Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-6: 750-759

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-6 pp. 750-759**
Journal homepage: http://www.ijcmas.com

Original Research Article

Response of Cabbage under Different Levels of Irrigation and Fertigation through Drip

Narendra Agrawal, S. K. Tamrakar, M. P. Tripathi and R. B. Tiwari

Dau Kalyan Singh Agriculture College and Research Station, Bhatapara, Chhattisgarh, India
**Corresponding author*

A B S T R A C T

Drip irrigation has the greatest potential for the efficient use of water and fertilizers. For minimizing the cost of irrigation and fertilizers, adoption of drip irrigation with fertigation is essential which maximize the nutrient uptake while using minimum amount of water and fertilizer. Proper fertigation management requires the knowledge of fertigation rate and nutrient uptake by the crop to ensure maximum crop productivity. Drip fertigation is the most effective way to supply water and nutrients to the plants which not only saves water but also increases yield of vegetable crops. Therefore this experiment was carried out at Borsi Farm, Dau Kalyan Singh Agricultural College & Research Station, Bhatapara (IGKV, Raipur) with three different irrigation and fertigation levels to work out the effect on yield and yield attributing parameters of Cabbage. The results of the two years study revealed that 0.8 CPE water and 80 per cent WSF through drip gave the maximum yield of 230.98 q/ha, which is 30.43 per cent more over conventional irrigation. The other biometric observations like diameter of head and net weight of head were also recorded maximum and the non-wrappers leaves, length of stalks and maturity days were recorded minimum under same treatment. The results also revealed that the water used by the crop was maximum in conventional method (710.44 mm), water use efficiency was recorded maximum in 0.6 CPE water by drip (103.36 q/ha-mm) and water saving was maximum in 0.6 CPE water by drip (73.35 per cent). Similarly the fertilizer use efficiency (58.98) and fertilizer saving (45.45 per cent) was observed maximum in 80 per cent WSF by drip. The net return from produce of Rs. 1,86,852 and the benefit cost ratio (1:2.23) was found to be highest under 0.8 CPE water by drip + 80 per cent WSF and same was lowest in conventional irrigation method.

Keywords

Irrigation, Fertigation, Drip, Fertilizers, Agriculture

Introduction

Cabbage (*Brassica Oleracea* L.) belongs to the family cruciferae has occupied important position in vegetable crop grown in winter season. The horticulture sector has emerged a key player in the overall economy of agriculture contributing about 30 per cent to GDP in agriculture from 8.5 per cent of area. Cabbage is rich in minerals and vitamins A, B1, B2 and C. It is the fourth most widely grown vegetable crop in India and is cultivated in 0.37 M ha producing 8.53 with the productivity of 23 t/ha and occupies 4% of the total vegetable area (NHB, 2014). Drip irrigation is most efficient method in irrigation technology offers the efficient and judicious utilization of irrigation water through frequent irrigation with the volume of applied water approximating the consumptive use of plants thereby minimizing conventional losses such as

conveyance deep percolation and application and stress on plant. This help in obtaining more yield of crop with less amount of water applied (Gorantiwar *et al.*, 1991).

The process of application of fertilizers through irrigation water is called fertigation. Pre-dissolved soluble fertilizers are injected into the feeder line of drip irrigation system in this process. The traditional fertilizers available in the markets are not fully soluble in water and contain insoluble impurities and therefore these fertilizers cannot be applied through drip irrigation system. Also these traditional fertilizers are applied in bulk, lot of fertilizers go waste due to leaching, evaporation and fixation in the soil. Moreover these fertilizers get transmitted to area beyond the active root zone and are no longer useful to the plants. The effective utilization by the plant is in many cases less than 50% of the fertilizers applied (Shirgure *et al.*, 1999).

Fertigation is an efficient method of applying fertilizer through drip irrigation as a carrier and distributor of crop nutrients holds key under these circumstances. It is well-established fact that fertilizer use can be minimizing through drip application. In India not much information is available on different aspects of fertigation on closely grown crops like cabbage. Therefore, the present investigation was carried out to generate data regarding different levels of irrigation and fertigation on growth and yield of cabbage in comparison with traditional method of application.

