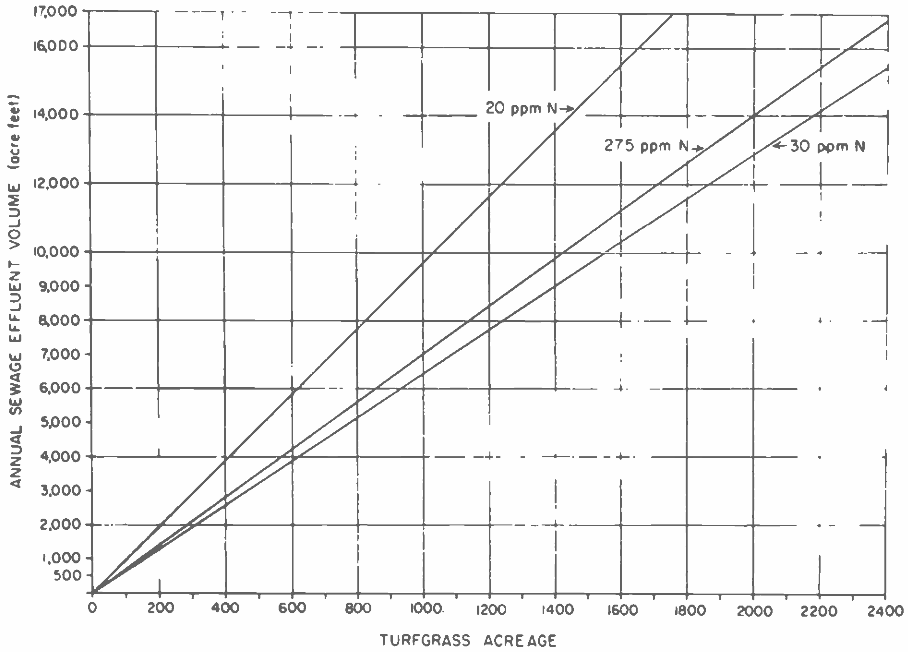
FIGURE I. SEWAGE EFFLUENT REQUIREMENT FOR TURFGRASS MAINTENANCE AT DIFFERENT EFFLUENT NITROGEN CONCENTRATIONS.



Irrigating Recreational Turfgrass with Sewage Effluent

*by Gordon V. Johnson**

Introduction

Sewage effluent usually is considered a waste product, and as such is most often disposed of as a valueless substance. In reality, however, sewage effluent is 99.9985% pure water after receiving modern primary and secondary treatment[1]. Furthermore, modern day treatment plants are capable of producing treated effluent which is safe for human consumption. Studies at the University of Arizona[2] have shown that treated municipal effluent can be benefically used to irrigate field crops. Effluent from the City of Tucson was used for this purpose for over 20 years by local farmers until it was discontinued in 1970[3]. While field crop irrigation provides an excellent means for disposing of the effluent and supplying needed nutrients and water for crops, it is not always economically feasible where agricultural crops are not grown near the supply of effluent. More recently[4], it has been demonstrated that turfgrasses, because of their great nitrogen requirement, are extremely effective in utilizing the nitrogen contained in sewage effluent. After nitrogen removal by the soil and turfgrass, 40% of the applied effluent passed below the root zone and was available for groundwater recharge.

Why Turfgrass?

Use of treated sewage effluent to irrigate recreational turfgrass may often be more feasible economically than alternative uses such as the irrigation of field crops or use by industry. Treatment plants and large acreages of turfgrass are usually situated on the periphery of cities, away from heavily populated sections because of the undesirable odors commonly emitted from treatment plants and lower land costs for recreation facilities. Consequently, transmission of sewage effluent from treatment plants to large acreages of turfgrass where it could be used for irrigation should not require extensive pipe lines.

A second advantage to using turfgrass acreage for disposal of effluent is that in southern Arizona, where disposal is of great concern because of rapid population increases, the climate is favorable for growing turfgrasses all year. Thus, unlike field grop irrigation which must be halted during harvest, between crops, and at other times when heavy equipment is brought onto the field, culture of bermudagrass during the summer and cool season grasses during the winter requires weekly and often daily irrigation throughout the year. Also, turfgrasses require nitrogen at a relatively constant level throughout the year, whereas field crops generally have a high demand early and a low demand late in their growth period.

