WATER DISTRIBUTION THROUGH SPRINKLERS

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INTRODUCTION

My purpose is to dray your attention to several factors that affect water distribution by sprinklers in the Columbia Basin. These factors should be carefully considered in evaluating the efficiency of water distribution by a sprinkler system and are especially important when thought is given to using the sprinkler system to apply fertilizers, herbicides, fungicides, and insecticides. Since water is the vehicle or carrier of the chemicals, my remarks will be concerned with water distribution. Certainly the distribution of any chemical carried by the water is going to be no better than the distribution of the water itself. I will use a few examples from the Columbia Basin to illustrate some points and I hope I can do this without giving you the idea that I am criticizing sprinklers or sprinkling as a method of irrigation.

In talking about water distribution through sprinkler systems, we use the term "coefficient of uniformity". This is a mathematical expression applied to a system or a portion of a system that gives it an efficiency rating for a given set of conditions. It is an attempt to say in one figure how uniformly water is being distributed over the ground surface. We like to talk about coefficients of uniformity no lower than 70% and preferably 80% or above.

Before I go any farther I want to say this. In general in the Columbia Basin we have been much less concerned about water distribution than we must be if we are going to apply chemicals in the water. I say this not only because we need to do a good job of application of the chemical, but because we have Food and Drug Administration tolerances and restriction limitations for all crops which must be met. We must not only comply with rates of material per acre, we must also be able to distribute that material uniformly enough so that none of the crop will exceed established F.D.A. residue tolerances. If this cannot be done do not apply herbicides, fungicides or insecticides through a sprinkler system. The by-words are water control and soil moisture control, both in quantity and distribution.

SOILS

Infiltration Rate

Before we talk about the sprinkler system itself, let's look briefly at the soil we are going to irrigate. In the Columbia Basin we irrigate soils with infiltration rates of only a few hundredths of an inch per hour and others with infiltration rates of 10 to 12 or more inches per hour. Also these infiltration rates vary throughout the season. Obviously to achieve the desired placement of water and chemicals in the soil, the application rate of water must be no greater than the soil infiltration rate at any time.

Soil Moisture Holding Capacity

Another very important soil characteristic is soil moisture holding capacity. After the water has moved into the soil, how much will it hold? Our soils in the Columbia Basin range from about three quarters of an inch to over three inches of available moisture holding capacity in each foot. In figure 1, I have shown an average figure to represent our coarse textured soils on the left and our fine textured soils on the right. To simplify this example I have used the same amount of available moisture in both the 1st and 2nd feet of the profile. Here we are talking about potatoes, which have an effective rooting zone of about two feet. So, even though we have a deep soil, we are only concerned with what happens in this top two feet of the soil profile, the area here shown above the dashed line.

Now if we plan to do a good job of irrigating and not permit over 30% of the available moisture to be withdrawn between irrigations, this will mean that we can use up to .30" from each of the top two feet or a total of .60" between irrigations. In the summer time when our evaporation rates normally run from .3 to .5" or more per day, we will have to irrigate every one to two days to maintain the desired moisture level.

On the fine textured soil which has 2.5 inches of available moisture per foot, .75" will be withdrawn from each of the top two feet for a total of 1.5" between irrigations. Using our daily summer evaporation rates of .3 to .5" per day again, you can see that this soil would need to be irrigated every 3 to 5 days for this moisture level.

One of the most common problems is growing potatoes under sprinklers in the Columbia Basin where we have coarse textured soils or a range in soil textures in the upper soil profile and where we do not have a sprinkler system that will permit one to two day coverage is that the interval between irrigations is too long and too much water is applied when we irrigate. Consequently we tend to over irrigate and leach water and fertilizers, especially on our coarse textured soils. If nitrogen is being applied in the irrigation water, much of it can be leached down through the root zone before the plants have a chance to absorb it.

