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# Water production function for chickpea under sprinkler method of irrigation

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## ABSTRACT

**A field experiment entitled, "Water production function for chickpea under sprinkler method of irrigation" was conducted at Research cum-Demonstration Farm of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri, Distt. Ahmednagar (Maharashtra) India during *rabi* season of 2006-07. The treatments were 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method ($T_1$), 1.68 mm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method ($T_2$), 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method ($T_3$), 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method ($T_4$), 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method ($T_5$), 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method ($T_6$) and 6 cm depth of irrigation at 75 mm CPE through surface irrigation method ($T_7$). A buffer plot was left between the sprinkler irrigation treatments ($T_1$ to $T_6$) and surface irrigation treatment ($T_7$). Treatment $T_4$ (3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler method) produced 25.90 q ha$^{-1}$ grain yield and showed its superiority over other irrigation treatments. Treatment $T_4$ (sprinkler with 3.12 cm depth) was economically for better than surface method of irrigation in terms of net seasonal income, B: C ratio, water productivity and water use efficiency. Thus, the study revealed that growing of chickpea under sprinkler, irrigation method resulted in the more seed yield (25.90 q ha$^{-1}$) and maximum benefit: cost ratio (2.57) as compared to the surface irrigation method.**

**Key words :** Production function, Sprinkler irrigation, Chickpea.

## INTRODUCTION

Pulses play significant role in sustainable agriculture and nutritional security to predominantly vegetarian population of the country. The importance of pulses in human diet and animal nutrition is well recognized. The roots of pulses crop penetrate deep into soil, fix the atmospheric nitrogen with the help of nodules. The shoot adds huge quality of dry foliage into soil and enriches the soil fertility.

Chickpea grain is the good source of proteins, carbohydrates, energy and minerals matters. Chickpea contains 17.7 per cent protein and 56.5 per cent carbohydrates. Chickpea is cultivated on 7.11 million ha area with 5.65 million tonnes production with 795 kg ha$^{-1}$ productivity in the country. In Maharashtra chickpea is the second most important crop cultivated in *rabi* season with 7.13 lakh tonnes production and productivity as 655 kg ha$^{-1}$.

In chickpea, irrigation is one of the most important factors for assured production. The proper irrigation and layout for chickpea are proved to be key factors to solve the problems of productivity. Chickpea is generally considerable as sturdy crop requiring small quantity of water, but responds immediately to over irrigation and non-availability of water during critical growth stages of crop resulting into sizable reduction in yield. It has already been reported that the productivity of chickpea increased considerably by adoption of improved technology under irrigated conditions (Masood *et al.*, 1998). Sprinkler method of irrigation is most widely used in the world and thus most important advanced irrigation method. In India, presently 6.60 lakh ha area is covered under sprinkler and Maharashtra is the leading state with 1.35 lakh hectare area. However, sprinkler is commonly used for high value crops and vegetables. It is useful in increasing productivity by 10-35 per cent with 30-35 per cent water saving and especially suited for those dose growing crops and thus, can be conventially used to all cereals, pulses, oilseed and vegetables. In closed spaced crops like chickpea sprinkler method could play effective role in obtaining potential yields with judicious management of irrigation water (Suryawanshi and Pampatiwar, 1985).

## MATERIALS AND METHODS

An experiment "Water production function for chickpea under sprinkler method of irrigation" was conducted at Inter Faculty Department of Water Management, Mahtama Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during the *rabi* season, 2006-07. The soil was well drained and 30-45 cm deep with sandy clay loam in textural class. As regards chemical composition available nitrogen is medium (245.42 kg ha$^{-1}$), available phosphorus (15.51 kg ha$^{-1}$) and available potassium is more (245.49 kg ha$^{-1}$) with 0.65 % organic carbon.The field capacity and PWP of the experimental site was 28.36 and 14.17 per cent, respectively. The experiment was laid out in Randomized Block Design with three replications and seven irrigation treatments. Digvijay

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variety of chickpea was used for sowing. The gross and net plot sizes were 6.00 x 3.60 $m^2$ and 5.00 x 2.40 $m^2$, respectively.

