

2nd ed. Ediciones de la Universidad de Chile, Santiago.

41. Perez-Arbelaez, E. 1956. *Plantas Utiles de Colombia*. 3rd ed. Libreria Colombiana—Camacho Roldan (Cia. Ltda), Bogota.
42. Pittier, H. 1926. *Manual de las Plantas Usuales de Venezuela*. Pub'd by author, Caracas.
43. Pulle, A. 1948. *Flora of Suriname*. Vol. I, Pt. 1. Koninklijke Vereeniging Indisch Inst., Amsterdam.
44. Radford, A. E., H. E. Ahles and C. R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas*. Univ. of North Carolina Press, Chapel Hill.
45. Riese, H. J., Managing Director, Boca Patrick Estate, Curacao, Netherlands Antilles. 1969-73. Personal communications.
46. Sauer, J. C. 1967. *Plants and Man on the Seychelles Coast*. Univ. of Wisconsin Press, Madison.
47. Schmeisser, Hans, Golf Course Architect, Gulfstream Golf Club, Delray Beach. Aug. 30, 1973. Personal communication.
48. Schmeisser, Otto, Superintendent, Indian Creek Golf Course. Aug. 38 and Oct. 9, 1973. Personal communications.
49. Schnee, L. 1960. *Plantas Comunes de Venezuela*. Alcance #3. Rev. de la Facultad de Agron., Univ. Central de Venez., Maracay.
50. Shiffet, T. N. 1963. *Major Ecological Factors Controlling Plant Communities in Louisiana Marshes*. J. Range Management 16: 231-5.
51. Small, J. K. 1933. *Manual of the Southeastern Flora*. Pub'd by the author, New York. (Reprinted by Univ. North Carolina Press, 1953).
52. Stahel, G. 1942. *De Nuttige Planten van Suriname*. Bul. 57. Departement Landbouwoverheid, Paramaribo.
53. Standley, P. C. 1937. *Flora of Costa Rica*. Pt. I. Pub. 391. Bot. Ser. Vol. 18, Field Mus. Nat. Hist., Chicago.
54. ————. 1928. *Flora of the Panama Canal Zone*. Contrib. U. S. Nat'l Herb. Vol. 27. Smithsonian Inst., Washington, D. C.
55. Stone, B. C. 1970. *The Flora of Guam*. Micronesica Vol. 6. University of Guam.
56. Swallen, J. R. 1936. *The Grasses of British Honduras and the Peten, Guatemala*. Pp. 141-189 & 4 pls., in *Botany of the Maya Area*. Misc. Papers. Pub. 461. Carnegie Inst., Washington, D. C.
57. Walker, A. R. and R. Sillans. 1961. *Les Plantes Utiles de Gabon*. (Encyc. Biologique LVI) Editions Paul LeChevalier, Paris.
58. White, R. *Southern Turf Nurseries*, Eustis, Fla. Sept. 6, 1973. Personal communication.
59. Woodson, R. E., R. W. Schery, et al. 1965. *Flora of Panama*, Pt. II. Fasc. I. Ann. of Mo. Bot. Gard. Vol. XXX, No. 2, 1943-4. Reprinted by Stechert-Hafner, New York.

DEEP ROOT INJECTION FEEDING, THEORY AND PRACTICE IN TREE AND SHRUB MAINTENANCE

H. C. BARDSLEY

Horticultural Consultant
F.E.C. Fertilizer Company
Homestead
and

C. P. JOHNSON, PRES.

Charlie P. Johnson Spray Co., Inc.
Miami

Abstract. A discussion of the agronomic theory of placing plant nutrients in the root zone of ornamental trees and plants by high pressure hydraulic injection. Definite beneficial effects of deep root injection feeding by high pressure injection of plant nutrients have been observed in tree and ornamental plant installation and maintenance. The response outperformed conventional surface applications of plant nutrients. Speculation is made on the value of the addition of nematicides as well as systemic fungicides and insecticides to the plant nutrient injection. Deep root injection feeding is an effective method of tree and plant maintenance that does not violate the ecology.

Introduction

Fertilizer placement in relation to a plants root system is often as important in plant re-

sponse as the analyses and units of plant nutrients applied. There are varying filtering and tyingup capacities in different soils that alter the analyses and amounts of plant nutrients applied to the surface of soils and those available at the soil depth of the root system.

In recognition of the response of plant nutrients in fertilizer placement on ornamental shrubs and trees it has long been the established practice in many areas of the United States to provide more effective feeding by physically placing the nutrients in the plants root zone area of the soil profile. Techniques of "punching" holes with a crowbar or drilling holes in the soil with a special drill have been used to provide access to the root zone area and then conventional fertilizers or compressed nutrient tablets were placed in the holes in the soil around the shrub or tree. Recently hydraulic injection techniques have been employed using soluble or liquid plants nutrients. Hydraulic injection was first tried by Charlie P. Johnson in 1953 in the Miami area.

Early hydraulic injection treatments with liquid or soluble nutrients provided only short term responses and did not justify the economic costs for shrub and tree maintenance.

Most Florida soils offer a challenge to improved fertilizing techniques because of their very low natural fertility and often antagonistic effects on plant nutrients. Fertilizer placement on cul-

tivated Florida crops has always been essential to successful commercial crop production.

The early objectives of DRIF (Deep Root Injection Feeding) was to place a sustaining plant nutrient suspension mix in the root zone soil profile area to give an improved plant response over soil surface applications of fertilizer.

Methods and Materials

DRIF injection is accomplished with a soil probe consisting of a length of one half inch pipe with a quick acting pistol grip trigger valve. On the other end is a specially developed needle point type tip with one eighth inch holes (2 holes approximately one and one half inches from the tip and a second set of holes at 90° angle one inch above the first set).