FACTORS AFFECTING WATER DISTRIBUTION BY SPRINKLERS IN THE

Soil Moisture Holding Capacity

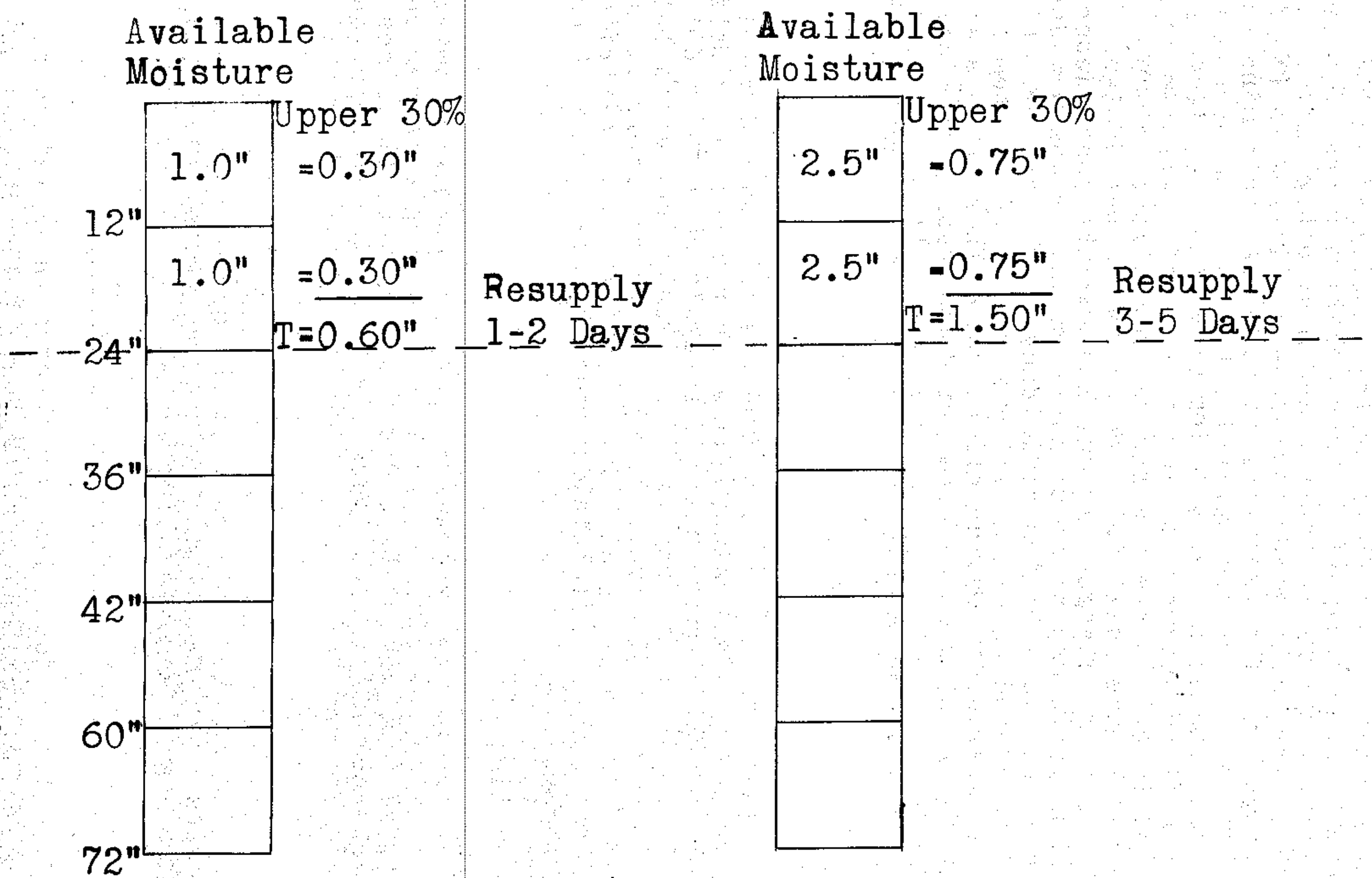

Figure 1

COLUMBIA BASIN

Design

Now let's consider the sprinkler system. I am sure that nearly all of the sprinkler systems installed in the Columbia Basin have been designed for the location where they are. The soil factors we have discussed and many other factors including the crops to be grown have been considered in the design of the system. The two major factors that determine the amount of water put out at the sprinkler head are the pressure at the nozzle and the nozzle size. Knowing these two, it then becomes a matter of adjusting set time or time of operation on a given location to obtain the desired water application. Nozzle size and pressure are built into the system in the design. These should never be changed without knowing the consequences of the change, because to do so nearly always means a reduction in the water distribution efficiency of the system. Likewise, worn nozzles and heads and other parts of the system also mean reduced water distribution efficiency. These things are especially important when we consider distributing chemicals through the sprinkler system. As I indicated earlier, the best job we can do in applying chemicals with a sprinkler system may not be good enough.

