sodium, potassium, calcium, magnesium, chloride, bicarbonate, sulfate, nitrate, borate, fluoride, iron, silica, aluminum, and other elements. Because these elements may accumulate in the soil in quantities which are injurious to turfgrasses, potential problems from the use of irrigation water can sometimes be anticipated by a laboratory chemical analysis. The most important of the items determined in the analysis for judging water quality are: 1) total salt content; 2) sodium hazard (permeability); 3) toxic ion levels; 4) bicarbonate; and 5) pH.

### 1. Total Salt Content

There is a high correlation between the salt concentration in the soil solution and turfgrass growth.

Salinity problems, most pronounced on heavy soils, occur when the salts dissolved in irrigation water accumulate in the grass root zone to levels intolerable to the species being grown. A high salt level in the soil may affect turfgrasses by increasing osmotic pressure of the soil solution, thus making water less available to the plants. Where salinity is very high, grass roots wilt and plants may eventually die. Nutritional imbalances and mineral toxicities may also occur at high salinity levels.

Salinity of water is measured as electrical conductivity (EC<sub>w</sub>). In the literature and in laboratory reports water salinity may be shown as decisiemens per meter (ds/m), millimhos per centimeter (mmhos/cm), parts per million total dissolved solids (TDSppm), and total dissolved solids milligrams per liter (TDS mg/l). The current preferred term is ds/m. The conversions from one to another are:

$$ds/m = mmhos/cm = \mu mhos/cm \times 1000$$

$$ds/m \times 640 = TDSppm = TDSmg/l$$

As a general rule, salinity problems are associated with irrigation waters with EC<sub>w</sub>'s greater than 0.75 ds/m. Although salinity problems may occur when waters with salinity levels of 0.75-3.0 ds/m are used, severe problems are caused by waters with EC<sub>w</sub>'s greater than 3.0 ds/m. Therefore, water with salinity that exceeds 3.0 ds/m is generally not recommended for irrigation.

The extent of salt uptake and its consequent effects on turf growth are directly related to the salt concentration of the soil solution. Growth of most turfgrasses is not significantly affected by soil salt levels below 2 ds/m, while at salt levels of 2 to 8 ds/m the growth of some turfgrasses is restricted. At 8 to 16 ds/m, the growth of most turfgrasses is restricted, and above 16 only very salt-tolerant turfgrasses can survive. Obviously, this categorization provides only the most general guidelines to the effect of salinity on turfgrass growth. Pronounced differences among turfgrass species and cultivars in their tolerance of both individual salts and total salinity necessitate evaluation of each species with regard to specific water and soil salinity characteristics. The information given in the accompanying table is a general guide to individual turfgrass salt tolerances.

Approximate Salinity Tolerance of Turfgrasses  
Electrical Conductivity (ds/m = mmhos/cm)\*

Turfgrass	<4	4-8	8-16	>16
Cool Season	Kentucky bluegrass ( <i>Poa pratensis</i> L.)	Tall fescue ( <i>Festuca arundinacea</i> Shreb.)	Creeping bentgrass ( <i>Agrostis palustris</i> Huds.)	Alkaligrass ( <i>Puccinellia</i> spp.)
	Colonial bentgrass ( <i>Agrostis tenuis</i> Sibth)	Perennial ryegrass ( <i>Lolium perenne</i> L.)	Western wheatgrass ( <i>Agropyron smithii</i> Rydb.)	
	Creeping red fescue ( <i>Festuca rubra</i> L.)	Smooth brome ( <i>Bromus inermis</i> Leyss.)		
	Meadow fescue ( <i>Festuca elatior</i> L.)	Orchardgrass ( <i>Dactylis glomerata</i> L.)		
	Annual bluegrass ( <i>Poa annua</i> L.)	Chewings fescue 'Dawson' ( <i>Festuca rubra</i> var. <i>Commutata</i> Gaud.)		
	Rough bluegrass ( <i>Poa trivialis</i> L.)			
Warm season	Centipedegrass ( <i>Eremochloa ophiuroides</i> (Munro.) Hack.)	Blue grama ( <i>Bouteloua gracilis</i> (H.B.K.) Leg. ex Steud.)	Bermudagrass ( <i>Cynodon</i> spp.)	Seashore paspalum ( <i>Paspalum vaginatum</i> Swartz.)
			Zoysiagrass ( <i>Zoysia</i> spp.)	
			St. Augustinegrass ( <i>Stenotaphrum secundatum</i> (Walt.) Kuntze)	

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\*Electrical conductivity of saturated soil extract (EC<sub>e</sub>).

Where salinity is a potential problem due to a poor quality water, the following management practices should be considered:

- \* Blending poor quality water with a less salty water. Frequently, a poor quality water can be used for irrigation if better quality water is also available. The two waters can be pumped into a reservoir to mix and then be used for irrigation. Although the end result salinity may vary according to the type of salts and climatic conditions, the quality of poor water should improve proportional to the mixing ratio (e.g., when equal volumes of 2 waters, one with an EC of 5 dS/m and the other with an EC of 1 dS/m, are mixed, the salinity of the blend should approximately equal 3 dS/m). The exact salinity content of the blended water, however, is determined by chemical analysis of the water.

- \* Planting salt-tolerant grasses.