Properly cultured recreational turfgrasses provide a plant density which requires large amounts of nitrogen per unit of land area. Consequently, more effluent would have to be supplied to meet the nitrogen requirement than would be necessary for water use by the turfgrasses. Since most field crops have a smaller nitrogen requirement, irrigation with treated effluent only may result in excessive application of nitrogen leading to groundwater pollution.[3]

Also important in the consideration of irrigating recreational turfgrass with sewage effluent is the fact that as cities grow and housing developments materialize, the acreage of recreational turfgrass (or the need for it) usually increases also. This parallel, evidenced by an increasing number of housing developments which have included a golf course (e.g. Tucson Estates and El Dorado Estates, Tucson) provides new disposal areas as the volume of sewage effluent increases.

How Much Effluent, How Much Turfgrass?

The relationship between effluent volumes and turfgrass acreage needs to be examined in considering sewage effluent irrigation of turfgrass to determine what proportion of the total effluent volume can be utilized in this manner. Current effluent volumes are usually known by treatment plant officials, and approximate future volumes can be estimated on the basis of population growth. Estimates on recreational turfgrass acreages available for effluent irrigation can also be

* *Assistant Professor, Department of Soils, Water and Engineering.*

[1] *Bohn, H. L. and G. V. Johnson.* 1972. *Saline and Organic Water Pollution. Hydrology and Water Resources in Arizona and the Southwest.* 2:209-220.

[2] *Day, A. D., T. C. Tucker and M. G. Vavich.* 1962. *Sewage Effluent. Progressive Agriculture in Arizona, Vol. XIV, No.* 5.

[3] *Schmidt, K. D.* 1972. *Groundwater Contamination in the Cortaro Area, Pima County, Arizona. Hydrology and Water Resources in Arizona and the Southwest.* 2:95-111.

[4] *Sidle, R. C. and G. V. Johnson.* 1972. *Evaluation of a Turfgrass-Soil System to Utilize and Purify Municipal Waste Water. Hydrology and Water Resources in Arizona and the Southwest.* 2:277-289.

[5] *Krans, J. V. and G. V. Johnson. Subirrigation and Fertilization of Bentgrass During Prolonged Heat Stress. Proceedings of the 2nd International Turfgrass Research Conference. (In press.)*

calculated, although predicting future available acreages is often more difficult. Once effluent volumes and turfgrass acreages for a community are known, estimates of the amount of effluent which can be used can be calculated.

Annual consumptive water use by creeping bentgrass (*Agrostis palustris Huds.*), a cool season turfgrass used exclusively for golf putting greens in the Tucson area, is about 56 inches.[5] Consumptive water use for other turfgrasses presumably is similar when grown under optimum soil moisture conditions. Turfgrasses will utilize an average of 1 lb. of nitrogen per 1000 $ft.^2$ per month although they can often be maintained in a fair to good condition using about one half this rate. Using the higher rate, annual nitrogen consumption would be approximately 525 lb. per acre. Assuming an average nitrogen concentration of 20 ppm in the effluent, one acre foot of effluent would supply 54 lbs. of nitrogen and about 9.7 acre feet would be required to satisfy the nitrogen requirement of an acre of turfgrass for one year. Approximately five acre feet of the applied effluent would be free to recharge groundwater. Research at The University of Arizona Turfgrass Research Center has demonstrated that the water available for recharge would contain less than one ppm nitrate-nitrogen and be of overall excellent quality[4].

Using the above values for turfgrass water and nitrogen requirements, the acreage of turfgrass which could be irrigated annually with a given volume of effluent can be found using Figure 1. For example, a city such as Green Valley, Arizona, with a population of about 5,000 and an annual sewage effluent volume of approximately 450 acre feet, could use all its effluent to irrigate 75 acres of turfgrass if the effluent contained 30 ppm nitrogen. Only 45 acres of turfgrass would be required to utilize the city's entire effluent supply if it contained an average of 20 ppm nitrogen. Obviously the two golf courses at Green Valley, comprising a total of about 210 acres of irrigated turfgrass could utilize all of the existing effluent from the city. For this community one may also project from Figure 1 that the effluent volume could be increased to 1,350 acre feet annually (assuming 30 ppm nitrogen) without danger of "overloading" the soil-turfgrass system. The population of Green Valley would need to be more than doubled in order to produce enough effluent for continual use on the two existing golf courses. The relationship between existing effluent volume and turfgrass acreage for the small community of Green Valley would indicate that the city is "effluent poor."

This approach to disposal of sewage effluent is ideally suited to use by small existing communities, such as Green Valley, or small rapidly growing communities which can incorporate the disposal system into expansion plans.

What About the Big City?