Materials and Methods

Experimental layout

The investigation was conducted at Borsi Research Farm, Dau Kalyan Singh Agriculture College and Research Station, Bhatapara (IGKV, Raipur), Chhattisgarh during winter season of the year 2014-15 and 2015-16. The experimental site is situated in the central part of Chhattisgarh in India. In this location the mean minimum and maximum temperature ranges from 12.2^{o}C to 25.8^{o}C to 20.6^{o}C to 48.2^{o}C, respectively and relative humidity ranges from 22.3 to 52 per cent and 55.7 to 73.2 per cent, respectively. The experimental site has sandy-loam soil and falls under the semiarid zone. The properties of the soil such as field capacity, wilting point, bulk density and soil depth were determined by usual standard methods. The moisture content was taken at 0.15, 0.30 and 0.45 m depths of soil in each plot. The experimental field was 50 m long and 30 m wide. The experimental plots of 30 x 2m were prepared for transplantation of the seedlings of cabbage. The row-to-row and plant-to-plant spacing were 0.60 and 0.45 m respectively. Recommended cultural practices were followed in raising the crops. The mean values obtained were used for estimating analysis of critical difference.

These investigations were carried out using ten treatments with three replications. Treatments were tested in randomized black design. The details of treatments are given below:

Irrigation treatments

I1 – Irrigation of 0.6 CPE by drip
I2 – Irrigation of 0.8 CPE by drip
I3 – Irrigation of 1.0 CPE by drip

Fertilizer treatments

F1 – 80 per cent RDF (Recommended dose of fertilizer)

F2 – 100 per cent RDF

F3 – 120 per cent RDF

Control

I4 – Surface irrigation at IW/CPE

Estimation of irrigation water requirement (V)

Reference crop evapotranspiration (ET_0) was calculated using Modified Penman Method (Doorenbos and Pruitt, 1977). The crop co-efficient (Kc) for different growth stages of cabbage was selected.

The actual crop evapotranspiration was estimated by multiplying reference crop evapotranspiration, crop co-efficient, area under each plant and wetting fraction. The crop water requirement of cabbage crop was estimated by using the following equation:

V = ETo x Kc x Ap – Ap x Re

Where,

V = Net depth of irrigation (litre/day/plant)

ETo = Reference crop evapotranspiration (mm/day)

Kc = Crop co-efficient

Ap = A x W = Effective area to be irrigated (Sq.m)

A = Area allocated to each plant (Sq.m)

W = Wetting fraction

Re = Effective rainfall (mm/day).

The water requirement was estimated for the growing season of Cabbage. Daily time of operation of drip irrigation system was worked out. Drip irrigation was scheduled on alternate days; hence total quantity of water delivered was cumulative water requirement of two days minus effective rainfall (if rain occurred).

The lateral lines of 12 mm diameter LDPE pipes were laid along the crop rows and each lateral served each row of crop. The laterals were provided with 'in line' emitters of 2 lph discharge capacity in such a manner that water emitting out of emitter wet the entire root zone of the plant. HDPE pipes of 75 mm diameter were used for main and 50 mm diameter was used for sub-main lines. The main line was directly connected to a 2-HP centrifugal pump installed to lift water from the tank. The manifold unit consisted of a screen filter, pressure gauge and control valve. The duration of delivery of water to each treatment was controlled with the help of gate valves provided at the inlet end of each lateral. In case of surface irrigation, irrigation was scheduled at weekly interval. The cumulative depth of water required for seven days was estimated and supplied to each plant. The water (through surface method of irrigation) was directly applied in the furrow with the help of PVC pipes.

Hydraulic performance calculation of drip irrigation

Uniformity Coefficient (UC)

For determination of uniformity coefficient of emitter *i.e.* in-line drip irrigation system, the catch beaker were placed at each selected emission devices of selected laterals. The system was operated at pressure 0.9 kg/ cm^2, 1.00 kg/cm^2 and 1.2 kg/cm^2. The water was allowed to emitter in the beaker for 6 minutes continuously.

The volume of water collected in the beaker was measured with the help of measuring cylinder. The precipitation depth was calculated by dividing the volume of collected water with cross sectional area of

beaker. These depths were used for computing the uniformity coefficient of the emitter calculated by the equation given by Christiansen.

$$UC = 100 \times \left[1 - \frac{\sum X}{mn}\right]$$

Where,

UC = Uniformity coefficient (%)

m = Average of all observations.

n = Total number of observations.

X = Numerical deviation of individual observation from average depth.

Irrigation efficiencies

The water use efficiency (WUE) and fertilizer use efficiency for drip irrigation were computed under the following section.

Water Use Efficiency (WUE)

The fruit yield obtained for each treatment was divided by the quantity of water used consumptively for the respective treatments by this method.

