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N Phani Bhushan Reddy
Department of Soil Water Engineering, S.V. College of Agricultural Engineering and Technology, I.G.K.V., Raipur

Dr. BL Sinha
Department of Soil Water Engineering, S.V. College of Agricultural Engineering and Technology, I.G.K.V., Raipur, Chhattisgarh, India

Dr. MP Tripathi
Department of Soil Water Engineering, S.V. College of Agricultural Engineering and Technology, I.G.K.V., Raipur, Chhattisgarh, India

Dr. Jitendra Sinha
Department of Soil Water Engineering, S.V. College of Agricultural Engineering and Technology, I.G.K.V., Raipur, Chhattisgarh, India

Dr. MK Pardhan
Assistant Professor (Computer Science), Department of Agricultural Statistics, College of Agriculture, Indira Gandhi Krishi Vishva Vidylay, Raipur, Chhattisgarh, India

Correspondence
N Phani Bhushan Reddy
Department of Soil Water Engineering, S.V. College of Agricultural Engineering and Technology, I.G.K.V., Raipur, Chhattisgarh, India

Performance of sprinkler irrigation system in Mungeli district of Chhattisgarh

N Phani Bhushan Reddy, Dr. BL Sinha, Dr. MP Tripathi, Dr. Jitendra Sinha and Dr. MK Pardhan

Abstract
A portable sprinkler irrigation system was installed with the objective of the performance of the sprinkler system in three patterns namely: application efficiency, uniformity coefficient and distribution efficiency. Uniformity measurements were performed using Catch can test were carried out to determine the performance of irrigation applied with the portable sprinkler irrigation systems under field conditions. The results of the field performance indicated that the average value of Uniformity Coefficient (CU), Distribution Uniformity (DU) and application efficiency were obtained 80.7%, 70.8 % and 73.1% respectively, indicating satisfactory performance of the sprinkler system. It can be concluded that Due to the change in the application rate and the area, different sprinkler shapes and types of heads resulted in different uniformities.

Keywords: Sprinkler irrigation, application efficiency, uniformity coefficient, distribution efficiency

Introduction
Water is essential substance for sustaining life on the earth. Its consumption by the agriculture sector continues to dominant the overall requirements of water. Moreover the increasing population, urbanization and unsustainable consumption of water have further imposed the greater demands on water in arid and semi regions of the country. Thus it becomes indispensable to properly manage water at all levels in order to fulfill their food and fiber requirements. Micro irrigation technologies constitute an element of such innovative intervention approaches. Originally, micro irrigation was often associated with the capital-intensive, commercial farms of wealthier farmers. The systems used on large farms, however, are unaffordable for smallholders and are not available in sizes suitable for small plots. Recently, these technologies have gone through technical transformations from largely capital-intensive features to an input mode. Though both drip and sprinkler irrigation methods of irrigation are treated as MI, there are distinct characteristics differences between the two in terms of flow rate, pressure requirement, wetted area and mobility.

In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small nozzles. The pressure is usually obtained by pumping. With careful selection of nozzle sizes, operating pressure and sprinkler spacing the amount of irrigation water required to refill the crop root zone can be applied nearly uniform at a rate to suit the infiltration rate of soil. Sprinkler irrigation methods are needed for more scientific and economic use of water for food production. This method prevents soil deterioration in the form of scouring, packing and crusting of soil, rise in water table, disposal of fertile top soil, reduction of soil permeability etc. Moreover the method is best suited for irregular topography, sloping grounds, and fields containing crops with different water requirements. It can serve a large number of farmers with the same supply line. The total area covered by MI systems is 4.94 million hectares of this, nearly 38 % is under drip systems, and the remaining 62 % is under different types of sprinklers. Sprinkler systems in the country are mainly used for field crops such as wheat, sorghum, pearl millet, groundnut and mustard. But the use of sprinklers is often limited to certain part of the crop season when farmers face severe shortage of water in their wells.

Material and methods

The need for nursery and landscape managers to test sprinkler uniformity cannot be overemphasized. This consists of setting up a grid pattern of rain gauges or catch cans, operating the system for a period of time under normal operating conditions, and measuring the amount of water collected in each can. Catch can measurements are used to determine the uniformity of a sprinkler irrigation system. Christiansen (1942) developed a numerical index representing the system uniformity of overlapping sprinklers. This uniformity coefficient (UC) is a percentage on a scale of 0 to 100 (absolute uniformity). A uniformity coefficient of 80 is considered by many to be the minimum acceptable performance. Higher uniformity coefficients are usually needed with intensively maintained ornamentals. Catch can measurements are also used to illustrate water distribution or patterns.