The use of sewage effluent for irrigation of recreational turfgrass in a large city would be more difficult to implement. This is due primarily to the fact that large cities have usually developed over a long period of time, during which their growth may encompass and spread beyond areas of recreational turfgrass initially intended to be near the outer limits of the city. Consequently, large acreages of turfgrass may be scattered at random throughout the city. Increasing volumes of sewage effluent, however, may have been handled by enlarging an existing treatment facility and trunk lines rather than periodically building separate new treatment plants. Using treated effluent, therefore, would require construction of a rather elaborate system of transmission lines from a single large treatment plant to the several locations of large turfgrass acreages within the city. The feasibility of using all of the effluent from a large city for irrigating recreational turfgrass can be illustrated using Tucson as an example.

The annual volume of treated sewage effluent from Tucson is about 36,500 acre feet and has an average nitrogen content of 25 to 30 ppm. Using a mean value of 27.5 ppm nitrogen and extrapolating from Figure 1, about 5,200 acres of turfgrass would be needed to utilize all of the effluent. A liberal estimate of the turfgrass acreage of golf courses, parks, and playgrounds in the metropolitan area would be only about 4,600 acres. Even if its recreational turfgrass were irrigated with effluent, Tucson could be considered an "effluent rich" metropolitan area, based on the relationship between available effluent and recreational turfgrass acreage.

Solution to the Big City Problem

One approach to the sewage disposal problem of an "effluent rich" city such as Tucson is to view it as being "turfgrass poor." From this point of view a solution to the problem would be to establish an additional 600 acres of turfgrass. While this may seem somewhat extravagant, its effect may have considerable appeal to much of the city's population. Consider, for example, three more 18-hole municipal golf courses of 80 acres each and an additional 360 acres of playground and picnic areas. These could be situated on the Rillito, Pantano and Santa Cruz flood plains to provide green belts within and around the outskirts of the city. Provision could be made for bridle and cycling paths.

Establishment of recreational turfgrass in these areas would be consistent with the concepts of Land Use Planning. The generally sandy alluvial soils of the flood plains are well suited to turfgrass culture and provide an ideal material for rapid infiltration of the irrigation effluent and the percolation of good quality water to conserve ground water sources. While the recreational areas in these locations would be subject to periodic flooding, the damage resulting from inundation would be minimal compared to similar flooding of residential or comercial housing. Establishment of turfgrass on these areas would reduce their erosion potential and tend to stabilize the soils.

Summary and Implications

Using sewage effluent to irrigate recreational turfgrass can provide water and nutrients required by the turf. Because of the relatively high nitrogen and low water requirements, excessive amounts of effluent must be applied. As the excessive effluent passes through the turfgrass and soil its chemical constituents (especially nitrogen) are removed allowing good quality water to percolate to groundwater aquifers. Disposal of effluent by this manner does not carry the stigma of pollution hazards associated with field crop irrigation or discharge of effluent into dry stream beds. In addition to the benefit of increased groundwater recharge, using effluent to irrigate recreational turfgrass could often relieve domestic water shortages.

This type of effluent disposal is technically feasible for most of the Southwestern United States where turfgrasses are grown all year. Eco-

(Turn to page 15)

was obtained by the first of July. During this period the alfalfa goes into the 'summer slump' and forage production is drastically reduced.

These observations should be of interest to the alfalfa producer since the water requirement of a forage crop in the arid southwest is of major importance, both with regard to economics and, more important, availability. They also point out some of the management practices that result in the maximum production of digestible forage per acre at a minimum cost. Although seasonal trends were noted for most of the variables studied, dry forage yield was the dominant factor influencing total ADDM production, or that portion of the forage produced per acre which is utilized by the animal. This was illustrated by the fact that although Mesa-Sirsa generally had a much lower leaflet to stem-petiole ratio (lower quality) than Sonora, Mesa-Sirsa was generally found to be the superior cultivar in ADDM production.

Conclusion

Differences in apparent digestibility among these four cultivars were insignificant. Therefore, from the standpoint of the maximum production of digestible forage, the producer should select among these cultivars based strictly on dry forage yield and water-use efficiency.

Literature Cited

1. *Schonhorst, M. H., R. K. Thompson and R. E. Dennis.* 1963. *Does it pay to irrigate alfalfa in the summer? Prog. Agric. Arizona* 15(6):8-9.
2. *Tilley, J. M. A. and R. A. Terry.* 1963. *A two-stage technique for the* in vitro *digestion of forage crops. J. Brit. Grassl. Soc.* 18:104-111.
3. *Van Soest, P. J., R. H. Wine and L. A. Moore.* 1966. *Estimation of the true digestibility of forages by the* in vitro *digestion of cell walls. Proc. 10th Int. Grassl. Congr.* 2/20:438-442.