Water use efficiency was worked out and expressed in q per ha-mm of water used.

$$WUE = \frac{\text{Yield (q/ha)}}{\text{Total amount of water used (mm)}}$$

Fertilizer Use Efficiency (FUE)

The fertilizer use efficiency was computed as described by Veeranna (2000).

$$FUE = \frac{\text{Yield (kg/ha)}}{\text{Total quantity of nutrient applied (kg/ha)}}$$

Economic feasibility

Benefit-cost analysis was carried out to determine the economic feasibility of using drip irrigation. The cost of drip irrigation system includes depreciation, prevailing bank interest rate, repair and maintenance of the system. The interest rate and repair and maintenance cost of the system were 12 and 1% per anum of the fixed cost respectively. The useful life of drip system was considered to be 10 years. The cost of cultivation includes expenses incurred in field preparation, cost of seedlings, fertilizer, weeding, crop protection measures, irrigation water and harvesting with labour charges. The income from produce was estimated using prevailing average market price as per the quality of the cabbage. The benefit–cost ratio, total cost of production and net return from cultivation of cabbage over 1 ha were then estimated.

Results and Discussion

The observations on growth and yield parameters of cabbage in each treatment were taken in order to know the effect of different levels of irrigation and fertigation. The results obtained from the study are discussed below:

Effect of irrigation and fertigation levels on yield attributes

Perusal of the data in Table 2 revealed that, application of irrigation at 0.8CPE irrigation regime proved its superiority by recording maximum and significant higher yield attributes viz., the number of non- wrapper leaves (15.76), diameter of head (15.12 cm) and net weight of head (0.571 kg) were recorded maximum under I2F1 i.e. 0.8 CPE water through drip and 80% water soluble fertilizer and the same characters were recorded minimum under I4 i.e. control. Similarly the length of stalks (4.96 cm) and

maturity (141.08 days) were recorded minimum in I2F1 and maximum in I4. This might be due that, the optimum moisture in the vicinity of root zone throughout the crop growth period which enhance the vegetative growth of the crop thereby increase the photosynthesis and efficient translocation of photosynthesis towards the reproductive organ i.e., head, which increases the length, width and weight of head finally resulted in increased head yield of cabbage. This may also be due to complete solubility, mobilization and availability of nutrients at regular interval in required quantity. Similar findings were reported by (Khan *et al.*, 2010). They reported that the combined effect of drip irrigation and fertigation was found superior than their individual effects. The treatment combination of 80% ET through drip irrigation and 80% recommended NPK through fertigation registered maximum fruit yield.

Effect of irrigation and fertigation levels on yield

The averaged marketable yield of drip based irrigation and fertigation levels is given in Table 3 and Figure 1. The highest yield was recorded with I2F1 (230.98 q/ha) which was significantly superior over all treatments combinations and lowest under control (159.12 q/ha). The highest yield was due to precise amount of water with fertilizer through drip system. This data further show that the percentage of increased in yield under drip irrigation levels over flood irrigation method was 22.98, 30.43 and 20.73 per cent under I1, I2 and I3, respectively. Similarly from Table 4, the percentage of increased in yield under drip fertigation levels over control was 33.45, 23.34 and 17.34 per cent under F1, F2 and F3 respectively. This increase in cabbage yield may be due to the better development of head. After observing the table, treatment combinations I2F1 was best as compared to rest of the treatments in terms of yield. Low productions of Cabbage in control treatment was due to poor management of water, inadequate fertilizers and lack of plant population per hectare because the crop is succulent leafy, hardy and thrive best in cool weather. Another possible reason was maximum weed infestation observed between the crop rows. Similar results were obtained by Gupta *et al.,* (2010), where they concluded that the growth and yield attributes of crop under drip irrigation at 80% ET water along with 80% recommended NPK as fertigation was found significantly superior over all other treatment combinations with maximum fruit yield. The results are also in conformity with Singh *et al.,* (2011), who also reported that the average fruit weight, fruit volume, benefit cost ratio and yield were found to be maximum with 80% recommended dose of fertilizers and 0.8 PET water application.

Hydraulic performance of drip irrigation system

The hydraulic performance of drip irrigation system was evaluated through uniform coefficient at different operating pressures. The results are discussed as follows:

Uniformity coefficient

The maximum uniformity coefficient was 96.3 % at 1.2 kg/cm² operating pressure in 2 lph emitter discharge. Similarly the uniform coefficients were 92.25% at 1.0 kg/cm^2 and 89.13% at 0.9 kg/cm^2 operating pressure in 2 lph emitters respectively. The minimum Uniform coefficient was found at 0.9 kg/cm^2 operating pressure with 89.13 %. What this means is that the uniform coefficient increases as the operating pressure increases accordingly operating pressure. At a particular spacing, the average rate of

discharge increased as the operating pressure head increased due to constant emission point per unit length of lateral. Hence uniformity coefficient increased as the operating pressure head increased for all emission devices. The values of uniformity coefficient at different pressures are given in Table 1. The results are in conformity with the findings of Popale *et al.*, (2011).

