Influence of Protective Sprinkler Irrigation on Yield and Water Productivity of Kharif Grown Rain Fed Crops

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ABSTRACT
Background: The food grain and non-food grain crops occupy 48 and 68% area respectively under rainfed conditions. Due to uneven rainfall, the rainfed crop suffers for want of adequate soil moisture at critical growth stages. Under such situation, protective irrigation ensures adequate soil moisture which results in higher production. Crops like tomato, maize, groundnut, and red gram are predominantly grown during kharif as rainfed crops. Relieving the soil moisture stress during the critical crop growth stages with more efficient irrigation system assumes importance in rainfed farming.

Methods: An experiment was conducted for three years during kharif 2008, 2009 and 2010 at the College Farm, Prof. Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad on a sandy loam soil to study the yield advantage of protective sprinkler irrigation to kharif grown rainfed tomato, maize, groundnut, and red gram crops. The trial was conducted in strip plot design with protective sprinkler irrigations as main plots and rainfed kharif crops as sub-plots and replicated thrice. The three main treatments comprised of- one protective sprinkler irrigation at flower/peg/tassel initiation, two protective sprinkler irrigations at flowering and fruiting, and three were the critical stages of crops grown as rainfed crops. The experimental soil was sandy loam in texture with low in nitrogen, medium in phosphorus and potassium contents. The soil moisture stress period.

Result: There was an increase in yield with one and two protective sprinkler irrigations by 16.7 and 27.9; 17.7 and 44.5; 26.4 and 34.5 and 21.1 and 28.9% over their corresponding rainfed crops of tomato, groundnut, maize and red gram, respectively. There was an increase of 20.4 and 36.1% in Maize Equivalent Yield (MEY) with one and two protective irrigations as compared to rainfed crop. The water productivity was lower in all the crops grown under rainfed conditions (0.77 kg MEY m⁻²) as compared to that of one and two protective irrigations.

Key words: Maize equivalent yield, Protective sprinkler irrigation, Rain fed crops, Water productivity.

INTRODUCTION
Rainfed agriculture plays an important role in the Indian economy and nearly 48% area of food crops and 68% area of non-food crops is grown under rainfed conditions. Ensuring adequate soil moisture at critical growth stages of crops is essential to ensure reasonable crop production in rainfed areas. Provision of protective irrigation ensures adequate soil moisture that secures crops during the dry spells and increases production. Crops like tomato, maize, groundnut, cotton, and red gram are predominantly grown during kharif as rainfed crops in Telangana. In the event of prolonged dry spells, the yield levels of these crops are drastically reduced as a result of soil moisture stress at critical stages of the crops (Ramulu et al., 2020). The chances of availability of abundant water supply for protective irrigation through surface methods of irrigation are very meagre in drought prone areas. Supplemental/protection irrigation is often proposed to increase yields of rainfed crops to mitigate soil moisture stress during dry periods (Brugere and Lingard, 2003; Fox and Rockstrom, 2000). Alleviating soil moisture stress during the critical crop growth stages and the application of limited available water more efficiently and economically through sprinkler irrigation assumes importance in rainfed farming. Hence, an experiment was conducted to see the possibility of increasing the yield of kharif grown rainfed crops if one or two irrigations were conducted at critical growth stages through sprinklers in the event of moisture stress period.

MATERIALS AND METHODS
An experiment was conducted for three years during kharif 2008, 2009 and 2010 at the College Farm, Prof. Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad to study the yield advantage of protective sprinkler irrigation to tomato, maize, groundnut, and red gram crops grown as rainfed crops. The experimental soil was sandy loam in texture with low in nitrogen, medium in...
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phosphorous and potassium. The water holding capacity of the soil was 20%. The experiment was conducted in strip plot design with three replications. The main treatments (irrigations) constituted of two levels of protective sprinkler irrigations (one protective irrigation each of 30 mm by sprinkler to tomato at flowering, maize at tasseling, groundnut at peg formation and red gram at flowering; two protective sprinkler irrigations one each of 30 mm to tomato at flower initiation and fruiting; maize at tasseling and grain filling; groundnut at peg formation and pod filling and red gram at flowering and pod filling stages) and rain fed. The sub treatments consisted of four crops - tomato, maize, groundnut and red gram. The varieties/ hybrids viz. Laxmi, DEKLAB 900M, TMV2 and LRG-41 were used for tomato, maize, groundnut and red gram, respectively in the experiment. The red gram, maize and groundnut crops were hand dibbled on 23rd, 9th and 13th July in 2008, 2009 and 2010, respectively whereas, 35-40 days tomato seedlings were transplanted on 20th, 10th and 23rd August in 2008, 2009 and 2010, respectively. The university recommended fertilizer doses viz. 160:60:50 kg N, P$_2$O$_5$ and K$_2$O ha$^{-1}$ for maize, 20:50 kg N and K$_2$O ha$^{-1}$ for redgram, 20: 40: 50 kg N, P$_2$O$_5$ and K$_2$O ha$^{-1}$ for groundnut and 150: 100 :50 kg N, P$_2$O$_5$ and K$_2$O ha$^{-1}$ for tomato were applied. The entire level of recommended fertilizers of respective crops was applied in the form of urea, single super phosphate and murate of potash near the seed/seedling as per the recommended split doses of the respective crops.