**Table 1 : Treatment details with symbols used**

| Sr. No. | Symbols | Treatment details |
|---|---|---|
| 1. | $T_1$ | 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method |
| 2. | $T_2$ | 1.68 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method |
| 3. | $T_3$ | 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method |
| 4. | $T_4$ | 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method |
| 5. | $T_5$ | 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method |
| 6. | $T_6$ | 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method |
| 7. | $T_7$ | 6 cm depth of irrigation at 75 mm CPE through surface irrigation method |

***Water production function:***

Water production function for chickpea under sprinkler method of irrigation was developed using date on yield and depth of water applied.

Second order polynomial relationship given below as found best fit.

$$Y = 0.0929\ X^2 + 5.4829 - 57.02$$

$$R^2 = 0.91$$

where,

Y = Estimated yield (q $ha^{-1}$)

X = Depth of water applied (cm)

The estimated yields of chickpea obtained using water production function developed as above are tabulated in Table 2.

**Table 2 : Details of irrigation scheduling criteria in sprinkler method of irrigation**

| Sr. No. | Treatment | Depth of water applied during each irrigation (cm) | CPE (mm) | IW/CPE ratio |
|---|---|---|---|---|
| 1. | $T_1$ | 1.2 | 37.5 | 0.32 |
| 2. | $T_1$ | 1.68 | 37.5 | 0.45 |
| 3. | $T_3$ | 2.24 | 37.5 | 0.60 |
| 4. | $T_4$ | 3.12 | 37.5 | 0.83 |
| 5. | $T_5$ | 3.44 | 37.5 | 0.92 |
| 6. | $T_6$ | 4.56 | 37.5 | 1.22 |

## RESULTS AND DISCUSSION

***Seed yield:***

The maximum and significantly superior yield (25.90 q $ha^{-1}$) over all other treatments was recorded in treatment $T_4$ (sprinkler with 3.12 cm depth) followed by $T_5$ (sprinkler with 3.44 cm depth) with 21.50 q $ha^{-1}$ and $T_3$ (Sprinkler with 2.24 cm depth) with 19.70 q $ha^{-1}$ (Table 3). The treatment $T_1$ (sprinkler with 1.2 cm depth) recorded significantly lower yield than all other treatments. The treatment $T_7$ (surface method of irrigation) recorded a seed yield of 18 q $ha^{-1}$ which was at par with sprinkler treatments $T_3$ and $T_6$.

**Table 3 : Mean seed yield, straw yield as influenced by different treatments**

| Treatment | Seed yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) |
|---|---|---|
| $T_1$ : 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 10.20 | 6.20 |
| $T_1$ : 1.68 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 14.10 | 10.90 |
| $T_3$ : 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 19.70 | 16.50 |
| $T_4$ : 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 25.90 | 23.20 |
| $T_5$ : 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 21.50 | 22.10 |
| $T_6$ : 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 18.50 | 23.20 |
| $T_7$ : Surface irrigation with 6 cm depth | 18.00 | 14.00 |
| S.E. $\pm$ | 0.72 | 0.55 |
| C.D. (P=0.05) | 2.24 | 1.70 |
| Mean | 18.27 | 16.58 |

The sprinkler method of irrigation with optimum depth of irrigation results into appropriate soil moisture status in root zone throughout crop growth period. It also distributes irrigation water more uniformly than surface method of irrigation. Moreover, the micro-climatic condition in terms of reduced temperature and increased relative humidity in crop canopy is maintained favorably due to applying water in sprinkling farm. All these factors have resulted into improved grain yield in respect of sprinkler treatments $T_4$, $T_5$ and $T_3$. These results are in conformity with Kulhare *et al.* (1988), Dahiwalkar *et al.* (1998) and Sable (1995).

