Effect of Basin, Furrow and Raingun Sprinkler Irrigation Systems on Irrigation Efficiencies, Nitrate-Nitrogen Leaching and Yield of Sunflower

M. A. Rana¹, M. Arshad and J. Masud²

ABSTRACT: A field study was conducted on sunflower by using different irrigation techniques, such as basin, furrow and raingun sprinkler systems at Post-Graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad during 1998-2002. The comparison of irrigation efficiencies, nitrate leaching and the yield of sunflower was noted. Both the efficiencies i.e., water application and water use efficiency, were maximum in case of raingun sprinkler irrigation system as compared to basin and furrow irrigation system. Use of raingun sprinkler irrigation during early crop season helped in saving water when the soil infiltration rate was very high and need of water in the rootzone was less. Using raingun sprinkler irrigation system, 30.8% and 28.3% higher water use efficiency and 21.1% and 9.0% more water application efficiency was achieved as compared to basin and furrow irrigation system, respectively. It was observed that nitrate-nitrogen leaching was low with 50 mm depth of irrigation by raingun sprinkler irrigation as compared to 75 mm depth of irrigation by basin and furrow irrigation system. Furthermore, sufficient amount of nitrate-nitrogen was available in the upper layer of soil under raingun as compared to basin and furrow irrigation in which more amount of nitrate-nitrogen leached down. About 5.64% and 1.71% more yield was obtained in raingun sprinkler irrigation system as compared to basin and furrow irrigation systems, respectively. Therefore, it was concluded that raingun sprinkler irrigation system is the most feasible system in barani areas.

KEYWORDS: Irrigation methods, Efficiency, Leaching, Crop yield.

INTRODUCTION

Lower water application efficiencies at field level must be improved to overcome the shortage of water. Improvement in application efficiencies will reduce the problem of waterlogging and salinity. It is, therefore, important to develop techniques to use the available resources of irrigation water more efficiently during field application. Application efficiency can be increased by adopting pressurized irrigation system like raingun sprinkler irrigation, however, this system is expensive and difficult to operate by common farmers. Studies have shown that well designed and well managed surface irrigation systems have comparable application efficiencies to those of pressurized system. Therefore, it is important to improve surface irrigation systems and their management to increase application efficiency without lowering crop yield.

Haq (1990) reported that water saving in case of sprinkler irrigation compared with surface irrigation system was 30%. Crop production per unit of water used in sprinkler irrigation was 4.13 kg/m³ as compared to 2.88 kg/m³ by surface irrigation. Electrical conductivity of soil remained almost same in case of sprinkler system while in gravity system it was increased at post harvesting at 30 to 45 cm depth. Same was the case for sodium adsorption ratio (SAR). However, nitrogen contents were more in case of sprinkler than gravity system.

Latif (1990) conducted different field experiments to compare the magnitude of water saving under sprinkler and surface irrigations. The saving of irrigation water under sprinkler irrigation was
found to be 46 to 65% for different crops with an average of more than 50%. Iqbal (1994) conducted a study in feasibility of raingun sprinkler irrigation for corn (fodder) under farmer’s condition and water use efficiency was 1.82 times more than surface method of irrigation with 34.52% of water saving.

Cetin (2002) used sprinkler irrigation system for cotton as a result of increased pressure to develop new irrigation technology suited to limited water supply as well as to specific topographic and soil conditions. In this study, the effect of three different methods (furrow, sprinkler and drip) on seed-cotton yield, shedding ratio and certain yield components were presented. The maximum cotton yields were 4380, 3630 and 3380 kg/ha for drip, furrow and sprinkler irrigation, respectively. Drip irrigation produced 21% more seed-cotton than the furrow method and 30% more than the sprinkler method. Water use efficiency proved to be 4.87, 3.87 and 2.36 kg/ha/mm for drip, furrow and sprinkler irrigation, respectively. Shedding ratios ranged from 50.8 to 59.0% (furrow), 52.9 to 64.8% (sprinkler), 50.8 to 56.8% (drip), depending on the amount of water applied.

Nazirbaye et al., (2005) compared furrow (conventional) and drip irrigated corn yields for two consecutive years. It was found that maize irrigation water use for furrow irrigation ranged from 547 to 629 mm per year compared with 371 to 428 mm per year for drip irrigation.

Rajak et al., (2006) conducted field experiments on a saline vertisols during 2000–2002 for evaluating the response of cotton with drip and furrow irrigation method in four different blocks varying in soil salinity (EC_e, surface 0.6 m) and watertable depth. The growth and yield performance of cotton irrigated through furrows, even though with good quality canal water, was poor when compared with drip irrigation with marginally saline water.

This study was planned to determine the suitability of most efficient system in the irrigated areas and to suggest measures helpful in promoting its adoption in the irrigated areas of the country.

MATERIAL AND METHODS

The experiment was conducted at the research area of the Water Management Research Centre (WMRC), at Post-graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad during 1998-2002. The type of soil in research area was sandy loam. The total area (0.75 hectares) was divided into three portions for basin, furrow and raingun sprinkler irrigation systems. The area for basin and furrow was 0.21 ha each while area for raingun sprinkler irrigation system was 0.23 ha. Three replications were used for each treatment, the size of the basin was 28 m x 24.5 m while in furrow irrigation system each replication was consisted of 12 furrows with a length and width of 75 m and 0.75 m, respectively for each furrow. For sprinkler irrigation, 48 m x 48 m plot was selected and water was applied through raingun sprinkler. Sunflower was sown in all the irrigation systems using fertilizer rate of 40, 30 and 20 kg/ha of N, P and K, respectively.

