MOISTURE & FERTILIZER DISTRIBUTION UNDER DIFFERENT SOIL-MANAGEMENT TECHNIQUES

BY

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2- REVIEW OF LITERATUE

2-1- Soil water- movement :

Green and Ampt (1911), proposed a model treating the soil as a " boundle of capillary tubes " subject to a boundry condition of $\psi \geqslant 0$ (ψ represents soil water pressure head at depth z). Soil water is considered to move as a unit with sharp front. They found that the infiltration rate decreases as the wetted depth increases. Expressed mathematically, the result of this conceptual model shows the infiltration rate :

$$f = K_s \frac{H_c + L + d}{L}$$

where : f = infiltration rate

H_c = represents capillary pressure head at the wetting front.

d = surface depth

L = distance to wetted front

K_s = effective saturated conductivity.

Kostiakove (1932), described the variation of the rate of infiltration "I" with time "t" and pertinent indices "k" and "n", in the following from :

$$I = kt^n$$

"k" and "n" are characteristic of the type and condition of soil, and can be determined from the experimental data.

Richards (1952), defined the infiltration rate in soil as the maximum rate at which a soil, in given condition at a given time, can absorb water. It has dimensions of the velocity. It is not to be confused by Darcy's equation, which is only one factor entering into the rate of infiltration.

Philip (1957 a), used the following general differential equation describing isothermal liquid phase movement in porous medium, including the effect of gravity.

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left(D \frac{\partial \theta}{\partial z}\right) + \frac{\partial k}{\partial z}$$

where : θ = volumetric moisture content,

k = permeability,

D = diffusivity ,

t = time,

z = is the downward axis.

Philip (1957 b) proposed an algebraic infiltration equation :

$$i = St^{1/2} + At$$

where : i = cumulative infiltration,

t = time,

S = sorptivity,

A = second parameter related to saturated hydraulic conductivity.

He also, stated that the first term of this equation dominates the infiltration process during the early infiltration stage and represents the horizontal infiltration. As infiltration continues, the second term becomes progressively more important until it dominates the infiltration process. Both the first and second terms represent the vertical infiltration.

Rolland (1972), stated that the laboratory studies, carried out on a dry material, not subject to swelling and strongly compacted, show that the general theory of philip would be applicable in cases of two and 3-dimensional flows. Experiments in case of one- dimensional flow showed that the cumulative infiltration curve is at first oblique, then it has a point of inflection in the neighbourhood of t=2 min. In the first few minutes of infiltration, experiments were satisfactory in that they permit good fitting of the various laws of infiltration, and in particular of philip's theory : $i = St^{1/2} + At$ " except as regards the first few minutes of the tests. He gave a value for philip's "S" coefficient (sorptivity), and for the "A" coefficient.

Awady et al. (1981),developed a statistical method based on the least square to determine philip's coefficients for different soils and methods of irrigation.

Awady and Mostafa (1975), made a study to get details required for proper trickle application including puddling, infiltration, and rate of trickling in loam. The following relationships were given to describe infiltration spread (r) at time (t) in any direction (α) from the horizontal for the rate of flow (q) :

$$\frac{r}{kt} = a\ (\alpha)\ _{w}(q^{1/3}/\ kt^{2/3})^{n(\alpha)}$$

Where (k) is an intake rate coefficient; was definitively estimated from dividing the rate of (q) by the quasi- constant pudding area after a long time after water release; a (α) and n (α) are directional indices given in the paper.

2-2- Effect of soil management on the crop yields :

The soil which is wet through capillary movement of water from a wet furrow does not lose water to evaporation as fast as from the wet portion of the soil in the furrow. Thus a method which supplies water in a manner that greatly reduces the amount of wetted surface should greatly reduce evaporation losses from the soil surface. This in turn would cause more efficient use of water in crop production and could actually conserve water.

Taylor (1952), proposed that for medium- textured soils the distance between furrows should be slightly less than twice the depth to which the soil is allowed to dry out. This is based on the finding that the wetting pattern in a clay soil is nearly circular. But after the wetting front contacts moist soil below, water conductivity increases into the moist soil, and lateral movements is greatly reduced. Often the distance between furrows is too great, then excessively deep penetration of water occurs while the essential lateral movement is taking place. The size of stream and furrow spacing should be adjected to give as uniform water penetration as possible. Frequently, a layer stream can be used at the beginning of irrigation to wet the furrow, and then the size is cut down to reduce outflow from the end of the furrow. Except for the danger of erosion, the size of stream and spacing could be increased.

Box et al. (1963), found that alternate-furrow irrigation (36- in. furrow spacing, 1320 ft. long, i.e. 0.91 -m. furrow spacing, 402 m. long) of potatoes grown on Pullman silty clay loam did not effect tuber yields compared with every- furrow irrigation. The alternate-furrow irrigation decreased water application by 30 % and intake by 13 %.

Grimes et al. (1968), reported that alternate - furrow irrigation of cotton on Hesperia sandy loam in San Joaquin valley reduced size of irrigation by 24 %. Lint yields were as good or better than every- furrow irrigation which received about 6- in. (0.15 m) of additional water. Alternate- furrow irrigation during vegetative development in May and June reduced excessive vegetative growth and plant height without affecting yield.

Newman (1968), stated that alternate- furrow irrigation on 40- in. (1.00 m) furrow spacing reduced cotton yields slightly, compared with irrigation of every furrow, but substantially increased water use efficiency. The amount of water applied per furrow was the same, thus the average size of application to alternate- furrow plots was reduced to one- half.

