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Hydraulic performance of different irrigation methods on chickpea and coriander intercropping in *vertisol* of Chhattisgarh plains

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Abstract
To study the effective and efficient irrigation methods for realization of higher return and find out the effect of different irrigation methods on yield of chickpea and coriander intercropping system. The experiment was laid out in RBD in five treatments with four replications. The treatments comprised of five different irrigation methods *viz.* flood irrigation, furrow irrigation, sprinkler irrigation, drip irrigation and control in chickpea-coriander intercropping. The highest yield (11.78 q ha^{-1}) was recorded in drip irrigation system followed by sprinkler irrigation (10.75 q ha^{-1}), furrow irrigation (9.93 q ha^{-1}), flood irrigation (9.86 q ha^{-1}) and lowest yield found in control (5.22 q ha^{-1}). The highest benefit cost ratio (2.03) was found in sprinkler irrigation and drip irrigation then followed by control (2.02), flood irrigation (1.80), furrow irrigation(1.74) and lowest was found in control (1.10). Water use efficiency was recorded highest in drip irrigation (4.71 kg/ha-mm of water) followed by sprinkler irrigation (4.30 kg/ha-mm of water), furrow irrigation (3.97 kg/ha-mm of water), flood irrigation (3.94 kg/ha-mm of water) and minimum was recorded under flood control (2.08 kg/ha-mm of water).

Keywords: *Chickpea, Coriander, irrigation methods, grain yield, straw yield, vertisols, intercropping*

1. Introduction
Access to enough food for healthy and productive life is the biggest challenge facing mankind in this millennium. In our country, the preoccupation of around 70% of population in subsistence farming makes it clear that agricultural improvement is the crucial need of today, which will lead to augmentation of food production for alleviating hunger. Out of the 328.73 million hectares total geographical area of the country, only 141.16 million ha is available for cultivation to sustain more than a billion populations. So far, much emphasis has been given to realize maximum production by managing sole crop, but concerted efforts are now needed for enhancing the productivity of intercropping system.

Intercropping may be a viable agronomic practice for stepping up the production of the pulses from a unit of land during a cropping period. Suitable intercropping systems gives greater stability in crop yields during aberrant weather conditions and epidemics of disease and pests. Generally, crop yield equivalent from intercropping is higher than the sole cropping. Winter cereals such as wheat and barley are intercropped with chickpea, lentil (*Lens esculenta*) or pea (*Pisum Sativum*) in the post rainy season in the Indian sub-continent.

Chickpea (*Cicer arietinum L.*) is the largest produced food legume in South Asia and the third largest produced food legume globally. Chickpea is grown in more than 50 countries. Asia accounts 89.7% of the area in chickpea production, followed by 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe (Gaur, MP. 2010). India ranked first in terms of chickpea production and consumption in the world. About 65% of global area with 68 % of global production of chickpea is contributed by India. India is the largest Chickpea producing country accounting for 64% of the global Chickpea Production.

India has been recognized as a land of spices and at present it is the world's largest producer, consumer and exporter of the seed spices. Among the seed spices, coriander commonly known as Dhania is major crop belonging to Apeaceae family. In India, it is mainly cultivated in Rajasthan, Gujarat, Karnataka and Orrisa. Rajasthan ranks first in area and production of coriander in our country. In Chhattisgarh 2860 hectares land used for Coriander and production achieved was 840 MT in year 2013-14.

Water is one of the most valuable resources for the survival of civilization. However, the agriculture sector is the largest consumer of water resources in India. Assured supply of water is necessary for sustainable agriculture. However, farmers are using water irrationally. Lack of awareness among the farmers about the consequences of irrational use of water and lack of

appropriate tools and instruments for regulated and uniform application of the desired quantity of water at the appropriate time are among the major causes of low water-use efficiency at the field-level. This has ultimately led to a decline of the water resources. Farmers' practices need to be critically observed and modified taking into view the perceptions, concerns and constraints of the farmers in adopting better irrigation methods.

Materials and Methods

The field experiment was carried out at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). Geographically, Raipur is situated in the centre of Chhattisgarh and lies between 21^0 16′ N latitude and 81^0 36′ E longitude with an altitude of 314 m above the mean sea level. To evaluate the effective and efficient irrigation methods for realization of higher return and find out the effect of different irrigation methods on yield of chickpea and coriander intercropping system. The adopted irrigation methods were flood irrigation, furrow irrigation, sprinkler irrigation, drip irrigation and control (only gave one irrigation). In the growing seasons, the amount of water applied for each irrigation was calculated according to the crop coefficient (K_c) and the daily reference crop evapotranspirationl (ET_o). At the end of the growing season. The quantity of water applied for the different irrigation treatments was calculated according to the total amount of water added from sowing until harvesting for the growing seasons. The average amounts of water during the growing seasons were 296 mm, 262 mm, 250 mm, 226 mm, and 124 mm for the five irrigation treatments, flood, furrows, sprinkler, drip and control, respectively. The experimental design used was a randomize block design with four, replications.