- \* Applying extra water to leach excess salts. To calculate the amount of extra water needed to leach the salt below the turfgrass root zone (and thus provide a suitable level for a specific turfgrass) the following formula is often used:

$$\% \text{ LF (Leaching Fraction)} = \frac{\text{EC}_{\text{iw}}}{\text{EC}_{\text{dw}}} \times 100$$

$\text{EC}_{\text{iw}}$  is the electrical conductivity of the irrigation water being applied (presumably a highly saline water) and  $\text{EC}_{\text{dw}}$  is the electrical conductivity of percolated drainage water (which should equal the salinity level tolerated by the specific turfgrass grown). For example, if a turfgrass, which can tolerate a salinity level of 4 dS/m ( $\text{EC}_{\text{dw}}$ ) is irrigated with a water having a salinity of 2 dS/m ( $\text{EC}_{\text{iw}}$ ), the leaching requirement would equal:  $2/4=50$  percent. In order for the salt contained in the irrigation water not to accumulate to hazardous levels for the specific turf species, at each irrigation 50 percent extra water should be applied in addition to the normal watering requirements of that turf. This extra water will continuously leach the salt which could potentially accumulate in the soil. *Obviously, any changes in the system, such as leaching caused by rainfall, can greatly affect the amount of water needed to satisfy the leaching requirements.*

- \* Irrigating more frequently to maintain a higher soil moisture content.

- \* If a hard or clay pan is present, modifying soil profile to improve water percolation and, thus, leaching.

- \* If shallow water tables are a problem, or soil does not drain well for any reason, install artificial drainage. Leaching does not occur if there is no drainage, natural or artificial.

## 2. Sodium Hazard (Permeability)

Sodium concentration is also a very important criterion of irrigation water quality. Although high levels of sodium may accumulate in grasses and become toxic, it is sodium's indirect effect on turfgrass growth via its deteriorating effect on soil structure which is of concern to the turf manager.

High irrigation water sodium content causes deflocculation of the soil colloids which in turn severely reduces both soil aeration and water infiltration into and through the soil. In other words, soil permeability is reduced when waters containing high levels of sodium are used for irrigation. Relative permeability is often expressed as SAR (sodium adsorption ratio), the ratio of sodium ion concentration to that of calcium plus magnesium. The following formula calculates the approximate SAR of a water where values for sodium (Na), calcium (Ca), and magnesium (Mg) are given in meq/L (milliequivalent per liter):

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}}}$$

If the values for these elements (Ca, Mg and Na) in a soil analysis report are given in ppm (mg/l) then the following formula can be used to determine the meq/l values:

$\text{Meq/l} \times \text{Equivalent Weight} = \text{ppm (mg/l)}$   
(Equivalent weights for Na, Ca and Mg are 23, 20 and 12.2, respectively.)

Generally, a high water SAR (>9) can cause severe permeability problems when applied to fine-textured turf soils (clay soils) over a period of time. In coarse-textured soils (sandy soils) permeability problems are less severe, and this relatively high SAR can be tolerated. Golf greens constructed on pure sand, for example, can be maintained using high SAR irrigation waters.

Sodic soils contain excess sodium ions in contrast to calcium and magnesium ions. Sodium does not usually cause direct injury to turfgrasses, which, in comparison with other plants, are relatively tolerant of sodium. Generally, however, if the soil exchangeable sodium percentage (ESP) exceeds 15, a turf stand may be damaged by resulting soil impermeability to water and air. Typical symptoms of reduced permeability include waterlogging, slow infiltration, crusting, and/or compaction, poor aeration, weed invasion, and disease infestation. All of these effects are detrimental to turfgrass growth and development.

Treatment of water or a turf soil for correcting or preventing permeability problems due to the use of water with high sodium levels may include:

- \* Blending the water with a water low in sodium content.

- \* Applying soil amendments such as gypsum (calcium sulfate), sulfur, or sulfuric acid. These amendments increase the soil supply of calcium either directly as in the case of gypsum, or indirectly as in the case of the other two. Sulfur and sulfur-containing materials may be used on soils naturally high in calcium because they make this calcium more soluble and thus available to replace the sodium. Calcium prevents excess accumulation of sodium on clay or organic matter particles. Leaching is then practiced to flush out sodium salts accumulated in the root zone. The amount of amendment used depends on the SAR of the irrigation water, quantity of water used, soil texture, and type of amendment. The two major factors in successful sodic soil reclamation are: a) incorporation of amendments into the soil's top 1-2 feet, and b) the presence of internal drainage to facilitate the leaching of sodium ions from the root zone.

- \* Frequent aeration.

*Note.* Reduced soil permeability can also occur when the salt content of irrigation water is very low (below 0.5 dS/m). Water with minimal salt content reduces permeability by dissolving calcium and other soluble salts from the soil. Removal of salts then causes the fine soil particles to disperse and fill soil pore space, resulting in impermeability.

## 3. Toxic Ions

Irrigation water usually contains a wide variety of elements in small concentrations. Problems can occur if certain trace elements accumulate in the soil to levels toxic to turfgrasses and other plants. For example, although chloride is not particularly toxic to turfgrasses, most trees and shrubs are quite sensitive to a chloride content of 10 meq/l (355 ppm).