The stepwise procedure for computing sprinkler performance explained as under

- Install the sprinkler system and divide the entire filed into girds, usually 3x3 m size and Place the catch can on each gird for collecting the sprinkler water then Count the number of catch cans, placed in the field.
- Start the sprinkler system for about 30 minutes duration.
- Measure the depth of collected water in each can and Find out the total depth of collected water in all cans.
- Compute the mean of all the observation to determine the sum of numerical deviations from the mean m.
- Compute the using equation as follow below

Coefficient of uniformity

One of the first and most common quantitative measures of uniformity is the Christiansen Uniformity coefficient (CU). This was developed for evaluating sprinkler systems in 1942, and is still the most widely used and accepted measure for uniformity. It is expressed by the equation developed by Christiansen (1942)

$$CU = 1 - \frac{\sum X}{m.n} \times 100 \ldots\ldots\ldots\ldots (1)$$

Where,
CU= Uniformity coefficient, %
Σx = sum of numerical deviation of individual observation from the mean application
Rate of water, m.
m = mean of all observation, that is average application tare of water, mm
n = total number of observations.

A uniformity coefficient of 100 per cent (obtained with overlapping sprinklers) is indicative of absolutely uniform application, whereas the water application is less uniform with a lower percentage. A uniformity coefficient of 85 per cent or more is considered to be satisfactory. A set of recommendations for the minimum requirements on uniformity coefficient showed in table 1.

Table 1: Uniformity classification of sprinkler irrigation system based on UC values

S. No	Uniformity coefficient, UC (%)	Classification
1	Above 90 %	Excellent
2	90%-80%	Good
3	80%-70%	Fair
4	70-60%	Poor
5	Below 60%	Unacceptable

Distribution uniformity

The pattern efficiency (also known as distribution efficiency) can be calculated after obtaining the total depths at each of the grid point. The minimum depth is calculated considering average of the lowest one fourth of the cans used in a particular test. Distribution efficiency > 87 excellent (calculation given appendix).Pattern efficiency is given by

$$DU = 100\frac{m4}{m} \ldots\ldots.\ldots (3.9)$$

Where,
m = is the mean depth, and
m4=is the mean depth of the lowest quarter of the observations.

The evaluated systems were classified according to the DU values, showed as a table 2.

Table 2: Uniformity classification of sprinkler irrigation system based on DUC values

S. No	Distribution uniformity, DU (%)	Classification
1	>87	Excellent
2	75-87	Good
3	62-75	Acceptable
4	<62	Unacceptable

Application efficiency

The application efficiency is defined as the ratio of water required in the root zone to the total amount of water applied. It shows how well irrigation water is applied that is, what percentage of water applied is stored in the root zone as required and is available for plant use.

The water required in the root zone is assumed to be applied at the minimum flow rate and over the total irrigation time. Therefore, application efficiency can be expressed as,

$$\text{Ea} = \frac{\text{minimun rate caught}}{\text{avarage application rate}} \ldots (3)$$

Results and discussion

Uniformity coefficient of sprinkler irrigation system: Christiansen's uniformity coefficient for the sprinkler irrigation system was above 75 to 85%. Comparing to the recommended value of sprinkler irrigation system, the uniformity was excellent thus the sprinkler irrigation was technically feasible for that field condition. The results of computing different *CU*s for all farmers fields are presented in Figure represent different percentage values. This uniformity coefficient (UC) is a percentage on a scale of 0 to 100 (absolute uniformity). A uniformity coefficient of 80 is considered by many to be the minimum acceptable performance. In Mungeli block out four one is unacceptable limit as shown Fig (1) then also Pathariya block also only one is unacceptable limit out of four as show Fig (2).in Lormi block only two is unacceptable limit out of four Figs (3).

Lower uniformity could have been achieved if there were leakage losses. These losses were observed from the coupling joints of the mains and the laterals. The losses invariably led to small pressure differential between the main and the laterals and hence a little less than normal pressure uniformity in the field. With the high coefficient of uniformity attained by the irrigation system, the irrigator will have to devote more time in perfecting the system's scheduling to achieve higher crop yield occurred with higher sprinkler uniformity in Mungeli district.