Longenecker et al. (1969), developed a "variable row spacing" system for irrigated cotton where 80-in. (2.00 m) spaced furrows were separated by wide beds. The space between rows of cotton on each side of the furrow was 26-in. (0.65 m). They concluded that the wide bed - furrow spacing reduced size of seasonal irrigations from

6 to 3-in. (0.15 to 0.075 m) and water use by 54 % compared with conventional 40- in. (1.00 m) spaced furrow.

New (1971), reported that alternate- furrow irrigation 40- in. (1.00 m) spacing and one half mile long (805 m) of grain sorghum on Olten loam in the Texas high plains reduced average size of five irrigations by one-third. The reduced water intake reduced grain yields from 7850 to 6890 lb per acre (8798.5 to 7722.5 kg/ha). In a separate test, water applied during five irrigations to alternate- furrows equaled the amount applied during four irrigations to every- furrow. The alternate - furrow method resulted in slightly increased yields.

Allen and Musick (1972), in reviewing previous works on alternate- furrow irrigation, concluded that a non-irrigated furrow did not serve a useful purpose when the same furrow was irrigated each time. The non-irrigated furrow zone was used to form a wide bed for a wheel traffic zone separate from the water intake zone. Yields from the 60- in. (1.50 m) bed furrows were similar to those from 40- in. (1.00 m) spacing.

Fishbach and Mulliner (1972), reported that alternate- furrow irrigation of corn on several soil types in eastern Nebraska produced yields similar to every-furrow irrigation. They also concluded that alternate- furrow irrigation (30- in. or 0.75 m furrow spacing) decreased average size of irrigation water on Sharbsburg silty clay loam by 29 %. Grain yield was reduced by 4.7 % which was not statistically significant. They also stated that electrical resistance block readings before and after irrigation indicated that 2.3 h application time resulted in soil water moving laterally under the non - irrigated furrow to a depth of 3 ft (0.91 m).

Musick and Dusek (1974, 1975), showed that alternate - furrow irrigation had little effect on water intake and yield of potatoes on Pullman slity clay loam but significantly reduced both intake and yields of sugar beets and grain surghum. The reduction in water intake and yields depend primarly on the irrigated furrow spacing and length of run. Lateral wetting extended from irrigated furrow into the adjacent nonirrigated furrow past midfield under all conditions evaluated. Some lateral wetting extended into the nonirrigated furrow on the lower part of the field when the surface layer was unconsolidated (loosend from prior tillage) or irrigated spacing did not exceed 60- in or 1.50 m (alternate-furrow irrigation of 30-in or 0.75 m bed furrow) but did not wet into the nonirrigated furrow on the lower third of the field when the surface of soil was consolidated from prior irrigation and irrigated furrow spacing was 80-in or 2.00 m (alternate- furrow irrigation of 40-in or 1.00m bed furrow). They also concluded that alternate-furrow irrigation of bed-furrow spacing exceeding 30-in (0.75m) is not recommended on slowly permeable clay loam soils. Althouth alternate- furrow irrigation significantly reduced size of irrigation, the concentration of this effect on the lower part of a field and associated yield reductions limits the usefulness of the practice for more efficient management and use of water. They also found that alternate- furrow irrigation was detrimental on water application at row lengths greater than 370 to 550 m. They attributed this to the lack of interaction between adjacent irrigation furrows. The greater tendency for lateral movement can cause greater nonuniformity in application by causing slower advance of water in the furrow.

Stone et al. (1979, 1982), found that wide-spaced furrow irrigation, applies water to the root zone while maintaining a relatively dry soil surface. This conduction reduced evaporation losses and can reduce water requirements by 20 to 50 % (depending upon amount of pre plant irrigation and whether one reverted to every-furrow irrigation after 1 August). They also reported that the principle of water conservation using wide- spaced furrow irrigation marely requires a medium to fine - textured soil. This ensures that lateral water movement from the furrow is about the same distance as vertial infiltration. Probability of yield reduction with this water conservation method is lessened by either:

1- Abandoning the wide- spaced furrow method on 1 August of a high water stress season which the atmospheric evaporated demand was high.

2- Alternating the dry furrows in an alternate-furrow scheme.

In general, they suggest that this water conserving practice should be valid in much of the semi- arid region of the world where water supply is limited .

2-3- Effect of soil moisture content on corn roots distribution :

Rhoades and Nelson(1955), Russel and Danielson (1956) , and Robins and Rhoades (1958), reported that corn roots in permeable soils removed moisture to a depths of five feets(1.52 m) or more, while with sub-soil of low permeability, root penetration and moisture removal was limited to the upper two feet (0.61 m) of soil. They added that irrigation greatly influenced the pattern of water removal. In Nebraska, where a high level of moisture on a permeable soil, about 95 % of the water used by corn was absorbed from the upper two feets (0.61 m) of soil profile. Without irrigation, only 63 % was removed from three feets (0.91 m) and 53 % from the upper two feets (0.61 m).

Letey and Peters (1957) , Boss, et al. (1962), showed that even where the top soil was kept moist, corn plants tended to extract the greater portion of their water from progressively deeper depth. They add that the extracted water increased with plant development.

Kleineidam (1965), and Vink et al. (1969),showed that corn roots were able to use soil moisture down to 160 cms during the critical period. During this period, 31 % of the total evaporation was extracted from below 60-cm and only 6 % between 100 cm and 160 cm.

2-4- Effect of nitrogen fertilizer on root growth :

Duncan and Ohlrogge (1958), found that corn roots proliferated in low- nitrogen, low-phosphorus soil contaning locolized application of nitrogen and phosphorus fertilizers together but not in soil receiving only nitrogen fertilizer.

Wiersum (1958), found that production and growth of lateral roots in media deficient in nitrogen was greater in local areas relatively high in nitrate than in