Boron, on the other hand, is a more likely cause of toxicity in turfgrasses. The major symptom of this toxicity is necrosis at leaf tips, where the highest boron concentration occurs. Since turfgrasses are mowed regularly and accumulated boron is thus continuously removed from the leaves, most regularly mowed turfgrass can tolerate high concentrations of boron in irrigation water. However, this high boron content of poor quality irrigation water poses a greater toxicity problem for non-turf plants, e.g., trees, shrubs, ground covers, etc. Most landscape plants show injury when irrigated with water containing more than 1.0 mg/l (ppm) of boron.

Practices that reduce the effective concentration of toxic elements include:

- \* Blending poor quality water with better quality water.
- \* Irrigating more frequently.
- \* Applying additional water for leaching. Boron is difficult to leach, and it takes three times the amount of water required to leach chloride.

#### 4. Bicarbonate( $\text{HCO}_3^-$ )

An irrigation water's bicarbonate content can also affect soil permeability and must be evaluated along with the sodium, calcium and magnesium content of both soil and water. The bicarbonate ion may combine with calcium and/or magnesium and precipitate as calcium and/or magnesium carbonate. As calcium and magnesium precipitate out of the soil solution, the SAR of that solution, and consequently the exchangeable sodium percentage (ESP) of the soil, increases. (When dealing with poor quality irrigation water, many analytical laboratories adjust the calculated SAR to include a more correct estimate of the calcium that can be expected to remain in the soil water after an irrigation. This adjusted SAR - expressed as Adj. SAR - reflects the water content of calcium, magnesium, sodium, and bicarbonate, as well as its total salinity.)

The water's bicarbonate hazard can also be evaluated in terms of residual sodium carbonate (RSC), where

$$\text{RSC} = (\text{HCO}_3^- + \text{CO}_3^{2-}) - (\text{Ca}^{2+} + \text{Mg}^{2+}).$$

Concentrations of carbonate ion ( $\text{CO}_3^{2-}$ ), bicarbonate ion ( $\text{HCO}_3^-$ ), calcium ion ( $\text{Ca}^{2+}$ ) and magnesium ( $\text{Mg}^{2+}$ ) are expressed in meq/l. Generally, a water with RSC values of 1.25 meq/l is safe for irrigation; those with RSC values of 1.25 to 2.5 are marginal; and those with RSC values of 2.5 are probably not suitable for irrigation.

In addition to affecting the soil permeability, a high bicarbonate content in water can increase soil pH to undesirable levels.

Practices that reduce the damaging effects of a water's bicarbonate content include those mentioned earlier to remedy problems caused by a high SAR. The impact of bicarbonate on pH may be reduced by applying acidifying materials to soil and/or water. Water with low bicarbonate concentrations may be managed by the use of acidifying fertilizer (e.g. ammonium sulfate) in the turf fertilization program. High levels of bicarbonate in the water may require more drastic measures (e.g., acidification of irrigation water with sulfuric or phosphoric acids) to correct the problem. Since acid injection into a poor quality irrigation water is a specialized practice and requires special measurements and equipment, a turf manager must work closely with a consulting laboratory to determine if acidification is required and, if so, how it may best be accomplished.

#### 5. pH (Hydrogen Activity)

The pH of irrigation water is seldom a direct problem by itself, but a pH outside the normal range is a good indicator of an abnormal water situation. Very high or very low pHs are warnings that the water needs further evaluation for other constituents. (The

use of pH in evaluating water quality is analogous to use of body temperature when diagnosing an ill individual: just as abnormal temperatures indicate an illness but do not specify its nature, abnormal pHs indicate a problem of some kind exists.) The desirable soil pH range for turfgrasses is 5.5 to 6.5. The desirable irrigation water pH, however, ranges from 6.5 to 8.4.

Irrigating with high bicarbonate water may gradually increase soil pH leading to moderately alkaline conditions (pH 7-8.5). A deficiency of trace elements is likely to occur in turfgrasses grown in soils with these or higher pHs. In the West, naturally high soil pH is one of the major factors causing iron deficiency chlorosis (lime-induced chlorosis).

Abnormal soil pHs may be corrected by application of amendments. Liming materials (oxides, hydroxides or carbonates of calcium and magnesium) are used to increase a soil's pH; i.e., to correct an acidity problem. To lower the pH of soils, acidifying amendments such as elemental sulfur or acidifying fertilizers such as ammonium sulfate are used. The kind and amount of amendments used to correct a specific pH problem are determined by factors such as: soil pH, soil texture, soil percent base saturation, fineness of the amendment material and turfgrass species. Working closely with a soil testing laboratory in correcting soil and water pH problems is highly recommended.

*Soil factors.* Water quality, soil quality, turfgrass species and irrigation management practices go hand in hand to establish and maintain a quality turf. Therefore, before establishment of turfgrasses, soil-related factors as well as water quality must be evaluated. These include soil texture, soil drainage, soil salt content, exchangeable sodium percentage (ESP), and soil fertility. *It is next to impossible to manage turfgrasses or many other plants when irrigating them with a highly saline or sodic water on soil with poor drainage.* A fine texture soil (clay) is much more adversely affected by poor quality water than a coarse texture (sandy) soil. In most cases the turfgrass problems associated with the use of poor quality irrigation water cannot be properly evaluated or treated without also considering associated soil factors.

