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Use of Raingun Sprinkler System for Enhancement of Wheat Production

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Abstract

The experiment was conducted on two hectares. One hectare was allocated for raingun sprinkler irrigation while other was reserved for the border irrigation. The magnitude of water saving, crop yield and benefit cost ratio were used as parameters for comparison of the two irrigation systems. The application efficiency under border irrigation varied from 56 to 67% while for raingun sprinkler system it was 88% in the beginning of the season and decreased to 78% with the maturing of the crop due to interception losses. The crop yield under raingun sprinkler irrigation was 2'7% higher as compared to the border irrigation method in addition to water saving of 41%. The benefit cost ratio was found to be 1.98. However, the performance of raingun irrigation system should be evaluated on a large scale under irrigated agriculture areas for recommendations for its adoption.

Key words: Raingun sprinkler, Enhancement, Wheat production

Introduction

Pakistan's irrigated agriculture is facing a deficit of irrigation water. From total available supply of 8.5 MHM of water, our fields get only 6.1 MHM. Thus Pakistan's crops have water deficit of about 30% against crop water requirements. (Ahmed, 1985). Each farmer during his turn of irrigation in Warabandi system is allocated specific time period in proportion to his land holding. the total time available to irrigate the crops usually varies from 37 to 54 minutes per hectare. Thus an average farmer owing 1.6 to 2.4 hectares of land gets water for only one to two hours during his turn. In his allocated time he is able to irrigate only a small area of about 0.4 to 0.6 hectares or even less, in case he is sitting at the tail end of the watercourse.

This low amount of irrigation water naturally results in less crop yield and cropping intensity. Micro-irrigation offers a large degree of control of water application to meet water requirements of crops. Irrigation scheduling of micro-irrigation systems is usually based on a water budget method to maintain a favorable soil water content status in the root zone, i.e., to minimize periods of water stress and leaching below the root zone. However, for localized micro-irrigation systems, it is difficult to evaluate the various terms of the water balance. Detailed soil water monitoring is necessary to obtain accurate estimates of actual water use.

A field study was initiated to evaluate the use of micro-sprinklers for irrigation of wheat crop for evaluating the physical performance of various micro-irrigation systems (Schwankl et aI., 1996).

Micro-sprinkler irrigation has the advantages of drip irrigation, but irrigation water is applied over a surface area larger than under drip irrigation. Consequently, the root system is distributed within the larger wetted soil volume, thereby making available a larger reservoir for plant nutrients and water which may be needed in high water demand periods. Moreover, most of the active roots will develop in the upper soil layers where the organic matter content is at a maximum (Dasberg. et al., 1985; Hamer, 1987; Kjelgren et. al., 1985; Meyer and Peck, 1985; Roth and Gardner, 1985. Micro-sprinkling is particularly suitable for soils with low permeability and small soil water storage, or on hill slopes where runoff might occur. As with drip irrigation systems, micro-sprinklers are designed for high frequency irrigation and application rates can be controlled to minimize -surface pounding. Moreover, the larger wetted area of the micro-sprinkler precludes the formation of localized salinity accumulation, whereas salinity levels are typically low near the soil surface and increasing with depth. Disadvantages of micro-sprinklers are associated with water losses due to wind effects and evaporation. Micro-sprinkler distribution uniformity has also been of concern since micro-sprinklers tend to have poor application uniformity over their wetted-area.

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Nevertheless, studies with different types of micro-sprinklers (Goldhamer et. al., 1985; Klassen, 1986; Post et. al., 1984 Post et aI., 1985, 1986; Renn, 1986) have shown a uniform soil water distribution in the root zone. Thus, the low application uniformity does not necessarily affect the spatial distribution of tree roots and the corresponding root water uptake (Boman, 199 I; Meyer and Peck, 1985).)

Since water is a scarce input for our agricultural fields, but unfortunately we still not effectively using this precious amount of water to boost our agricultural production. It was estimated that our overall irrigation efficiency is about 41%. From the water available at the field Nakka, water lost during application to fields is about 20% (Clyma et al, 1975). As we all aware that: we have already deficit of irrigation water, hence there is a dire need to effectively use irrigation water by using modern irrigation methods exhibiting high efficiency in water application. in addition to a promising maximum yield per hectare.