In order to evaluate the nutrient status of soil and physico-chemical properties, randomly ten samples were collected upto the depth of 20 cm from different places and after aggregation, the same was used to analyse the physico-chemical properties of soil. Physico-chemical properties of the experimental site are with low organic carbon, low nitrogen, phosphorus and potassium medium and neutral soil pH. Seeds of chickpea (JG-130) and coriander (JD-1) which were obtained from Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), were sown on 22 November in *rabi* seasons and continuously fertilizers were applied in field through seed cum fertilizer drill at a dose of (20:40:20). During *rabi* crops growth period of *rabi* season 2015-16, the maximum temprature varied between 22 ^{0}C to 35 ^{0}C. The maximum and minimum relative humidity during the crop period was 96 to 19% respectively. A total of 16.7 mm rainfall was received during the crop period.

Results and Discussions

Hydraulic performance of Drip Irrigation System

Hydraulic performance of drip irrigation system was evaluated on the basis of Horizontal and vertical movement of wetting front advance, discharge variation, coefficient of variation, uniformity coefficient and irrigation efficiency at 1.2 kg cm^{-2} pressure for varying durations. The results are discussed as follows:-

Variation of horizontal and vertical wetting front advance at operating pressure of 1.2 kg cm^{-2}

Drip irrigation system was operated at 1.2 kg cm^{-2} pressure. The lateral of 16 mm was connected with the submain of 63 mm diameter, on lateral emitters of 4 lph was fitted. The average flow rate obtained at emitters was 3.82 lph. The horizontal wetting front advance with respect to space and time was found nearly uniform all around the point source. It was observed that slight surface irregularities affected the wetting front due to inertial forces. The vertical water front advance was recorded just below the emitter and at a distance of "0" to maximum distance covered by dripper along the lateral after the end of elapsed time 30, 60, 90, 120, 150 and 180 min by cutting vertical cross section of the soil across the lateral length according to wetting front advance of soil in horizontal and vertical direction. The wetting front movement as observed in the horizontal and vertical direction from the dripper for different elapsed time is shown in Table 3. The observed and plotted data is indicating nearly uniform distribution both vertically and horizontally. The maximum horizontal and vertical wetting front advance from emitter were observed horizontal as 17, 22, 30, 34, 37, 39 cm and vertical 23.5, 27.5, 33.2, 37.2, 39.2, 41.5 cm after elapsed time 30, 60, 90, 120, 150 and 180 min respectively. From the Table 4.16 it is clear that when the horizontal distance from emitter increases then the vertical depth decreases and vertical depth is more below the emitter.

Uniformity coefficient (UC)

We found uniformity coefficient of drip irrigation was 97% at operating pressure 1.2 kg cm^{-2}. Hence uniformity coefficient increases as per the operating pressure for all emission devices. Uniformity coefficient of drip irrigation was shown in table 2.

Behavior of wetted soil width and depth

The behavior of wetted width with wetted depth of soil under drip irrigation is presented in Table 4. it is clear that in case of clayey soil wetting front advance obtained in horizontal direction is more compared to vertical direction due to compaction of soil and low permeability because in high compact soil water moves laterally more than vertically. The wetted width increased with wetted depth with duration of water application

Hydraulic performance of Sprinkler Irrigation System

Swath radius determination

Swath radius of sprinkler is depends of size of nozzle, pressure, height of riser and wind direction. We found sprinkler swath radius is 6m (12 m diameter) at 2.5 kg cm^{-2}.

We maintain sprinkler swath radius through the ball valve. When we close ball valve then sprinkler line pressure is increase and swath radius also increased. Discharge of sprinkler was 15 liter per hour.

Uniformity coefficient

A uniformity coefficient of 100% is indicative of absolutely uniform application. A uniformity coefficient of 85% or more is acceptable. Uniformity coefficient of sprinkler was found 92.3%. Uniformity coefficient of sprinkler irrigation was shown in table 2.

Irrigation efficiency

Irrigation efficiencies are presented in Tab 1. Irrigation efficiency was found better in drip irrigation method as compare to other irrigation methods. Drip irrigation save large amount of water then flood and furrow irrigation methods..

Water conveyance efficiency (%)

Water conveyance efficiency was found highest value (98.08 %) in drip irrigation and lowest in control (92.60 %) which was at par with flood irrigation method (92.98%). We found better conveyance of water because we use PVC pipe line to supplied water for water source to field.

Water application efficiency (%)
Drip irrigation method gave highest water application efficiency (97.40%) as compare to other irrigation methods and lowest water application efficiency was found in control (62.40%).

Water storage efficiency (%)
Drip irrigation method gave highest water store efficiency (97.65%) and lowest in control (82.33%) as compare to other irrigation methods.

Water use efficiency (kg/ha mm of water)
Water use efficiency is presented in Tab 6. Water use efficiency was found highest in drip irrigation method (5.75 kg/ha mm of water) and lowest in flood (2.46 kg/ha mm of water) as compare to other irrigation methods.