*The use of effluent water.* Recently the concept of irrigating turfgrasses with reclaimed water has become increasingly attractive, especially in highly populated areas. This is primarily due to water shortages and/or costs of fresh water rise, and also due to the availability of better quality reclaimed waters.

Among the more important considerations when evaluating effluent waters for turfgrass irrigation are: health factors, seasonal and annual variations in quantity and quality, constancy of supply, soil-related factors, irrigation factors, water conservation, cost, plant factors, nutrient content and the chemical properties of the water. Chemical properties of effluent waters are of special interest, because quite often this factor alone can restrict the use of a given water on a specific site. For turf irrigation, the quality of effluent water can be evaluated based on the guidelines discussed earlier in this article.

In addition to the factors discussed, effluent waters can be high in turfgrass nutrients. This is a plus and usually quite beneficial in turfgrass management programs. Although quantities are low, because nutrients are applied on a frequent and regular basis, they are efficiently used by the plants. In most cases turfgrasses will obtain all the phosphorus and potassium they need, and a large part of their nitrogen need will be supplied. Sufficient micro-nutrients are also supplied by most reclaimed waters.

## CONCLUSION

Turfgrasses grow in a very complex turf-soil-water system and not in soil or irrigation water alone. Turfgrass problems associated

with the use of poor quality irrigation water require consideration of many factors including water chemistry, soil chemistry, soil physical properties, irrigation practices and the turfgrass species grown. Only by evaluating them can turfgrass be managed effectively.

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## Seashore Paspalum Scalping Study

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Seashore Paspalum, *Paspalum vaginatum* Swartz, a warm season turfgrass, was introduced into California for turf use in the mid 1970s. Early University of California research evaluated the performance characteristics of two varieties, Adalayd (later sold as Excalibre) and Futurf (2,3). Excalibre is commercially available.

Seashore Paspalum has many desirable turfgrass characteristics. As a warm season turfgrass it is well adapted to the Subtropical and Transitional Turfgrass Climate Zones of California. It is a deeply rooted, very salt-tolerant grass with a low water use rate similar to other commonly used warm season species. Seashore Paspalum has a moderate fertility requirement and can tolerate varying mowing heights. It establishes fairly rapidly from stolons and appears to have moderate wear tolerance during the growing season.

Seashore Paspalum has the disadvantage of an extended winter dormancy, which is similar in duration to common bermudagrass (*Cynodon dactylon* (L.) Pers.). Also, the species is subject to scalping, usually in late summer or early autumn. The scalping is a particular problem when it occurs because the affected areas do not regrow until the following spring when basal nodes produce new tillers. Therefore, scalped areas can be unsightly for a considerable time. Scalping has been associated with spring and summer nitrogen fertilization (3,4) and irrigation amount (1).

The objective of this trial was to evaluate the effects of vertical mowing and nitrogen fertilization on the autumn recovery of a previously scalped stand of Seashore Paspalum.

## METHODS

Seashore Paspalum "Excalibre," was established in 1984 at the University of California Riverside Turfgrass Research Project. It was mowed regularly at 5/8 inch with a reel mower, fertilized approximately monthly with 1 lb N/1000 sq ft during the growing season, and irrigated to replace water use and avoid stress. In late summer, 1986, the grass was scalped severely by normal mowing operations. The scalping was very uniform over an extensive area, and no recovery was noted for several weeks following the scalping.

The study started on October 16, 1986. The treatments included: 1) vertical mowing; 2) nitrogen application; 3) vertical mowing plus nitrogen; and 4) control, or no treatment. Vertical mowing was performed with a Ryan Ren-O-Thin with blades set just below the soil. The nitrogen treatment was 2 lb N/1000 sq ft with ammonium nitrate.

The following spring (April 15, 1987) all plots were split when a nitrogen treatment of 2 lb N/1000 sq ft of ammonium nitrate was applied to one-half of each original plot area. The original experimental design was a Randomized Complete Block with eight replications.

Data taken included turf scores and, on occasion, scalping ratings. Turf scores are visual ratings of turfgrass quality and include factors such as color, density, texture, uniformity and pest activity, including weed invasion. A 1 to 9 scale is used with 1 representing dead turf and 9 representing an ideal turfgrass sward.

Differences among treatments were determined by Analysis of Variance and Duncan's Multiple Range Test.

## RESULTS

Figures 1-4 present the turfgrass scores during late autumn, winter and early spring of 1986-87. In December, 1986, Seashore Paspalum that had received nitrogen alone or nitrogen plus vertical mowing had significantly higher turf scores than plots with vertical mowing only, or no cultural treatment. The reason for better appearing turf was due to the regrowth of new tillers, following nitrogen or nitrogen plus vertical mowing treatments. There was better Seashore Paspalum color and density with these treatments. Figure 2, January, 1987, again supported the differences previously noted even though the plots were totally dormant, which accounts for the comparatively low turf score ratings.

As Seashore Paspalum came out of winter dormancy in March, 1987, the combination of vertical mowing and nitrogen produced a significantly better turf quality than the nitrogen or vertical mowing alone and the control. All treatments produced better turf quality than the control, as shown in Figure 3. Improved turf quality was due to enhanced color and shoot density.