Spacing

We all have seen crooked and unevenly spaced wheel lines and hand lines. This always means poor water distribution. Ten feet of extra space between laterals on a 40' x 60' system means an increase in area of 15%. Twenty feet extra between laterals means a 30% increase in area to be covered. Errors such as these cause drastic reductions in water distribution efficiency and are intolerable from the standpoint of chemical application.

Self-Leveling Heads

Very often when we see crooked wheel lines or twisted wheel lines we also see risers operating at an angle rather than vertically as they should be. Dry areas between the lines are sure to occur when this is the case. But there is a solution for this problem and yet it is seldom seen in the Columbia Basin. I am talking about self-leveling heads. I am confident that self-leveling heads would be a good investment for most farmers in the Columbia Basin who use wheel lines especially if the application of chemicals through the sprinkler system may be a practice. I urge all of you who use wheel lines to consider also the use of self-leveling heads.

Slope or Elevation Differences in the Field

What effect does slope or changes in elevation in the field covered by the sprinkler system have on its performance? You will note that manufacturers of sprinkler equipment recommend reduced rates of application as the slope increases. However, our main concern is with the effect of slope on water distribution. Slope or elevation differences in the field cause pressure differences in the sprinkler system unless compensated for in the design or by other means. Let's use an example of an installation here in the Basin that will illustrate the point I am trying to make. T his is a circular self-propelled system installed on a field that has 100 feet of difference in elevation from top to bottom. Now is we convert that 100 feet of elevation difference into pressure, we have 43.3 pounds per square inch of pressure. If the sprinkler on the end of the lateral has an operating pressure of 35 pounds per square inch when it is on the highest part of the field, it will have an operating pressure of 78 pounds per square inch when it reaches the low part of the field [35 psi + 43 psi = 78 psi]. The actual difference would be somewhat less than this because of the increased friction loss resulting from the increased water flow in the lateral. Using a 9/64" nozzle as an example, at 35 pounds per square inch it puts out 3.40 gallons per minute. At 78 pounds per square inch a 9/64" nozzle puts out 5.11 gallons per minute. This means that as this system rotates it could apply up to 50% more water on the lower part of the field than it applies on the upper part of the field. It is obvious then that if the upper part of this field is adequately irrigated, that leaching will occur on the lower part because it will be constantly over irrigated. If nitrogen is applied through this system, as it was this past year, it can also be expected to be leached since it moves readily with the water in the soil. Likewise any other chemical applied through this system could be expected to have an application pattern similar to that of the water. Elevation differences in the field will affect the performance of all systems because of pressure changes unless they are compensated for in the design or corrective measures are used to prevent it. In this system the corrective measure needed is the installation of pressure control regulators in each sprinkler riser.

Sprinkler Head and Nozzle Size

Now I would like to show you the results of some tests we ran on a solid-set sprinkler system this past season. Here changes in sprinkler head and nozzle size resulted in considerable improvement in the distribution pattern of the system. In running these tests "catch cans" were placed in a grid pattern under a portion of the system. You see here in graph form, figures 2, 3, 4, and 5, the amounts of water that fell in the cans at the different locations between the laterals.

We ran the first test, figure 2, because the crop was showing definite signs of moisture stress between the laterals. The test pattern clearly shows the reason for these drought symptoms. The dashed lire shows the theoretical application rate in each case based on nozzle pressure, nozzle size and the coefficient of uniformity. Wind was a factor in this test. In a second test, figure 3, a larger nozzle in the same head gave an improved distribution pattern but it still was not satisfactory. Heads 2 and 3, figures 4 and 5, tested at the same time

