International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 695-698

Received: 15-05-2017
Accepted: 16-06-2017

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Effect of different irrigation methods on yield attributes and economics of chickpea and coriander intercropping in *Vertisol* of Chhattisgarh plains

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Abstract
The field experiment was carried out at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during rabi seeason of 2015-16. 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. The experiment was laid out in Randomize Block Design 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 maximum horizontal and vertical front advance from emitter at 1.2 kg cm^{-2} were observed to be 18, 24, 32, 35, 38, 40 cm and 23.8, 27.9, 33.5, 37.4, 39.6, 42.1cm, respectively. Uniformity coefficient, application efficiency, distribution efficiency, water stored efficiency and water use efficiency were found higher at drip irrigation method as compare to other irrigation methods.

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)

Keyword: 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. Agriculture improvement is an "engine of change" that catalyses many improved economic and social changes. In addition, it has role in creating overall stability through suitable development. It carries further importance in view of shrinking land resources. 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 *et al*. 2007) [6].

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. At 75 days from sowing, five plants were randomly taken for estimating the vegetative growth parameters or yield attributes i.e. plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}and total dry matter plant^{-1} (g). At harvest (100 days from sowing) the following data were recorded plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}, weight of pods plant^{-1} (g), sees test weight (100 seeds weight.), seed yield (kg ha^{-1}), and straw yield (kg ha^{-1}). The crop equivalent yield was calculated with the help of the following formula.

$$\text{Crop equivalent yield } \left(\frac{\text{q}}{\text{ha}}\right) = \frac{\text{Yield of Coriander } \left(\frac{\text{q}}{\text{ha}}\right) \text{ X Price of Coriander } \left(\frac{\text{Rs}}{\text{q}}\right)}{\text{Price of Chickpea } \left(\frac{\text{Rs}}{\text{q}}\right)}$$

The obtained data were statistically analyzed according to analysis of variance method described by Snedecor and Cochran (1980).

Results and Discussions

Plant population m^{-2}

Data on plant population m^{-2} of chickpea was recorded at harvest the highest plant population of chickpea recorded in drip irrigation (28) and the lowest plant population in control (26) which was at par with furrow irrigation (27). At harvest of coriander the highest plant population was recorded in drip irrigation (18) and the lowest plant population found in control (16). The result shows that the plant populations among the all different irrigation methods were on par.

Plant height (cm)

At harvest of chickpea the highest plant height of chickpea was recorded in drip irrigation (40.5) and the lowest plant height under control (35.7 and 36.2). Results revealed that plant height of chickpea was affected significantly with various irrigation methods. At harvest of coriander the highest plant height was recorded under drip irrigation (79.1and 82.7 respectively) and the lowest plant height was found in control (72.8 and 75.5 respectively).

In chickpea and coriander intercropping system application water by the drip irrigation gave the significantly highest plant height as compared to other irrigation methods.

Number of branches plant^{-1}

At harvest of chickpea the highest number of branches per plant was recorded under drip irrigation (25.2 and 25.3) and the lowest number of branches per plant recorded in control (20.6 and 20.7). At harvest of coriander significantly highest number of branches per plant was recorded under drip irrigation (15.3) and lowest number of branches per plant was recorded in control (12.1).

Dry matter production plant^{-1} (g plant^{-1})

At harvest the maximum dry matter production was recorded under drip irrigation (34.67) and the lowest dry matter

production was noted in control (27.89). At harvest of coriander the highest dry matter production was found under drip irrigation (19.31) followed by sprinkler irrigation (17.66), furrow irrigation (17.30), flood irrigation (16.64) and control (14.15) respectively.

Number of pods plant^{-1}

The number of pods per plant of chickpea under various irrigation methods was found significant which is shown in Table 4.2. Number of pods per plant of chickpea found highest under drip irrigation (103) which was at par with sprinkler irrigation (97) and the lowest number of pods per plant of chickpea obtained in control (72) which was at par with flood irrigation (78). The highest number of seeds per plant of coriander was found under drip irrigation (883) followed by sprinkler irrigation (773), furrow irrigation (740), flood irrigation (740) and control (683).

Number of seeds pod^{-1}

The number of seed pod^{-1} of chickpea under various irrigation methods was found significant which is shown in Table 4.2. In chickpea number of seeds pod^{-1} was significantly higher in drip irrigation (2.58) which was at par with sprinkler irrigation (2.5) and the lowest number of seeds per pod found in control (1.58).

100 seeds weight (g)

The highest weight of 100 seeds of chickpea was recorded in drip irrigation method (23.36) and the lowest weight of 100 seeds of chickpea was recorded in control (21.06) which was at par with furrow irrigation (21.45) and flood irrigation (21.15). The 100 seeds weight of coriander was shown in Table 4.2. Among different irrigation methods highest 100 seeds weight in gram was recorded under drip irrigation (1.2) and the lowest 100 seeds weight was recorded in control (1.02) which was at par with flood irrigation (1.05). The second highest 100 seeds weight was recorded under drip irrigation (1.2), sprinkler irrigation (1.1), followed by furrow irrigation (1.08), flood irrigation (1.05) and control (1.02).

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 4.3. 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: Effect of different irrigation methods of yield attributes on chickpea-coriander intercropping

	Plant population in m^{-2}		Plant height (cm)		Number of branches plant^{-1}		Dry Matter Production (g plant^{-1})	
Treatments	**chickpea**	**coriander**	**chickpea**	**coriander**	**chickpea**	**coriander**	**chickpea**	**coriander**
Flood	24	16	38.1	78.3	23.9	13.4	29.75	78.3
Furrow	25	16.	38.3	79.6	24.0	13.7	30.23	79.6
Sprinkler	27	17	39.8	80.3	24.4	14.6	32.01	80.3
Drip	28	17	40.5	82.7	25.3	15.3	34.67	82.7
Control	24	15	36.2	75.5	20.7	12.1	27.89	75.5
S Em±	0.24	0.03	0.20	6.67	0.19	0.03	0.01	6.67
CD	0.75	0.11	0.63	21.02	0.62	0.09	0.06	21.02

Table 2: Effect of different irrigation methods of yield attributes on chickpea-coriander intercropping

	Number of pods		Number of seeds pod^{-1}	Weight of 100 seeds	
Treatments	**chickpea**	**coriander**	**Chickpea**	**Chickpea**	**coriander**
Flood	78	740	2.20	21.15	1.05
furrow	88	740	2.30	21.45	1.08
Sprinkler	97	773	2.50	22.17	1.1
Drip	103	883	2.58	23.36	1.2
Control	72	683	1.58	21.06	1.02
S Em±	2.57	6.16	0.04	0.06	0.01
CD	8.09	19.43	0.13	0.19	0.05

Table 3: Effect of different irrigation methods on economics 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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