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By April, 1987 (Figure 4), the Seashore Paspalum was well out of winter dormancy, and the effects of the previous year's scalping was overcome by spring regrowth. Still, the nitrogen/vertical mowing and nitrogen treatments were superior in quality to the vertical mowing or control treatments.

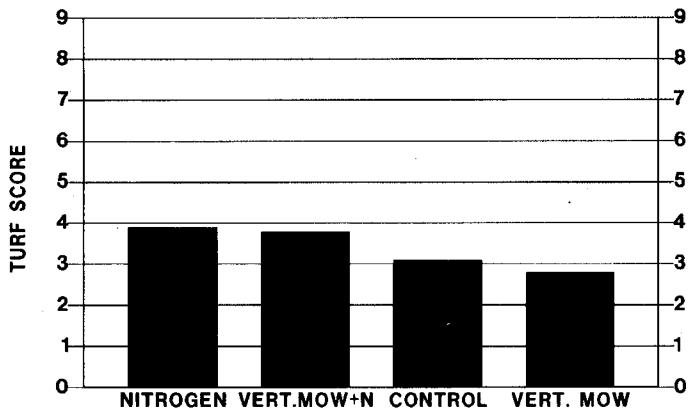


Figure 1. Turf scores of Seashore Paspalum in December 1986. 1-9 scale with 1=dead turf, 9=ideal turf. Treatment columns with the same letter are not significantly different at the 5% level of probability.

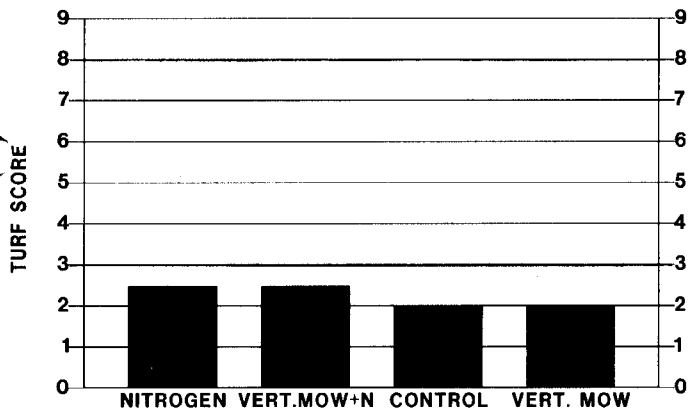


Figure 2. Turf scores of Seashore Paspalum in January 1987. 1-9 scale with 1=dead turf, 9=ideal turf. Treatment columns with the same letter are not significantly different at the 5% level of probability.

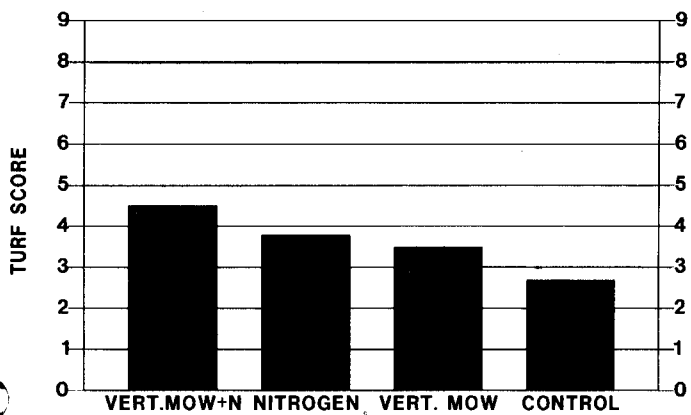


Figure 3. Turf scores of Seashore Paspalum in March 1987. 1-9 scale with 1=dead turf, 9=ideal turf. Treatment columns with the same letter are not significantly different at the 5% level of probability.

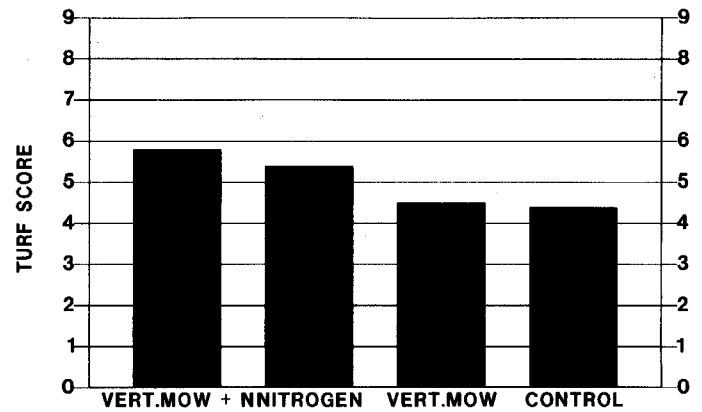


Figure 4. Turf scores of Seashore Paspalum in April 1987. 1-9 scale with 1=dead turf, 9=ideal turf. Treatment columns with the same letter are not significantly different at the 5% level of probability.

Figure 5 illustrates turf quality 37 days after the April 15 split-plot nitrogen application. When this application was made, there were no significant differences among the original treatments. However, the second nitrogen treatment produced significantly higher turf scores, irrespective of previous cultural treatments, than plots not receiving the second nitrogen application. The grass response through the summer months of 1987 to the original treatments and to the nitrogen split treatment remained comparatively the same as given in Figure 5.