***Straw yield:***

Maximum straw yield of 23.20 q $ha^{-1}$ was observed

in treatment $T_4$ (sprinkler with 3.12 cm depth) and $T_6$ (sprinkler with 4.56 cm depth) which was significantly superior over all other treatments except $T_5$ (sprinkler with 3.44 cm depth). The straw yield in treatment $T_5$ (22.10 q $ha^{-1}$) was at par with $T_4$ and $T_6$ treatment. Minimum straw yield of 6.20 q $ha^{-1}$ was observed in treatment $T_1$. The surface method of irrigation recorded straw yield as 14.00 q $ha^{-1}$ which was significantly superior over sprinkler treatments $T_1$ and $T_2$.

***Water management studies:***

In surface irrigation treatment, fixed quantity of water *viz.*, 6 cm was applied at every 75 mm CPE.

***Hydraulics of sprinkler method of irrigation:***

The uniformity coefficient for sprinkler method of irrigation was determined using Christianson's equation. It is revealed that uniformity coefficient in all the treatments was above 80 per cent and thus, can be considered as good. The values of uniformity coefficient ranged from 80.55 per cent in treatment $T_3$ to 84.72 per cent in $T_5$ treatments.

The depth of precipitation in cm per hour (Table 4) was also worked out for different sprinkler treatments. These values were found to be varied from 0.30 to 1.14 cm $hr^{-1}$ in different treatments. Depending on variation in the depth of precipitation along different locations within sprinkler plot different sprinkler treatments were demarcated. To obtain required depth of irrigation in respective treatments the sprinkler system was operated for 4 hours.

***Water use and water use efficiency:***

It is clear from data presented in Table 5 that the depth of water applied in different treatments was varied from 17.20 to 37.36 cm. Minimum water (17.20 cm) was applied in treatment $T_1$ (sprinkler with 1.20 cm depth) whereas, maximum water was applied

**Table 4 : Uniformity coefficient and depth of precipitation in sprinkler method**

| Treatment | Uniformity coefficient (%) | Depth of precipitation (cm/hr) | Depth of water applied in 4 hrs (cm) |
|---|---|---|---|
| $T_1$ : 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 83.36 | 0.30 | 1.20 |
| $T_1$ : 1.68 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 82.63 | 0.42 | 1.68 |
| $T_3$ : 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 80.55 | 0.56 | 2.24 |
| $T_4$ : 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 83.03 | 0.78 | 3.12 |
| $T_5$ : 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 84.72 | 0.86 | 3.44 |
| $T_6$ : 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 81.05 | 1.14 | 4.56 |

**Table 5 : Water use and water use efficiency under different treatments**

| Treatment | Depth of water applied (cm) | Yield (q $ha^{-1}$) | WUE (q $ha^{-1}$-mm) | Water saving (%) | Increase in yield (%) |
|---|---|---|---|---|---|
| $T_1$ : 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 17.20 | 10.20 | 5.93 | 38.60 | -43.30 |
| $T_1$ : 1.68 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 20.08 | 14.10 | 7.22 | 28.30 | -21.70 |
| $T_3$ : 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 22.00 | 19.70 | 6.68 | 21.40 | 9.40 |
| $T_4$ : 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 28.72 | 25.90 | 9.02 | -2.60 | 43.90 |
| $T_5$ : 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 30.64 | 21.50 | 7.02 | -9.40 | 19.40 |
| $T_6$ : 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 37.36 | 18.50 | 4.45 | -33.40 | 2.80 |
| $T_7$ : Surface irrigation with 6 cm depth | 28.00 | 18.00 | 6.43 | - | - |

**Table 6 : Deviation in the observed yields under sprinkler from yields estimated using water production function**

| Treatment | Observed yield (q ha$^{-1}$) | Yield estimated using water production function (q ha$^{-1}$) | Per cent deviation |
|---|---|---|---|
| $T_1$ : 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 10.20 | 9.78 | 4.13 |
| $T_1$ : 1.68 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 14.10 | 15.59 | -10.54 |
| $T_3$ : 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 19.70 | 18.60 | 5.58 |
| $T_4$ : 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 25.90 | 23.76 | 8.28 |
| $T_5$ : 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 21.50 | 23.69 | -10.17 |
| $T_6$ : 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method | 18.00 | 18.04 | 2.47 |