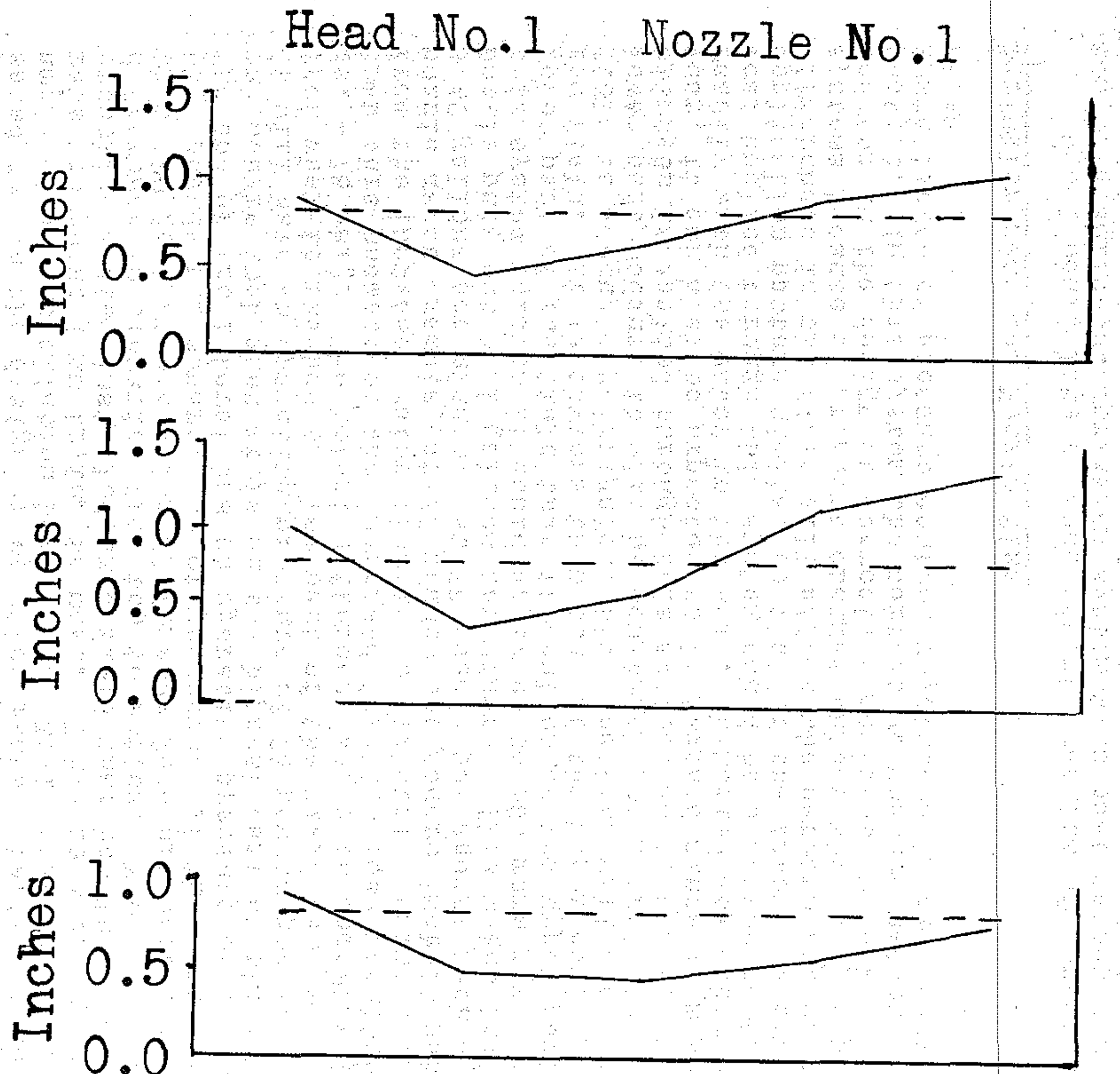
Head No.1 Nozzle No.1
Inches
1.5
1.0
0.5
0.0
Inches
1.5
1.0
0.5
0.0
Inches
1.0
0.5
0.0