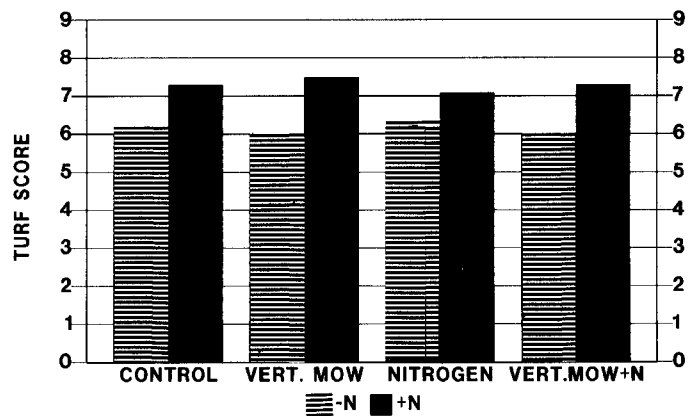


Figure 5. Turf scores of Seashore Paspalum in May 1987, 37 days following a split nitrogen application. 1-9 scale with 1=dead turf, 9=ideal turf.

Scalping was again noted in late summer, 1987, and injury was recorded on September 9 with a 1 to 9 rating scale, 1 being no scalping and 9 being severe scalping. The results are presented in Figure 6. Significantly more scalping occurred on those plots that received the April 15, 1987, nitrogen fertilization than on plots that did not receive the spring nitrogen application. Other reports have also noted autumn scalping following spring fertilization (4). The nitrogen-only treatment also increased scalping severity in 1987 when compared to the other cultural treatments.

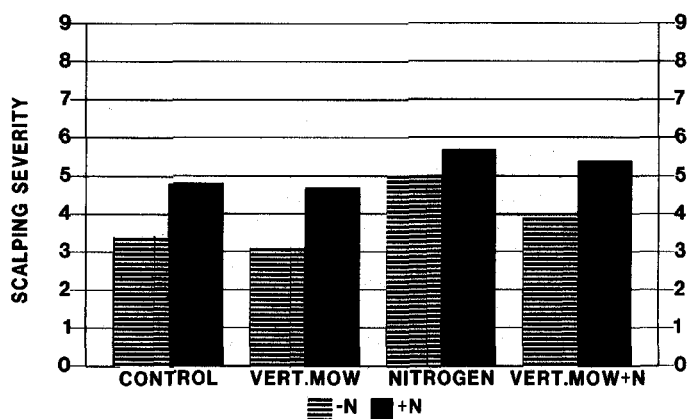


Figure 6. Scalping of Seashore Paspalum in September 1987. Scalping scale 1-9; 1=no scalping, 9=severe scalping.

## SUMMARY

Late summer scalping of Seashore Paspalum can be a serious aesthetic problem because the grass does not fully recover until the following spring. At that time new tillers are formed at the crown of the scalped, dormant grass plants. This study evaluated cultural practices that would speed recovery from scalping.

It was found that vertical mowing plus nitrogen application was the most effective treatment, in comparison to nitrogen alone, vertical mowing alone or no treatment, when all aspects of the recovery process were considered.

Subsequent spring nitrogen application improved turf quality irrespective of previous cultural practices and their effect on scalping recovery. However, spring nitrogen predisposed the Seashore Paspalum to greater scalping potential, as had been previously reported.

Previous information has indicated that to avoid or minimize scalping:

- \* Concentrate nitrogen fertilization in the autumn, with only light fertilization in the spring if necessary for color or increased growth/recuperative rate. Avoid summer fertilization.

- \* Irrigate as infrequently as possible by watering thoroughly and deeply at each irrigation time. To hasten recovery from scalping:

- \* Vertical mow and apply readily available nitrogen.

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## Overseeding of Bermudagrass in Coachella Valley

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The densest concentration of golf courses is in California's Coachella Valley. Warm season grasses, primarily bermudagrasses, are predominately used on them. Winter play on these golf courses, however, requires that cool season grasses be used to maintain their attractiveness and function. Annual ryegrass is usually the grass of choice, but perennial ryegrass is increasingly being used. Overseeding rates vary considerably from as high as 600 pounds per acre (lb/A) to as low as 100 lb/A. This study evaluated several seeding rates of various grasses for overseeding purposes.

### METHODS

An overseeding study was started September 29, 1983 on a common bermudagrass fairway at the Cathedral Canyon Country Club, Cathedral City, California. Grasses tested were annual ryegrass, perennial ryegrass (cv Palmer), intermediate ryegrass (cv Agree) and a 50/50 mix of the perennial ryegrass and intermediate ryegrass.

Each of the grasses and the mix was established on 50 sq ft plots and seeded at a 100, 200, 300, 400, 500 or 600 lb/A rate. The treatments were replicated four times and arranged in a randomized complete block design. The fairway was closely

mowed, and all irrigations withheld for two weeks prior to seeding. All plots were hand-seeded and then lightly hand-raked to insure a seed-soil contact. The test area was irrigated frequently to keep it moist. Irrigations were then gradually reduced as the stand matured. Mowing began 21 days after seeding. First mowings were at a 1-inch height, reduced to 1<sup>3</sup>/<sub>16</sub>-inch and shortly thereafter to 1<sup>1</sup>/<sub>16</sub>-inch for the remainder of the overseeding season. The plots were mowed three times per week. A complete fertilizer was applied about once a month at rates between 0.5 and 1.0 pound of nitrogen per 1000 sq ft. The test was monitored regularly, especially during initial establishment and during high temperature transition. Treatments were evaluated for color, uniformity and percent ryegrass. Data were subjected to an Analysis of Variance and differences determined by the Duncan's Multiple Range Test.