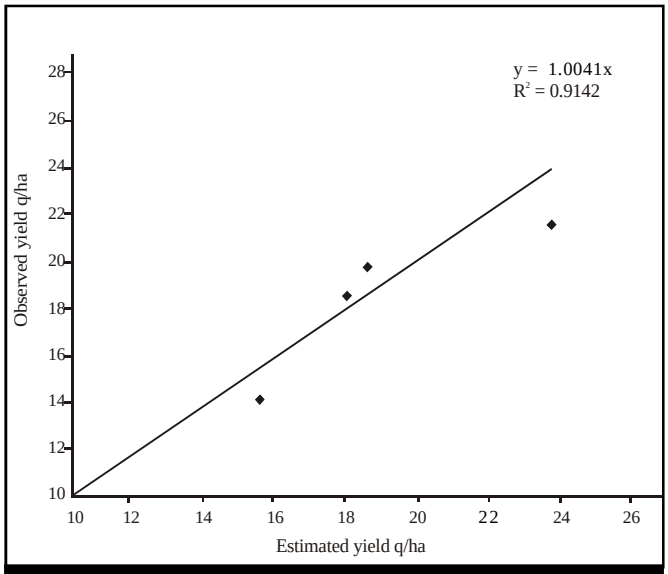


**Fig. 1 : Deviation between observed and estimated yield values**

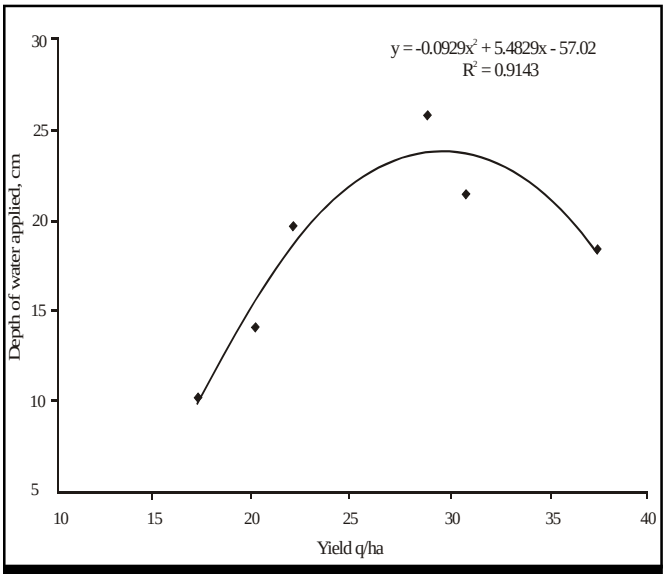


**Fig. 2 : Water production function for chickpea under sprinkler**

(37.36 cm) in treatment $T_6$ (sprinkler with 4.56 cm depth). In surface method of irrigation 28 cm depth of water was applied. The treatment $T_1$ (sprinkler with 1.2 cm depth) resulted into 38.60 per cent water saving as compared to surface method of irrigation. The treatments $T_2$ and $T_3$ resulted into 28.30 and 21.40 per cent water saving, respectively when compared to surface method of irrigation. The treatment $T_6$ used 33.40 per cent more water than surface method of irrigation.

The maximum value (9.02 q ha$^{-1}$-mm) water use efficiency was recorded in treatment $T_4$ whereas minimum value (4.45 q ha$^{-1}$-mm) was recorded in treatment $T_6$. The WUE in surface method was found to be 6.43 q ha$^{-1}$-mm.

It is also clear from the Table 6 that, the deviation between obtained yields and estimated chickpea yields are 2 to 10 per cent only indicating that relationship can be used to estimate chickpea yields under sprinkler method of irrigation if depth of water to be applied is known.

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