The crop was sown with cotton hand-drill maintaining row to row distance of 0.75 m and plant to plant distance of 0.23 m. Each irrigation was applied at 50% soil moisture deficit (Michael, 1978) using cut-throat flume of 9’x8” for basin and furrow irrigations while for raingun sprinkler, the flow was measured from the storage tank for specified time interval. Gravimetric method was used for the soil moisture determination. Replicates of the treatments were placed in the experimental plot according to the randomized complete block design.

RESULTS AND DISCUSSIONS

Water Application Efficiency

The results of water application efficiency are presented in Figure 1, which showed highest application efficiency of 90.5% in case of raingun sprinkler irrigation system. The application efficiency of furrow irrigation system was 82.3%. Thus, by saving 25 mm depth of irrigation and using highest application efficiency of 90.5%, a reasonable increase in yield was achieved by raingun sprinkler irrigation system. In addition to this, by achieving highest application efficiency of 90.5% under Raingun Sprinkler Irrigation System...
Effect of Basin, Furrow and Raingun Sprinkler Irrigation Systems on Irrigation Efficiencies, Nitrate-Nitrogen Leaching and Yield of Sunflower

5.33% and 1.70% more yield was obtained as compared to basin and furrow irrigations.

**Water Use Efficiency**

The results of water use efficiency for the basin, furrow and raingun are given in Figure 2. The results indicated significant differences in the three irrigation systems. Highest water use efficiency i.e. 0.85 kg/m$^3$ was obtained in case of raingun sprinkler irrigation system as compared to 0.61 and 0.55 kg/m$^3$ for furrow and basin irrigation systems, respectively.

![Figure 1: Water Application Efficiency for Different Irrigation Methods](image1)

![Figure 2: Water Use Efficiency for Different Irrigation Methods](image2)
It was observed that the raingun sprinkler irrigation system used the water more efficiently as compared to other two irrigation systems. Water use efficiency in case of basin and furrow irrigation system was nearly equal with only 3.72% difference, whereas this difference of efficiency was greater (31%) in case of raingun sprinkler irrigation system. Water use efficiency in case of raingun irrigation was 28.3% and 30.96% higher than furrow and basin irrigation systems, respectively. Furthermore, the selection of sprinkler or surface irrigation system depends upon the suitability of the system to socio-economic conditions of the farmer, his technical skills and availability of servicing facilities and spare parts. The benefit-cost ratio of the raingun sprinkler irrigation was found as 1.81, which indicated that the raingun sprinkler irrigation system was economically feasible.

Nitrate-Nitrogen Concentration under Different Irrigation Methods

The concentration of nitrate-nitrogen under basin, furrow and raingun sprinkler irrigation methods are shown in Figures 3, 4 and 5, respectively. The analysis showed that by applying recommended dose of fertilizer (40, 30 and 20 kg/ha of N, P and K, respectively) and by using 75 mm depth of irrigation in basin and furrow, and 50 mm in raingun sprinkler irrigation system, highly significant results were obtained under different methods of irrigation, depths of irrigation, and number of irrigation. It was observed that by using less amount of irrigation in case of raingun sprinkler irrigation system, more nitrate (2.79 ppm) was available for plants, while less amount of nitrate-nitrogen (2.13 ppm) was found in case of basin irrigation at each depth. It was also noted that as the soil depth increased from 0-60 cm, nitrate-nitrogen concentration also showed a declining trend. It was found that 63% less amount of nitrate-nitrogen was available in the lowest soil depth (45-60 cm) as compared to top depth (0-15 cm) of soil. Highest amount of nitrate-nitrogen (4.22 ppm) was available in upper depth (0-15 cm) of soil under raingun sprinkler irrigation system while minimum amount (1.16 ppm) was found in basin irrigation system in the lowest depth (45-60 cm) of the soil. Finally, it was concluded that nitrate-nitrogen leaching was low.
when 50 mm depth of irrigation was applied by raingun sprinkler irrigation as compared to 75 mm depth of irrigation applied for basin and furrow irrigation systems. Hence, more amount of nitrate-nitrogen was available in the upper layer of soil, which contributed to increase in the yield as compared to basin and furrow irrigation in which most of the nitrate-nitrogen leached down.

### Grain Yield

It was observed that the yield in case of raingun sprinkler irrigation system was 5.64% and 1.71% higher as compared to basin and furrow irrigation systems, respectively. It was concluded that by saving 254 m$^3$ of irrigation water, a reasonable increase in yield i.e. 152.35 kg/ha and 48.9 kg/ha was obtained in raingun sprinkler irrigation system as compared to basin and furrow irrigation systems, respectively, as shown in Figure 6.
CONCLUSIONS

- Water application and water use efficiencies were maximum in case of raingun sprinkler irrigation system as compared to basin and furrow irrigation system. Use of raingun sprinkler irrigation during early crop season helped saving water when the soil infiltration rate was high and need of water for roots was less.
- About 30.8% and 28.3% higher water use efficiency was achieved by using raingun sprinkler irrigation system as compared to basin and furrow irrigation system, respectively.
- About 21.1% and 9.0% more water application efficiency was observed by using raingun sprinkler irrigation system as compared to basin and furrow irrigation systems, respectively.
- In case of raingun sprinkler irrigation system, about 5.64% and 1.71% more grain yield was obtained as compared to basin and furrow irrigation systems, respectively.

REFERENCES