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# RESULTS

## Initial Establishment:

Table 1. Initial percent ryegrass cover by species and varying seeding rates on three consecutive dates following seeding

Species and Observation Dates	Seeding Rates lb/A					
	100	200	300	400	500	600
<b>Annual Rye</b>						
10/18/83	32.5Z*	60.0Y	70.0XY	77.5X	80.0X	95.0X
10/25/83	32.5Z	47.5YZ	50.0XYZ	57.5XY	72.5X	72.5X
11/01/83	27.5Z	42.5YZ	47.5Y	50.0Y	70.0X	77.5X
<b>Intermediate Rye</b>						
10/18/83	17.5Z	32.5YZ	47.5XY	50.0X	62.5WX	72.5W
10/25/83	22.5Z	37.5YZ	52.5XY	65.0WX	72.5WX	77.5W
11/01/83	20.0Z	30.0YZ	49.5XY	59.5X	65.0X	62.5X
<b>Rye Mix</b>						
10/18/83	10.0Z	37.5Y	60.0X	65.0WX	72.0WX	80.0W
10/25/83	35.0Z	50.0YZ	60.0Y	65.0XY	85.0X	85.0X
11/01/83	35.0Z	40.0YZ	55.0Y	57.5XY	5.0WX	77.5W
<b>Perennial Rye</b>						
10/18/83	22.5Z	17.5Z	40.0Y	65.0X	80.0WX	82.5W
10/25/83	32.5Z	52.5YZ	60.0XY	65.0XY	75.0XY	80.0X
11/01/83	35.0Z	55.0XY	50.0YZ	65.0XY	70.0X	70.0X

\*Values followed by the same letter are not significantly different at the 5% level of probability.

Table 1 presents the percent ryegrass during the early stages of overseeding. As would be expected, there was a direct, positive relation between seeding rates and cover at the three observation times. For purposes of evaluating Table 1, a 60 percent cover was considered to be an acceptable overseeding for aesthetic purposes. Although all plots seeded to the 500 and 600 lb/A rates established more quickly and completely, the most significant difference in "acceptable" versus "less than acceptable" treatments was noted between the 300 versus 200 lb/A rates. Unusually high temperatures experienced from late October through November stimulated a resurgence of bermudagrass growth. Therefore, the establishment of the ryegrass sward, regardless of species, was substantially delayed, as can be seen from the 10/25 and 11/1 rating dates.

The effects of seeding rates on the percent ryegrass cover can be seen in Table 2, where data are averaged across grasses and analyzed only for seeding rates. Again, the high seeding rates provided quicker cover than the lower seeding rates; once mature, as shown in the December and April ratings, there was little difference among rates tested. It was noted that seeding rate had only a slight effect on the spring transition with the 600 lb/A rate being slightly more persistent than the 100-400 lb/A rates (June rating).

Table 2. Percent ryegrass cover at six seeding rates at eight dates following overseeding

Seeding Rates lb/A	Observation Dates							
	10/18/83	11/1/83	12/20/83	12/28/83	4/20/84	5/3/84	6/1/84	6/22/84
100	20.6Z*	29.4Z	43.6Z	69.8Z	65.3Z	32.9Z	5.2Z	0.0Z
200	39.9Y	41.9Y	54.4Y	76.6Y,	64.4Z	31.6Z	7.5YZ	0.0Z
300	54.4X	50.0XY	70.9X	82.5XY	67.2Z	38.8YZ	9.8YZ	0.6YZ
400	64.4W	57.5X	69.7X	83.1XY	78.2YZ	44.4XY	7.5YZ	0.6YZ
500	73.1V	70.0W	77.5X	89.7X	77.5Y	46.6X	10.9XY	1.9Y
600	80.1V	71.9W	77.5X	90.3X	80.6Y	44.7X	14.7X	0.6YZ

\*Values followed by the same letter are not significantly different at the 5% level of probability.

Table 3 presents the percent ryegrass cover when analyzed for the grass species in this study. Annual ryegrass was the quickest to establish in the fall and the first grass to decrease stand in the spring. During most of the overseeding season, the perennial ryegrass and the mix of perennial ryegrass and intermediate ryegrass had higher percent cover ratings than the annual ryegrass or the intermediate ryegrass. The value of the annual ryegrass is its ability to establish quickly, whereas for the intermediate ryegrass, it may be in its use as a mix when costs are a consideration.

Table 3. Percent ryegrass cover with four species, or mix, at eight dates following establishment

SPECIES	Observation Dates							
	0/18/83	11/1/83	12/20/83	12/28/83	1/4/84	4/20/84	5/3/84	6/1/84
AR	67.5Y*	52.5YZ	51.9Z	71.7Z	80.0Z	61.7Z	20.0Z	7.7
IR	47.1Z	47.1Z	59.8Z	77.9Z	82.3Z	66.7Z	33.1Y	10.2
PR&IR	53.8Z	56.7Y	74.2Y	88.2Y	93.2Y	79.2Y	51.9X	7.7
PR	51.3Z	57.5Y	76.5Y	88.8Y	92.0Y	77.3Y	54.3X	11.2

\*Values followed by the same letter are not significantly different at the 5% level of probability.