Turfgrass

(From page 9)

nomically, application of this use for effluent is most favorable for small existing communities or communities which are rapidly expanding. It is implied that communities may evaluate the success of their efforts to provide the public with adequate recreation facilities by comparing the existing turfgrass acreage with that required for the disposal of current effluent volumes.

Economics of Short Season Cotton

(From page 5)

This explains why larger break-even yield losses are reported for the higher cost water sources. The sources of water reported in Table 3 are arranged from the least to the most expensive source, i.e., Colorado River and 700 foot well, respectively.

Table 4 presents the break-even yield losses for a two-week shortening of the growing season. The change in these losses that is associated with different water sources and lint parallels those noted in Table 3 for the same reasons. Break-even yield losses are less for the two week than the one month earlier termination because the former has less cost savings, thus less yield can be lost.

Summary

Cotton producers electing to shorten their growing season will normally experience a reduction in both production costs and gross returns. Obviously, for early termination to be a profitable practice, costs must be reduced more than returns. This study has indicated the kinds of cost-return (and net income) changes that will likely occur under various early termination circumstances. As demonstrated in Table 2, yield losses are an especially important factor. At a given lint price, early termination can be either a highly profitable or a very costly policy, depending upon the extent of the yield loss. The importance of yield losses is further magnified by higher lint prices. The source and cost of water was also found to be an important factor. For example, with 50 cent lint, producers using cheaper Colorado River water can afford to lose about nine percent of their full-season yield through a one month shortening of the growing season and still break even; this compares to approximately 12 percent for those pumping water from 700 foot underground. Because of the variation over time and space in these and other cost-return factors, it is extremely hazardous to make general recommendations regarding the advisability or inadvisability of shortening the growing season for cotton. However, this study has developed guidelines that should permit producers to make better decisions in light of their unique resources and risk preferences.

Acknowledgements

The authors wish to extend their appreciation to several individuals who provided assistance at various points in the study. Those who were particularly helpful include Scott Hathorn, Jr., Extension Farm Management Economist, University of Arizona; Leonard J. Erie, Agricultural Engineer, U.S. Conservation Laboratory, Phoenix, Arizona; Robert S. Firch, Department of Agricultural Economics, University of Arizona; Leon Moore, Extension Entomologist, University of Arizona; H. N. Stapleton, Department of Agricultural Engineering, University of Arizona; and Theo Watson, Department of Entomology, University of Arizona.

References

1. *Bennett, O. L., L. J. Erie, A. J. Mackenzie, "Boll, Fiber and Spinning Properties of Cotton as Affected by Management Practices," U.S. Department of Agriculture, Technical Bulletin No.* 372, *June* 1967.
2. *Buxton, D. R., H. N. Stapleton, Y. Makki, and R. E. Briggs, "Some Effects of Field Weathering of Seed Cotton in a Desert Environment,"* Agronomy Journal, *Volume* 65, *January-February* 1973.
3. *Erie, L.J., D. A. Bucks, O. R. French, "Irrigation and Water Management for Economical Cotton Production," Summary Proceedings — Western Cotton Production Conference, Bakersfield, California, March* 1-3, 1972.
4. *Erie, L. J., O. R. French, K. Harris, "Consumptive Use of Water by Crops in Arizona," Technical Bulletin No.* 169, *Agricultural Experiment Station, The University of Arizona, September* 1965.
5. *Hathorn, S., B. B. Taylor, "High Yield Cotton Grower Production Practices in Arizona — A Survey," Series P-27, Cooperative Extension Service and Agricultural Experiment Station, The University of Arizona, August* 1972.
6. *Stapleton, H. N., "Production Costs Related to Cotton Production System Strategies,"* Cotton-A College of Agriculture Report, *Series P-21, Cooperative Extension Service and Agricultural Experiment Station, The University of Arizona, February* 1971.
7. *U.S. Department of Agriculture, "Cotton Situation," Economic Research Service, May* 1971 *and May* 1972 *issues.*
8. *U.S. Department of Agriculture, "Cotton Quality for Western Area," Consumer and Marketing Service,* 1964-1971 *issues.*
9. *Willett, G. S., B. Brooks Taylor, Dwayne R. Buxton, "An Economic Comparison of Short and Full-Season Cotton Production in Arizona," Research Report* 269, *Agricultural Experiment Station, The University of Arizona, August* 1973.