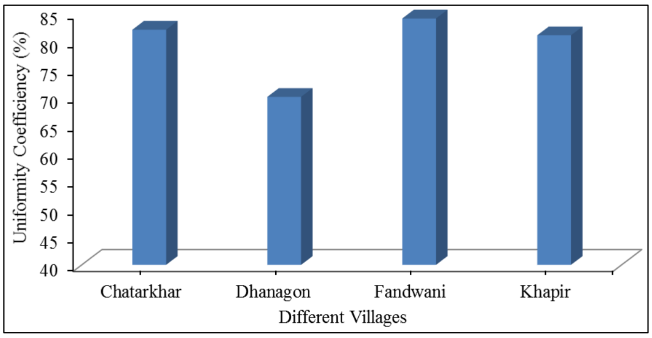

Fig 1: Uniformity coefficient in Mungeli Block

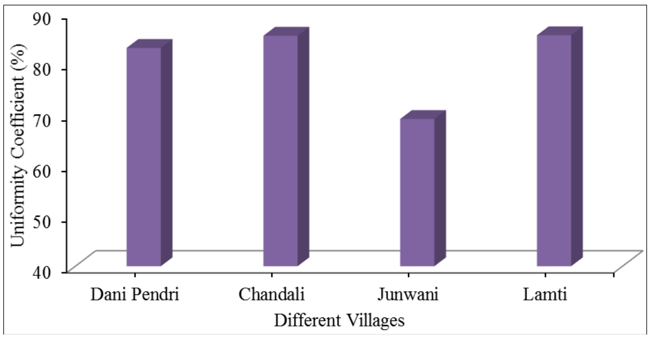

Fig 2: Uniformity coefficient in Pathariya block

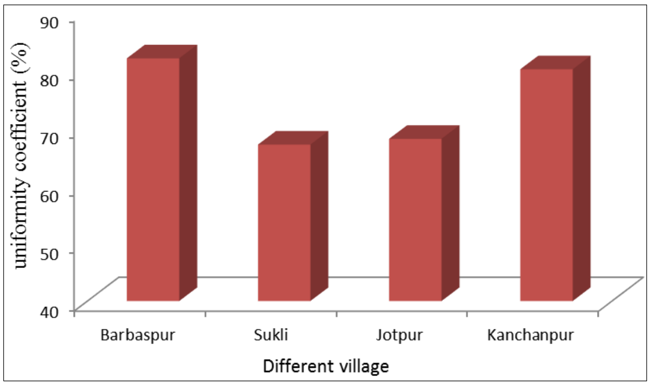

Fig 3: uniformity coefficient in Lormi Block

Distribution efficiency (du)

DU varies between 55% to 80% in all farmers filed in Mungeli district. The foregoing is not surprising since DU is based on the collected water depths in the lower quarter. Given the strong under-irrigation it is logic that DU yields lower values than UC that is based on the measured water depths in all catch cans. In DU 3 fields are unaccepted limit and 9 fields are acceptable limit (Fig 4 to 6).During the experiment DU of sprinkler irrigation was found in acceptable limit.

The foregoing is not surprising since DU is based on the collected water depths in the lower quarter. Given the strong under-irrigation it is logic that DU yields lower values than UC, which is based on the measured water depths in all catch cans. The values of the System UC and System DU are very closely to the calculated UC and DU values, indicating that the pressure variations within the systems are small. The foregoing is because all sprinkler systems studied are small, consisting of a sub main of less than 60 to 100 m and a lateral with maximum 4to 10 sprinklers.