As noted in Table 4, perennial ryegrass maintained a substantially higher percentage of cover throughout the transition period followed by the perennial ryegrass and intermediate ryegrass mix. Their transition was slower and at substantially higher percentages than annual ryegrass and intermediate ryegrass. Annual ryegrass made a quick spring transition.

Table 4. Percent ryegrass at six dates during spring transition

SPECIES	Observation Dates					
	5/3/84	5/11/84	5/25/84	6/1/86	6/8/84	6/22/84
AR	20.0Z*	14.4Z	7.9Z	7.7	1.2	0Z
IR	33.1Y	18.8Z	11.0YZ	10.2	1.7Z	0Z
PR&IR	51.9X	26.5Y	17.1XY	7.7	6.3	0Z
PR	54.3X	34.7X	21.8X	11.2	22.4Y	2.5Y

\*Values followed by the same letter are not significantly different at the 5% level of probability.

Tables 5 and 6 present the turfgrass characteristics of color, density, uniformity and overall quality for the grasses and seeding rates. Perennial ryegrass alone, or in mixture with intermediate ryegrass, displayed the better turfgrass characteristics when compared to intermediate ryegrass alone or annual ryegrass. The perennial ryegrass treatments were darker green, denser, more uniform and of higher overall turfgrass quality. Intermediate ryegrass was superior to annual ryegrass in these same characteristics.

Table 5. The color, density, uniformity and turf quality of four ryegrass treatments

SPECIES	COLOR*	DENSITY	UNIFORMITY	QUALITY
AR	2.6Z**	6.7Z	4.9Z	5.1Z
IR	5.3Y	6.6Z	5.4Z	5.7Y
PR&IR	6.9X	7.4Y	6.9Y	6.8X
PR	7.5W	7.2Y	6.6Y	7.1X

\*Color 1-9; 9 darkest. Density 1-9; 9 densest. Uniformity 1-9; 9 most uniform. Quality 1-9; 9 highest quality. Color (average of October, December and February ratings); Density (average of October and February ratings); Uniformity (May 11); Quality (May 3).

\*\*Values followed by the same letter are not significantly different at the 5% level of probability.

As shown in Table 6, turfgrass color was not influenced to a large extent by seeding rates; however, density, uniformity and overall quality increased, or improved, with higher seeding rates. The increased quality with the higher seeding rates was primarily due to the increased density of the turfgrass stand.

Table 6. The color, density, uniformity and turf quality of ryegrass at six seeding rates

SEEDING RATES	#/M	COLOR*	DENSITY	UNIFORMITY	QUALITY
100		5.9X**	5.6Z	5.5Z	5.4Z
200		5.8XY	6.1Y	5.8YZ	5.7YZ
300		5.3Z	6.8X	5.3Z	6.1XY
400		5.6XYZ	7.4W	6.2XY	6.4WX
500		5.3Z	7.8VW	6.7X	6.8W
600		5.5YZ	8.0V	6.3XY	6.8W

\*Color 1-9; 9 darkest. Uniformity 1-9; 9 most uniform. Density 1-9; 9 densest. Quality 1-9; 9 highest quality. Color (average of October, December and February ratings); Density (average of October and February ratings); Uniformity (May 11); Quality (May 3).

\*\*Values followed by the same letter are not significantly different at the 5% level of probability.

## SUMMARY

In California, annual and perennial ryegrass are the most commonly used grasses for overseeding a warm season turfgrass. Intermediate ryegrass, although seldom used, was tested for overseeding characteristics. The following are conclusions from this study.

\* Annual ryegrass was the fastest to establish and the first to transition in the spring.

\* The turf quality of perennial ryegrass and the mix of perennial ryegrass/intermediate ryegrass was better than intermediate ryegrass which, in turn, was better than annual ryegrass.

\* The initial stand of the overseeding grass was directly dependent on the seeding rate, irrespective of species, with the higher seeding rates giving a quicker acceptable grass stand.

\* Seeding rate had little effect on the mature overseeding in terms of percent cover.

\* A reasonable seeding rate, irrespective of species, was the 300 or 400 lb/A rate, recognizing that a faster establishment can be achieved with a higher rate and also recognizing that a slower, but ultimately mature overseeding can be achieved with a lower seeding rate.

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## WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in their original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Recommendations are based on the best information currently available, and treatments based on them should not leave residues exceeding the tolerance established for any particular chemical. Confine chemicals to the area being treated. THE GROWER IS LEGALLY RESPONSIBLE for residues on his crops as well as for problems caused by drift from his property to other properties or crops.

Consult your County Agricultural Commissioner for correct methods of disposing of leftover spray material and empty containers. **Never burn pesticide containers.**

**PHYTOTOXICITY:** Certain chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury may also result from excessive amounts or the wrong formulation or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, diluents, and solvents, can cause plant injury. Since formulations are often changed by manufacturers, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

NOTE: Progress reports give experimental data that should not be considered as recommendations for use. Until the products and the uses given appear on a registered pesticide label or other legal, supplementary direction for use, it is illegal to use the chemicals as described.

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