Water use efficiency and fertilizer use efficiency

Data on the water use efficiency of cabbage crop as influenced by different treatments are presented in Table 3, 4 and Figure 2. The mean water use efficiency under flood irrigation and irrigation schedule were 22.39 q/ha-mm and 82.23 q/ha-mm, respectively. The application of irrigation water through drip irrigation method appreciably improved water use efficiency approximately 3.6 times higher than flood irrigation. It is revealed from the Table 3 that the water use efficiency was found higher in I1 (103.36 q/ha-mm) followed by treatment I2 (82.23 q/ha-mm), I3 (60.88 q/ha-mm) and minimum in control I4 (22.39 q/ha-mm). The lowest WUE in control was primarily due to higher amount of water used. Similarly, it is revealed from the Table 4 the fertilizer use efficiency was found higher in F1 (58.98) followed by F2 (43.61), F3 (34.58) and lowest in control (24.12). The application of water soluble fertilizer through drip appreciably improved the fertilizer use efficiency 2.5 times higher than control. The results are in accordance with (Punamhoro *et al.*, 2003) who reported that increase in water use efficiency in drip system over furrow irrigation was mainly due to the controlled water release near the crop root zone. Similar findings have also been reported by Sharma *et al.*, (2012). They reported that maximum WUE was noted in the treatment which was irrigated with drip at 60% ETc. The lowest WUE was noted in the conventional irrigation system.

Water saving and fertilizer saving

Table 3 shows that the treatment combinations I1F2 and I3F2 were statistically at par with each other resulting in saving of 64.47 per cent irrigation water. Likewise, I2F1 and I2F3 were statistically at par with each other resulting in saving of 45.45 per cent fertilizer requirement. The result also shows that water applied under flood irrigation I4 was higher than drip irrigation. Among drip irrigation method water was applied as per irrigation schedules, it was lowest in I1 i.e. 0.6 CPE of water, while it was highest under irrigation schedule I3 i.e. 1.0 CPE of water. This data further shows that the percentage of water saving in drip irrigation system over flood irrigation method was 73.35, 64.47 and 55.59 per cent under I1, I2 and I3, respectively. Similarly Table 4 shows that the percentage of fertilizer saving in drip irrigation over control was 45.45, 31.81 and 18.18 per cent under F1, F2 and F3 respectively. Similar results were obtained by Kaushal *et al.*, (2012), where they reported that the drip irrigation adoption increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation.

Economics feasibility

Table 5 shows the cost economics of cabbage and Figure 3 and 4 shows the relationship between irrigation levels and B: C ratio & net return. Maximum net returns of Rs. 1,86,852 per ha was obtained under treatment I2F1, which is almost 4.78 times more as compared to control (Rs. 39,148 per

ha). The benefit cost ratio was also obtained maximum under I2F1 (4.23) and minimum under control (1.60). The selling price of cabbage was taken of Rs.10 per kg because the quality of produce was good in treatment I2F1 as compared to rest of the treatments. This increase in income may be due to application of water-soluble-fertilizer through drip system, which could help in a long way for efficient and uniform application of fertilizers with minimum labour involvement to improve the productivity and quality of the produce. Recommended dose of fertilizer through fertigation (80%) will minimize the cost of cultivation with increase in production resulted maximum benefit-cost ratio. Similar findings were reported by Gupta *et al.*, (2010), where they concluded that by adopting drip irrigation system, the highest income could be generated in capsicum as against realized under conventional method. Benefit cost ratio was also noticed maximum with the same treatment combination i.e. 80% ET through drip + 80% recommended NPK through fertigation.

Acknowledgements

Authors are thankful to the Head, Department of Soil and Water Engineering, Faculty of Agricultural Engineering, IGKV, Raipur and Dean, DKS College of Agriculture and Research Station, Bhatapara for providing the necessary funds and research related facilities to conduct this research at Borsi Farm, Bhatapara.