Economics of chickpea and coriander intercropping
The highest gross return (Rs 70325) and net return (Rs 47120) was obtained under drip irrigation method. While Benefit and cost ratio of different irrigation methods is shown in Table 5. Drip and sprinkler irrigation obtained highest benefit and cost ratio 2.03 and lowest benefit cost ratio was obtained under control 1.10 as compare to other irrigation methods. Different irrigation methods gave different benefit and cost ratio. The highest benefit and cost ratio obtained under the drip and sprinkler irrigation due to higher yield produced under these irrigation systems with minimum losses of water. Soil nutrients were efficiently utilized by the plants.

Table 1: Hydraulic performance of different irrigation methods on chickpea-coriander intercropping

Treatments	Irrigation efficiency					
	Water conveyance efficiency (%)	Water application efficiency (%)	Water storage efficiency (%)	Water use efficiency of chickpea (kg/ha-mm of water)	Water use efficiency of coriander (kg/ha-mm of water)	Total Water use efficiency (kg/ha-mm of water)
Flood	92.98	65.15	85.08	1.79	0.67	2.46
Furrow	94.15	69.33	88.35	2.10	0.78	2.88
Sprinkler	95.08	93.88	96.08	2.2	0.92	3.12
Drip	98.08	97.40	97.65	2.84	1.12	3.96
Control	92.60	62.40	82.33	2.41	0.88	3.29
SEm±	0.37	0.39	0.30	0.37	0.39	0.3
CD	1.19	1.24	0.94	1.19	1.24	0.94

Table 2: uniformity coefficient of sprinkler and drip irrigation methods on chickpea-coriander intercropping

Uniformity coefficient of sprinkler irrigation
Sprinkler discharge= 20 lpm
Sprinkler diameter (swath) = 12m
Time= 10 min
Wind velocity= 1 kmph

Bowl No.	Observed value (mm)	Frequency	Observed value x frequency	Numerical deviation	Frequency x deviation
1	40	6	240	6	36
2	38	4	142	4	16
3	37	1	37	3	2
4	36	3	108	2	6
5	34	5	170	0	0
6	32	3	96	2	6
7	30	2	60	4	8
8	35	1	35	1	1
		Total=25	Total=984		Total=75

Uniformity Coefficient:

$C_u = 100\ (1- \frac{\sum x}{mn})$

$= \frac{100(1 - \frac{75}{984})}{}$

= 92.37%

Uniformity coefficient of drip irrigation
Drip discharge= 4 lph
Operating pressure= 1.2kg/cm^2
Time= 20 min

Bowl No.	Observed value (mm)	Mean	Numerical deviation from mean	Average of numerical deviation
1	210	201	9	6
2	205	201	4	6
3	208	201	7	6
4	190	201	11	6
5	197	201	4	6

6	202	201	1	6
7	207	201	6	6
8	210	201	9	6
9	208	201	7	6
10	205	201	4	6
11	207	201	6	6
12	209	201	8	6
13	204	201	3	6
14	208	201	7	6
15	195	201	6	6
16	190	201	11	6
17	199	201	2	6
18	204	201	3	6
19	209	201	8	6
20	205	201	4	6
	Total=4027		**Total=120**	

$$C_u = 100\left(1 - \frac{\text{Average numerical deviation from mean}}{\text{Mean of observed data}}\right)$$

$$= 100\left(1 - \frac{120}{4027}\right)$$

$$= 97.02\%$$

Table 3: Maximum wetting front advance (in horizontal and vertical direction)

30 Min		60 Min		90 Min		120 Min		150 Min		180 Min	
HR	**VR**	**HR**	**VR**	**HR**	**VR**	**HR**	**VR**	**HR**	**VR**	**HR**	**VR**
0	23.5	0	27.5	0	33.2	0	37.2	0	39.2	0	41.5
05	22.3	5	26.0	5	32.5	5	36.0	5	37.1	5	40.2
10	18.5	10	25.2	10	29.5	10	33.2	10	33.9	10	38.1
15	13.1	15	22.5	15	22.0	15	30.4	15	32.5	15	36.4
17	9.5	20	19.5	20	17.5	20	26.0	20	30.2	20	33.8
		22	10.5	25	10.2	25	22.4	25	27.1	25	27.2
				30		30	17.4	30	22.6	30	21.9
						34	9.8	35	17.2	35	18.5
								37	9.1	39	11.0

Table 4: Effect of elapsed time on wetted width and depth of soil at 1.2 kg cm^{-2}

Elapsed time (min)	Wetted width (cm)	Wetted depth (cm)
30	25	10
60	31	13.5
90	38	15.7
120	45	17.6
150	52	20.1
180	60	22.1

Table 5: Effect of different irrigation methods on yield attributes of chickpea-coriander intercropping

Treatments	Gross income (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net income (Rs ha^{-1})	B:C ratio
Flood	61245	21805	39440	1.80
Furrow	62525	22805	39720	1.74
Sprinkler	64105	21105	43000	2.03
Drip	70325	23205	47120	2.03
Control	39605	18805	20800	1.10

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