The probe is connected by a one half inch high pressure hose to a conventional pump capable of providing at least twenty gallons per minute capacity at three hundred pounds pressure.

The pump should have incorporated in it a screen with not smaller than one hundred mesh. Since the material to be injected is a suspension material the sprayer tank should have continual mechanical agitation. A small tank (one hundred gallons or less) is more desirable than a large tank since there will be less loss from tank sump residue that can not be picked up by the suction line.

The volume of liquid to be injected is calibrated on a time basis. Prior to injection the tip is placed in a container and the time determined to fill the container. Experimentation determined that there is no difference in the flow rate between the amount of flow into a container and flow when the point is in the soil profile.

The amount of liquid to be used at any one point of injection is referred to as a "shot". Initial work was done using a two quart "shot". Subsequent work indicated that improved results could be obtained where the quantity of liquid was increased to one gallon "per shot". There appears to be a relation between the amount of soil solution present and the volume of a "shot". The dryer the soil the greater the volume of the "shot" should be to give desirable response.

The amount of plant nutrients does not vary with the "shot" volume. The tank mix is formulated so that the amount of plant nutrient remains the same on a per "shot" basis.

The nutrient materials on a "shot" basis, currently being used in the DRIF program is four

(4) ounces of a micro fine suspension fertilizer analyzing 16% nitrogen, 22% available phosphoric acid and 22% potash. Approximately 29% of the nitrogen is water insoluble and derived from urea-form.

Micro nutrients are derived from a lignin liquid chelated mix called F.E.C. Claw-El that has the following analyses 3.0% mgO, 1.5% Fe₂O₃, 1.25% MnO, 1.25% CuO and 9.98% SO₃. Two fluid ounces of the micro nutrient mix is used per "shot".

Where there are definite micro nutrient problems present in the plant material to be treated, the general micro nutrient mix is fortified with additional minor elements such as magnesium sulfate and Geigy 330 or 138 iron as soil pH indicates. On palm trees the addition of chelated zinc and borax have shown response.

Treatment Technique and Theory

The probe tip is injected into soil to the depth of the shrub or tree's effective feeding root system. This is generally from a few inches to eighteen inches depending on the soil profile. If the hand valve is "cracked" slightly emitting a slight amount of liquid at the tip the soil will be softened and the probe enter the soil easily.

The proper amount of tank mix is dispensed in the "shot" on a time basis. It is desirable to rotate the probe 90 degrees while the liquid is being dispensed to provide a circle penetration of nutrient bearing liquid in the soil.

With 350 psi at the pump there is approximately 150 psi at the probe tip. This amount of pressure in the soil causes fracturing or lifting of the soil with the results of soil aeration and pruning of small fibrous roots. It is felt that the root pruning in most cases is beneficial in that new clean effective roots are regenerated in the soil that has been saturated with plant nutrients. If it is felt that the shrub or tree has a very restricted root system then this practice should be approached with caution. Certain plants drop their leaves when their roots are disturbed but generally they respond with new healthy foliage.

The most effective location for the point of injection on a tree or shrub is midway between the trunk of the tree and the "drip line" of the foliage. The number of shots for any particular tree is determined by the circumference of a circle midway between the trunk of the tree and the foliage "drip line". One shot is made for every three feet of circumference. If a tree has 15 feet of circumference at this point, it would receive 5 shots.

The five shots would provide 20 ounces of 16-22-22 suspension fertilizer and 10 fluid ounces of liquid micro nutrients in 5 gallons of water (1 gallon shots).

The number of "shots" on palm trees is determined by the height of the tree and vary from three to five "shots".

Shrubs are treated in a similar manner as trees except that the number of shots are determined by their height with generally one "shot" for shrubs up to three foot in height and two "shots" for shrubs over three foot in height.

Ground cover beds and solid plantings are "shot" on three foot centers through the area.

One of the most effective uses of DRIF has been in the transplanting of shrubs and trees. In this treatment the point of injection is in the space between the shrub or trees root ball and the adjacent soil. The depth of injection is one half the depth of the root ball. This treatment saturates both the root ball and the adjacent soil providing the shrub or tree a nutrient "path" for its developing roots to follow in its establishment. Plants treated with DRIF in this manner show a increased survival rate in transplanting.

Discussion

DRIF treatment is an effective method of shrub and tree feeding. It provides a significant amount of balanced plant nutrients dispersed in the effective root zone of the plant in the soil profile. The ratio of nutrients has not been altered by filtering action of the soil. Physical manipulation of the soil has taken place during the action of injection with the result that soil compaction has been

broken and root pruning by the pressure of injection encourages the development of a new effective root system.

DRIF treatment is particularly well adapted to the installation of shrubs and trees in reducing the mortality.

Plant maintenance feeding problems created by complicated landscape design such as restricted spacing, soil mulches and pavements can be overcome with the use of the *DRIF* technique and materials.

The nutrients used in *DRIF* show a plant response for six to nine months from time of application although the general plant vigor may be reflected for a much greater length of time from treatment.

Deep root injection feeding is in keeping with better ecology philosophy in that contamination of the environment through surface runoff is removed by placing the nutrients deep in the soil structure.

Experimental work has indicated that nematocides and systemic insecticides can be used in conjunction with *DRIF* feeding with beneficial effects. Systemic fungicides have been used with *DRIF* feeding but no positive observations have been made at this time. It is felt that if Benlate is used it should be applied as a separate injection because of the possible deleterious effects of the nutrients on this compound.

DRIF treatment offers a method of property maintenance by commercial operators that is adapted to urban and city area plantings that does not contaminate the environment. It offers the only method of plant feeding under some landscaping configurations.