Figure 2

Head No. 1 Nozzle No. 2

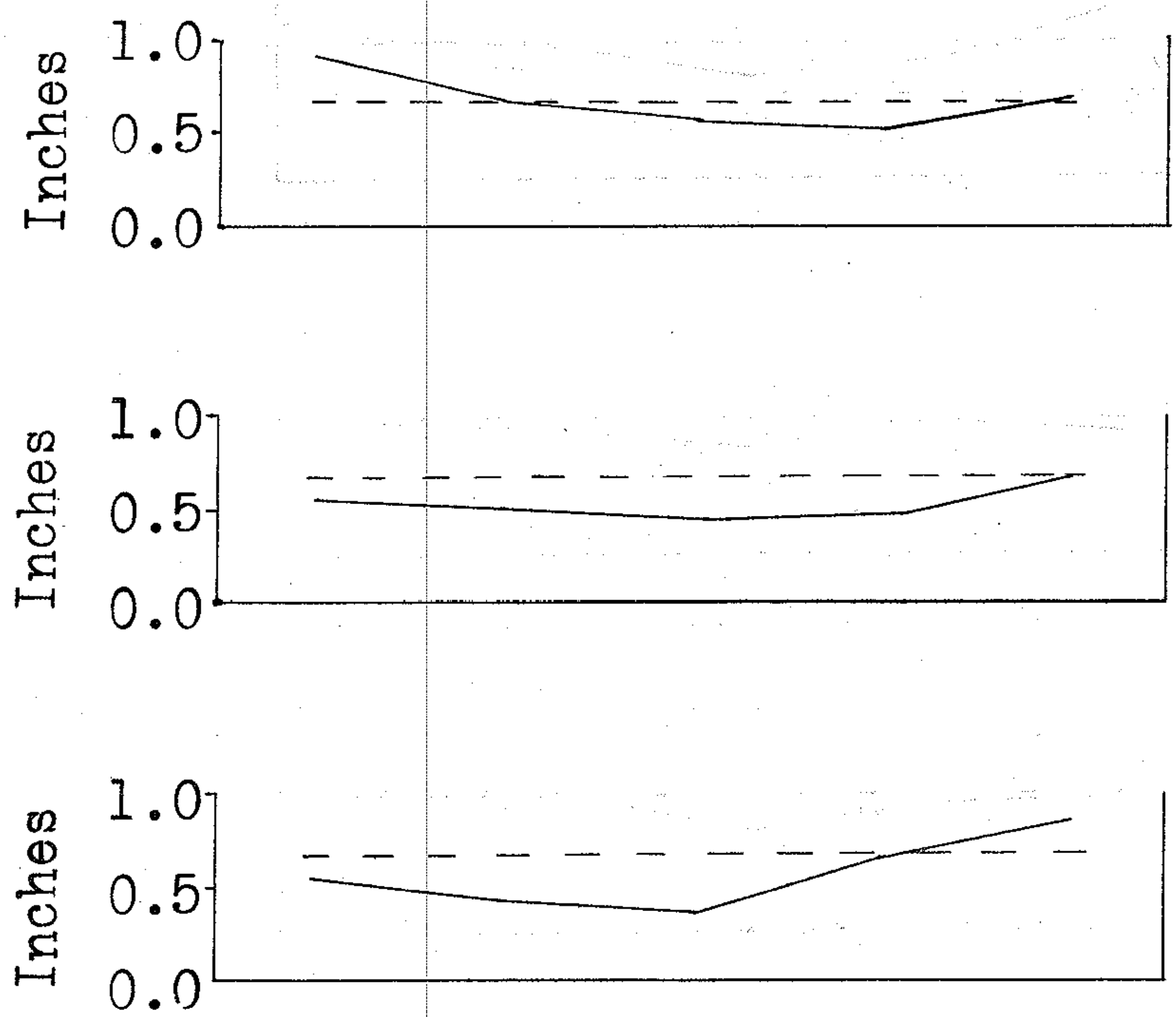

Figure 3

Head No. 2 Nozzle No. 2

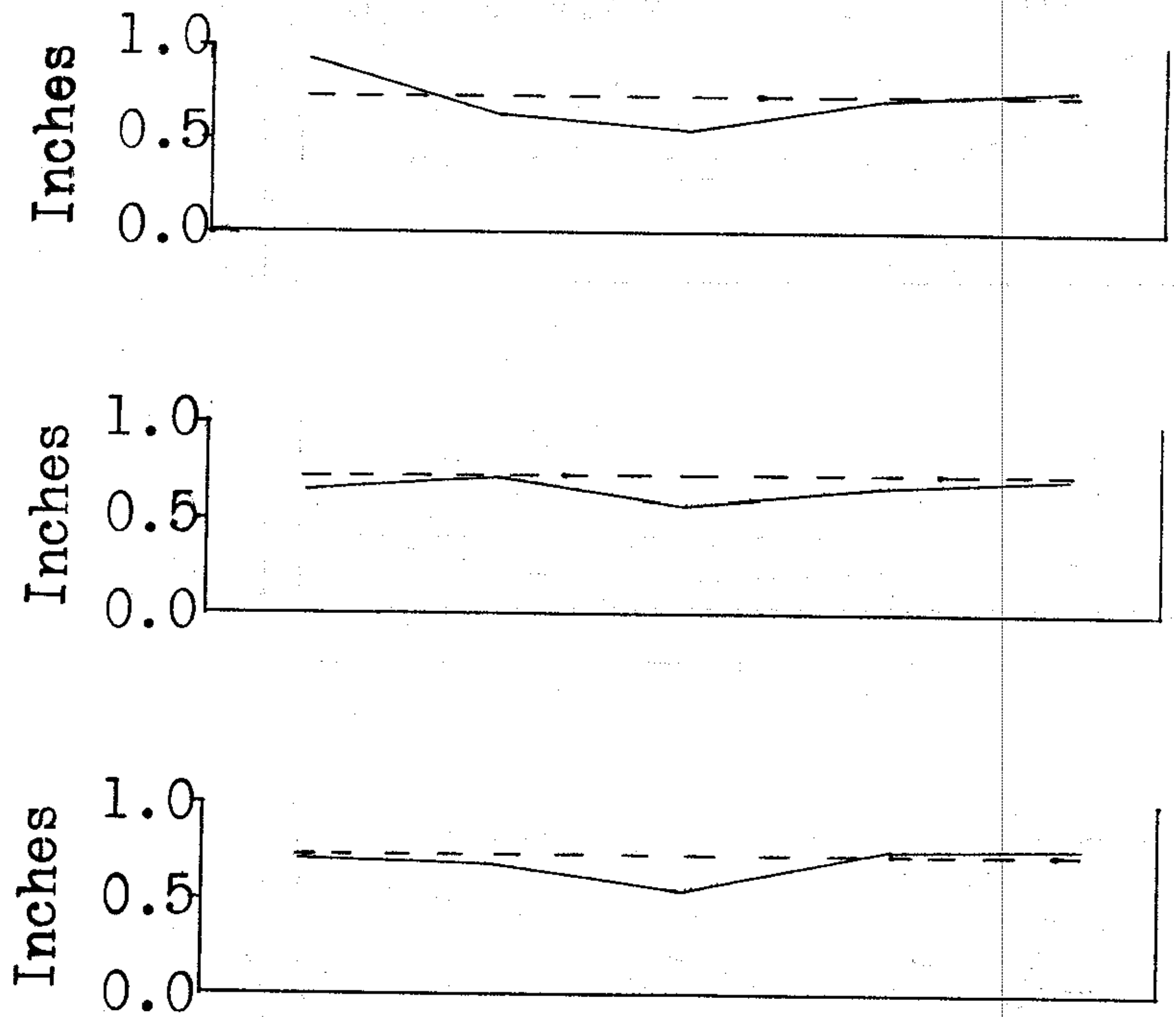

Figure 4

Head No.3   Nozzle No.2

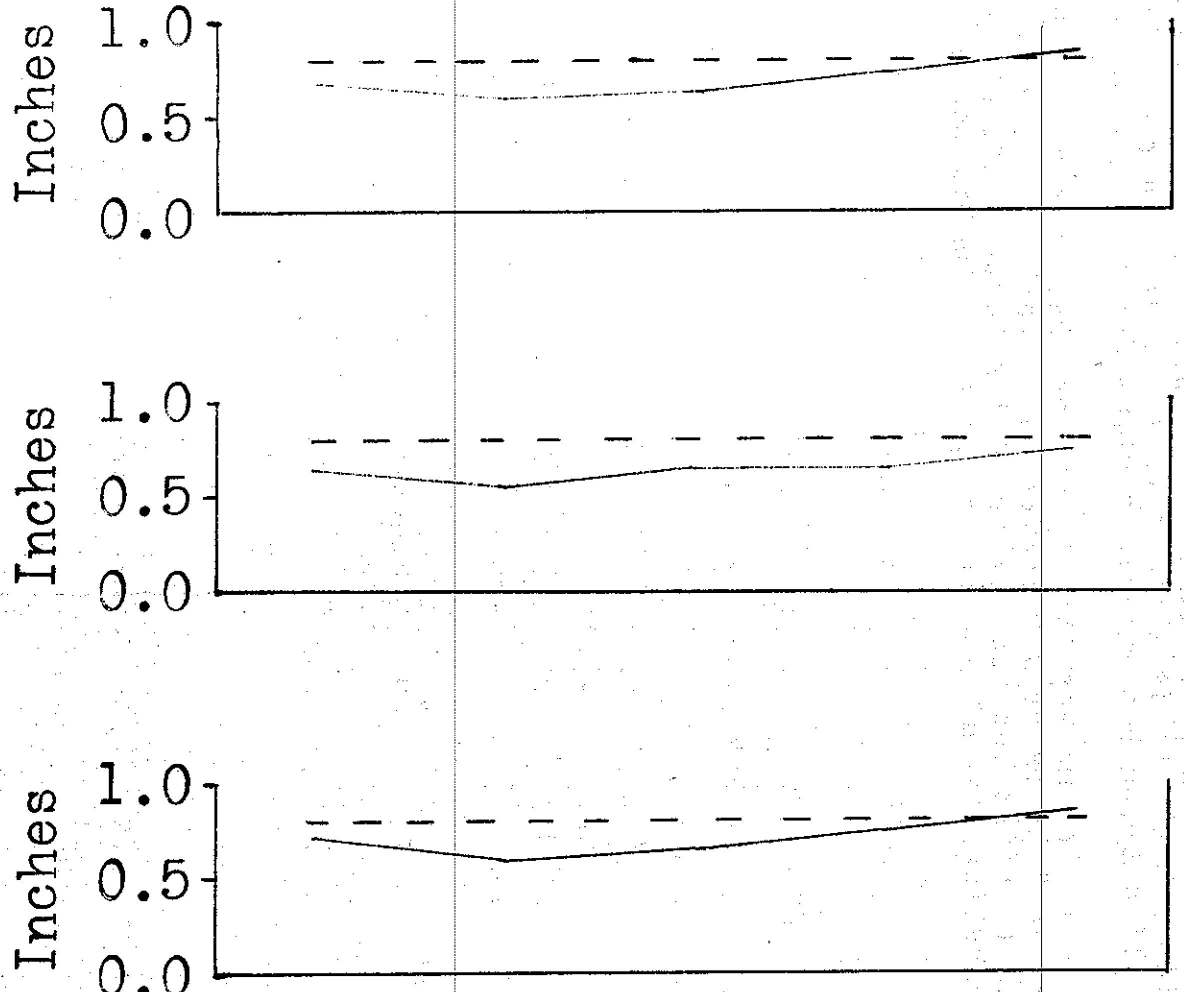

Figure 5

and under the same conditions as head No. 1 gave much more uniform distribution patterns.

Last of all we get to the biggest culprit of all --- wind! There is little doubt that wind is the major cause of distorted sprinkler patterns in the Columbia Basin and it is the one over which we have the least control. The same conclusion has been reached in other areas. We have all seen its effects on our fields. Systems do vary in the amount of distribution pattern distortion that a given amount of wind will cause. The height of the sprinkler head above the ground, the stream size, the nozzle angle, the pressure, the spacing, the wind speed and direction all have their influence on the amount of distortion that wind will cause. Research is going on to provide better wind tolerance in sprinkler systems. However, wind still remains, at the present time, our number one problem in water distribution through sprinklers. The main suggestion I can make is that fertilizers and other chemicals not be applied through sprinkler systems during windy periods.

Again let me say that my purpose here was not to be critical of sprinklers or sprinkling as a means of irrigation, but rather to point out some of the major factors affecting water distribution through sprinklers in the Columbia Basin.