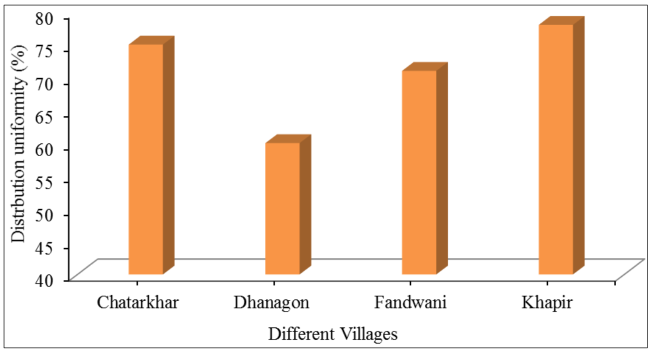

Fig 4: Distribution efficiency in Mungeli Block

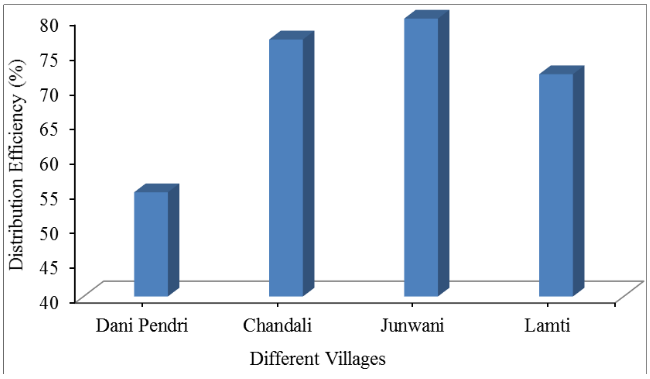

Fig 5: Distribution efficiency in Pathariya Block

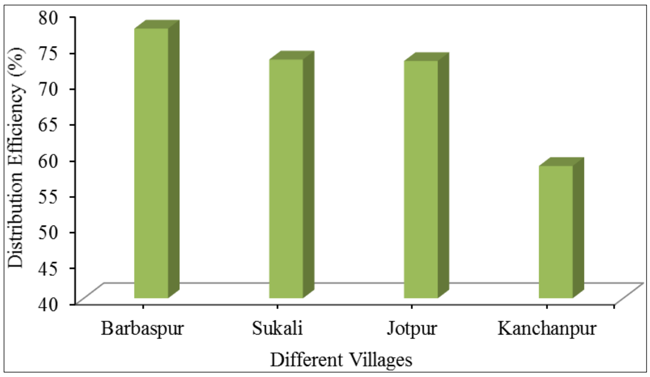

Fig 6: Distribution efficiency in Lormi

Application efficiency

Application efficiency is the ratio between the amount of water that leaves the sprinkler nozzle and the amount of water that eventually falls on the soils, infiltrates and is available for the plant. The application efficiency was calculated from the uniformity data. The purpose was to determine the loss of water as a result of evaporation and wind. The highest value of AE indicated that the average depth emitted from the sprinkler compared to the average depth recorded on the ground was similar. This was because of the wind speed in which it reached at peak during this time and the water applied to the crop was affected by drift losses

The results of computing application efficiency of three blocks for all are presented in fig Shows the represents different percentages values of application efficiency of sprinkler irrigation. The application efficiency seems of acceptable to good level. For sprinkler irrigation the recommended minimum design application efficiency is 70%. In Mungeli block highest Ea 80 % but only one field below recommended level (Fig 7) followed Pathariya block (Fig 8) two field, Lormi block only one field (Fig 9) due the region is sprinkler system not proper arrangement and not in good condition.

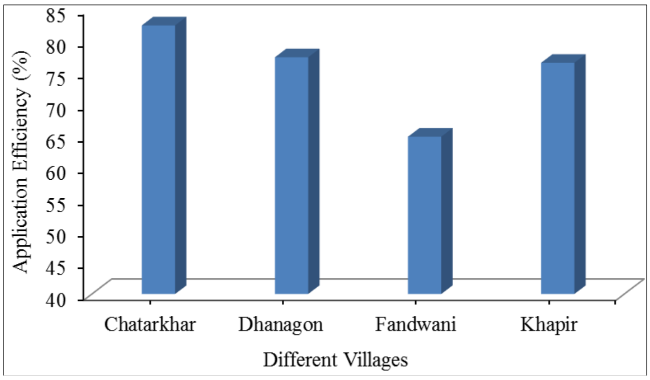

Fig 7: Application Efficiency in Mungeli Block

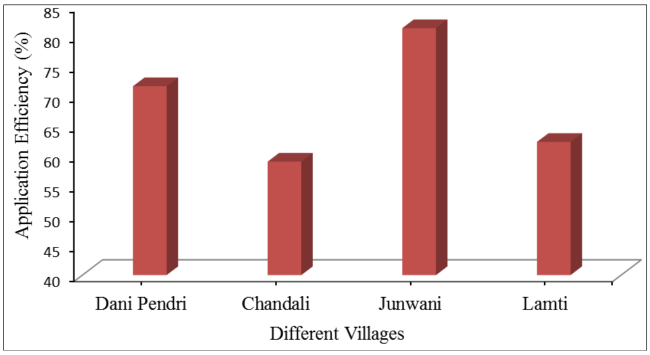

Fig 8: Application Efficiency in Pathariya block

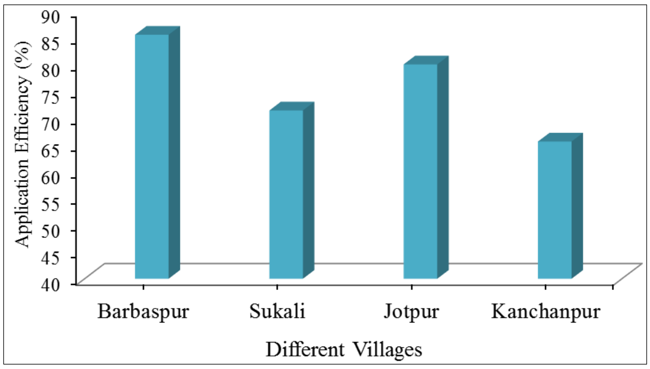

Fig 9: Application Efficiency in Lormi Block

Conclusion

It implies that sprinkler irrigation method is provision of subsidy would encourage the farmers to adopt sprinkler irrigation system for a larger extent of crop cultivation. Further the training on the sprinkler irrigation system usage and the credit facilities to purchase appropriate water pumps could also contribute for the adoption of this technology. The values of application efficiency, Christiansen's uniformity coefficient, and distribution uniformity range between 58.9% to 85.4%, 68.2 to 85.5 % and 58.4% to 80% respectively. All the parameters were in acceptable limit but some fields (4 to 5) they were in below acceptable limit due not proper maintenance of sprinkler system and rotation speed.

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