The total rain fall received during June to October was 911, 601 and 948 mm in 38, 33 and 55 rainy days in 2008, 2009 and 2010, respectively. In 2008, the tomato crop failed due to heavy rains at the initial seedling stage of crop. The measured quantity of irrigation water was applied to each plot through sprinklers. The effective rainfall was estimated by using CRIWAR method. In 2009, to save the crop from the prevailing dry spell in the month of August, an amount of 27 mm of water was applied uniformly through sprinklers to all the treatments and in 2010 as no dry spell was prevailed during growing period and the soil was near field capacity (F.C.) at full bloom stage in Tomato, Maize and Groundnut, hence protective irrigation was skipped at this stage.

Data was recorded on yield, water applied and to make the comparative study of protective irrigation, the individual crop yields were converted into Maize Equivalent Yields (MEY) and analyzed statistically.

Maize Equivalent Yield (kg ha$^{-1}$) =

$$\text{Yield of the particular crop, kg ha}^{-1} \times \text{price of the crop, Rs kg}^{-1}$$

For calculation of maize equivalent yields, the price per 100 kg economic produce considered were Rs.900/-, 2800/-, 3500/- and 500/- for maize, groundnut, red gram and tomato, respectively in 2009 and 2010. Whereas, in 2008 it was Rs.787/-, 2700/-, 3143/- and 500/- per 100 kg of economic produce of maize, groundnut, red gram and tomato, respectively.

The water productivity (WP) i.e kg maize equivalent yield m$^{3}$ of water was calculated by

$$\text{WP} = \frac{Y}{WA}$$

Where

$Y$= maize equivalent yield (kg ha$^{-1}$),

$WA$ (total water used) = IR (irrigation) + ER (effective rainfall).

RESULTS AND DISCUSSION

Yield

The grain/seed yield of individual crops was less under rain fed condition as compared to crops grown with one or two protective sprinkler irrigations applied at critical stages. The mean tomato fruit yield was 8.03 t ha$^{-1}$ under rain fed cultivation which was 16.7 and 27.9% less than that observed in 2008 and 2009, respectively.

Table 1: Maize Equivalent Yield (MEY) of kharif grown rain fed crops (t ha$^{-1}$) as influenced by protective sprinkler irrigations (Mean of 2008, 2009 and 2010).

| Protective Irrigation | MEY of crops, t ha$^{-1}$ | Tomato | Maize | Groundnut | Red gram | Mean |
|-----------------------|--------------------------|--------|-------|-----------|---------|------|
| I$_1$ - Rain fed      |                          | 4.48(8.03)* | 3.45(3.45) | 2.50(0.79) | 4.49(1.14) | 3.73 |
| I$_2$ - One protective sprinkler irrigation (30mm) | | 5.20(9.37) | 4.36(4.36) | 3.00(0.93) | 5.39(1.38) | 4.49 |
| I$_3$ - Two protective sprinkler irrigation (each 30 mm) applied at full bloom and fruit/ pod/seed development stages | | 5.70(10.27) | 4.64(4.64) | 3.63(1.14) | 5.65(1.47) | 4.91 |
| Mean                  |                          | 5.13 | 4.15 | 3.04 | 5.18 |
| Sig. (S)              |                          | S | 0.049 | 0.20 |
| S.E.m. +/-            |                          | S | 0.29 | 0.86 |
| Crops                 |                          | NS | 1.12 | - |

S= Significant at 5% level; NS= Non Significant.

*Values within parenthesis are actual yields of the respective crops.
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Table 2: Water productivity of kharif grown crops as influenced by protective sprinkler irrigation (Mean of 2008, 2009 and 2010).

| Treatments                  | Water applied (mm) | Effective rainfall (mm) | Total water consumed (mm) | MEY (t ha⁻¹) | Water productivity (kg m⁻³) |
|-----------------------------|--------------------|------------------------|---------------------------|--------------|----------------------------|
| Crops                       |                    |                        |                           |              |                            |
| Tomato                      | 31                 | 451                    | 482                       | 4820         | 5.13                       | 1.06                        |
| Maize                       | 31                 | 451                    | 482                       | 4820         | 4.15                       | 0.86                        |
| Groundnut                   | 31                 | 451                    | 482                       | 4820         | 3.04                       | 0.63                        |
| Red gram                    | 31                 | 451                    | 482                       | 4820         | 5.18                       | 1.07                        |
| Irrigations                 |                    |                        |                           |              |                            |
| I₁ - Rain fed               | 9*                 | 451                    | 460                       | 4600         | 3.73                       | 0.77                        |
| I₂ - One protective sprinkler irrigation (30mm) applied at Fruit/pod/seed development | 36 | 451 | 487 | 4870 | 4.49 | 0.93 |
| I₃ - Two protective sprinkler irrigation (each 30 mm) applied at full bloom and fruit/ pod/seed development stages | 49** | 451 | 500 | 5000 | 4.91 | 1.02 |

*Includes the irrigation of 27 mm of water given to all the plots in 2009.

**Only one irrigation given as there was rain and enough moisture in 2010.

Application of three supplementary irrigations doubled the seed yields of pigeon pea in alfisols (Chauhan, 1990). These results were further confirmed that depending on water stress, supplementary irrigation was helpful in up-scaling grain yield (Praharaj et al., 2017 and Ramulu et al., 2020). The results obtained in the present experiment are also in conformity with the findings of Rao et al. (1983) and Khanna et al. (1980).

CONCLUSION

In this 3 years study it can be concluded that high variability in rainfall during the kharif season leads to considerable variability in the expected yields of rain fed crops and provision of one or two protective irrigations through sprinkler irrigation to kharif grown rain fed crops viz. red gram, tomato, maize and groundnut at critical moisture stages improve the yield and water productivity over its respective rain fed crops.

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