Raingun sprinkler system introduced in the country for using the rain water in Barani areas is looked upon to have equal potential *for* applying the available water supplies efficiently under irrigated areas.. In the sprinkler irrigation system the farmers have to store the irrigation water in the tanks thus helping them to offer flexibility in the supply of irrigation water to the fields. Moreover a sprinkler can apply irrigation at a rate which is less than the inflow rate of the soil. This helps in the total elimination of runoff losses, thus eliminating deep percolation losses also. This system is also suitable for tail end users which are facing the difficulty in getting equitable distribution of irrigation water.

Keeping these facts in mind, this study was developed to check the performance at sprinkler irrigation system as compared with traditional border irrigation method.

Methodology

This experiment was conducted at the Post Graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad. The soil type of the site was loamy sand. A storage tank of the size of 6 by 3 m was constructed in the experiment area to store water during Warabandi system. One hectare was irrigated with border irrigation method while the other one by raingun sprinkler irrigation. The area under border irrigation was divided into eight equal plots, each of size 15.25 by 7.50 m. Thus to irrigate each border a stream size of 4.00 l/s/m was used. On the rest one hectare under sprinkler irrigation, a raingun (PYl-50 China) with nozzle size of 18 mm diameter was used. The wetted area was calculated from the measured wetted radius at raingun. The depth of irrigation water applied was calculated as under:

$$I_a = 3600\ Q/A_w$$

Where

A_w = Wetted area m^2

Q . = Sprinkler discharge, lps.

I_a = Rate of irrigation applied, mm/hr.

It was observed that the circle of influence varied from 47m to 63m with water application rate from 9.6mm/hr to 11.52 mm/hr respectively. The said nozzle was operated through a 16 hp diesel engine with high pressure pump. Pressure ot the pump was measured by a pressure gauge of '7.00 kg/cm^2 installed on the pump. The pressure of the pump was varied from 3.15 to 5.95 kg/cm^2 at 2900 rpm using suction and delivery pipes of 7.60 and 6.35 cm diameter respectively. The discharge of the pump was measured and noted to be, varied from 5.55 lps to 8.11 lps.

The soil of the experiment was analyzed for bulk density and was calculated to be 1.43 gm/cm3. To determine the available soil moisture range, soil infiltration rate was also calculated and was measured to be 12.5 mm/hr. Water in both treatments was applied at 50% soil moisture deficit.

Application efficiency in the sprinkler irrigation system is the ratio of the amount of water reaching the root zone to the amount of applied water as measured by the sampling cans, spread in the field in the range of circle of influence. Water stored in the root zone was measured by gravimetric method up to 60 cm soil depth. Considering 2% evaporation losses (Christiansen, 1976) from sprinkler gun spray in still air, the application efficiency was calculated using the equation

$$Ea = 100\ Ws/Wp$$

Where

Ea = Application Efficiency (%)

Ws = Water stored in the root zone (cm)

Wp = Water delivered by the system (cm)

Application efficiency for border irrigation was also calculated using the same formula. Application efficiency of raingun sprinkler irrigation and border irrigation was compared to work out how effectively water was applied in each system.

Economic viability of any irrigation system is an important criteria that suggests its adoption by the farmers. Economic analysis was worked out using benefit cost ratio, by the following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross benefits (Present value)}}{\text{Gross costs (Present value)}}$$

The gross costs and benefits are discounted over the life of the project by a selected annual rate cf interest. The difference between the two amounts is the present value of net benefits. The ratio of the two amounts is the gross cost-benefit ratio (Gilpin.A. 1973). Costs include the fixed costs i.e. depreciation cost and interest on capital, the variable costs i. e. repair & maintenance of any engine, sprinkler clamps, couplings etc, labour cost and fuel and lubricant costs. The life expectancy of a sprinkler system varies with treatment, use and storage thus averaging bout 15 years.

Results and Discussion

The comparison of sprinkler and border irrigation system were made based on the application efficiency, magnitude of water saving and crop yield and benefit cost ratio.

Application efficiency

In case of border irrigation the application varied from 56 to 67% during the whole cropping season (Table 1). The increase in application efficiency after first irrigation in border can be attributed to progressively decreasing soil infiltration rate due to filling of soil air spaces by sedimentation during irrigation. The second reason might be the increase in evapotranspiration with the growth at the crop.

The application efficiency of raingun sprinkler system varied from 88 to 78% during the whole season differs with border irrigation. The decrease in application efficiency with the time under the raingun sprinkler system was due to the interception losses as the crop moves towards maturity. These interception losses increased due to more leaf area and growth of plants. On account of this interception losses, more water was needed to be applied for replenishing soil moisture deficiency with the growth of the crop and this reduced the application efficiency.

Water saving

In case of border irrigation water required to replenish the soil moisture deficit at each irrigation varied from 2.00 cm to 5.70 cm and water applied varied from 9.95 to 8.69 cm. The total water applied was *45.25* cm in case of border irrigation for the whole season. In case of sprinkler irrigation water required to replenish the soil moisture deficit varied from 2.00 cm to 5.75 cm through out the season for different irrigations.

Table 1: Application efficiency under border and sprinkler irrigation.

Irrigation No.	Border irrigation		Ea	Sprinkler Irrigation		Ea
	Ws	Wd		Ws	Wd	
1	5.57	9.95	56	2.14	2.43	88
2	5.64	9.10	62	3.98	4.61	86
3	5.68	8.80	64	4.85	6.01	81
4	5.75	8.71	66	5.05	6.37	79
5	5.82	8.69	67	5.80	7.48	78

Table 2 Water applied and water saved in border and sprinkler irrigation.

Irrigation No.	Water required to maintain field capacity (cm)		Water applied (cm)		Saving (%)
	Border irrigation	Sprinkler irrigation	Border Irrigation	Sprinkler Irrigation	
1	2.00	2.00	9.95	2.43	76
2	3.60	3.69	9.10	4.61	49
3	4.33	4.81	8.80	6.01	32
4	4.51	4.90	8.71	6.37	27
5	5.70	5.75	8.69	7.48	14
Total			45.25	26.82	41

The depth of water applied was from 2.43 to 7.48 cm for different irrigations. The total water applied through. raingun sprinkler irrigation was worked out to be 26.82 cm during the whole season. It implies that 18.43 cm more water has applied on plots under border irrigation till the maturity at the crop. Thus the saving of water in sprinkler irrigation, observed for different irrigations, varied from 6 to 14% (Table 2) with an average saving of about 41% as compared to the border irrigation. It indicates that 70 percent more area can be irrigated with the amount of water saved by raingun sprinkler irrigation. In other words, 1.7 times more area can be irrigated with sprinkler method of irrigation as compared to border irrigation which agrees with the results obtained by Sivanappan, 1992.

Yield of wheat

Data on yield of wheat in g/m^2 has recorded from randomly selected four locations in both the fields under border and sprinkler irrigation as shown in Table 3. The average yield was observed to be 3975 and 5077 kg per hectare under border and raingun sprinkler irrigation respectively. Hence raingun sprinkler irrigation gave 27 percent more yield as compared to border irrigation method. It may be attributable to high irrigation and fertilizer use efficiency in sprinkler method of irrigation as less water was leached in comparison with border irrigation. Besides, raingun sprinkler irrigation also provided an ideal seed bed for the Young plants and minimized the effect of crust formation on young shoots.

Table 3: Yield of wheat under border and sprinkler irrigations.

Plot No.	Border Irrigation (GM/M^2)	Sprinkler Irrigation (GM/M^2)
1	388	518
2	401	506
3	409	509
4	392	498
Average	398 (3975 kg/ha)	508 (5077 kg/ha)

Economic analysis

In order to workout the feasibility of using the raingun sprinkler system under farmer's conditions, the gross benefit ratio was calculated. For this purpose the economic analysis was worked out and the computed benefit cost ratio figures to 1.98. The high benefit cost ratio shows that it is quite economically feasible to use the raingun sprinkler irrigation system for crop production under irrigated agriculture and it conforms with the results obtained by Sivanappan. K. R. 1992.

However apart from many advantages in the sprinkler irrigation system there are certain problems faced during this study. Transportation of the sprinkler system, rolling of canvas pipe, stability of raingun under high pressure water pumping and starting of diesel engine are some of the laborious works during the operation of the system.

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