Table.1 Uniformity coefficient under different operating pressures

Operating pressure	Uniform coefficient, %	Classification
	2 lph emitters	
1.2 (kg/cm2)	96.3	Excellent
1.0 (kg/cm2)	92.5	Excellent
0.9 (kg/cm2)	89.13	Very good

Table.2 Effect of drip irrigation and fertigation on the growth of cabbage

Treatments	No. of leaves	Maturity (days)	Length of Stalk (cm)	Dia. of Head (cm)	Net Wt of Head (kg)	Yield (q/ha)
I1F1	13.28	110.23	4.42	14.98	0.562	204.32
I1F2	13.67	122.63	4.48	13.65	0.463	195.58
I1F3	14.76	126.54	4.62	12.56	0.381	187.15
I2F1	**11.72**	**110.65**	**4.25**	**15.12**	**0.571**	**230.98**
I2F2	14.32	120.76	4.51	13.87	0.452	200.89
I2F3	15.14	125.56	4.76	12.78	0.373	190.76
I3F1	13.45	110.20	4.46	14.76	0.541	201.74
I3F2	14.54	122.43	4.58	13.44	0.431	192.34
I3F3	15.34	127.37	4.85	12.37	0.362	182.26
I4	15.76	141.08	4.96	9.81	0.212	159.12
CD at 5%	**1.39**	**26.12**	**NS**	**1.80**	**0.42**	**43.15**

Table.3 Effect of drip irrigation levels on the yield of cabbage

Drip Irrigation Levels	Fertigation Levels				Water Used (mm)	Water Use Efficiency (q/ha-mm)	Water Saving (%)	Increased in Yield (%) over control
	F1	F2	F3	Mean				
I1	204.32	195.58	187.15	**195.68**	189.31	103.36	73.35	22.98
I2	230.98	200.89	190.76	**207.54**	**252.41**	**82.23**	**64.47**	**30.43**
I3	201.74	192.34	182.26	**192.11**	315.52	60.88	55.59	20.73
Mean	**212.35**	**196.27**	**186.72**	-				
I4				**159.12**	710.44	22.39	-	-

Table.4 Effect of drip fertigation levels on the yield of cabbage

Fertigation Levels	Drip Irrigation Levels				Fertilizer Used (q/ha)	Fertilizer Use Efficiency	Fertilizer Saving (%)	Increased in Yield (%) over control
	I1	I2	I3	Mean				
F1	204.32	230.98	201.74	**212.35**	**3.60**	**58.98**	**45.45**	**33.45**
F2	195.58	200.89	192.34	**196.27**	4.50	43.61	31.81	23.34
F3	187.15	190.76	182.26	**186.72**	5.40	34.58	18.18	17.34
Mean	**195.68**	**207.54**	**192.11**	-				
I4				**159.12**	6.60	24.12	-	-

Table.5 Cost economics of cabbage

Treatments	Yield (q/ha)	Gross Return	Cost of Cultivation			Cost of Prod (Rs./q)	Net Return	B:C ratio
			Seedlings + Spray materials + Labour Cost + Interest & Depreciation on Drip	Fertilizer Cost	Total Cost			
I1F1	204.32	204320	17200	26928	44128	215.97	160192	3.63
I1F2	195.58	195580	17200	33660	50860	260.05	144720	2.85
I1F3	187.15	187150	17200	40392	57592	307.73	129558	2.25
I2F1	**230.98**	**230980**	**17200**	**26928**	**44128**	**191.05**	**186852**	**4.23**
I2F2	200.89	200890	17200	33660	50860	253.17	150030	2.95
I2F3	190.76	190760	17200	40392	57592	301.91	133168	2.31
I3F1	201.74	201740	17200	26928	44128	218.74	157612	3.57
I3F2	192.34	192340	17200	33660	50860	264.43	141480	2.78
I3F3	182.26	182260	17200	40392	57592	315.99	124668	2.16
I4	159.12	63648	16500	8000	24500	153.97	39148	1.60

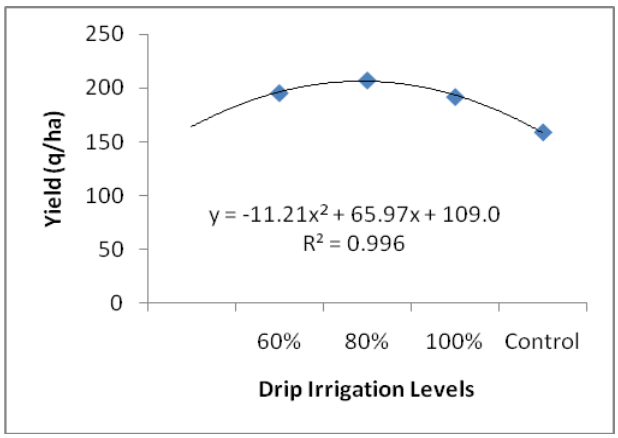

Fig.1 Relationship between irrigation levels and yield

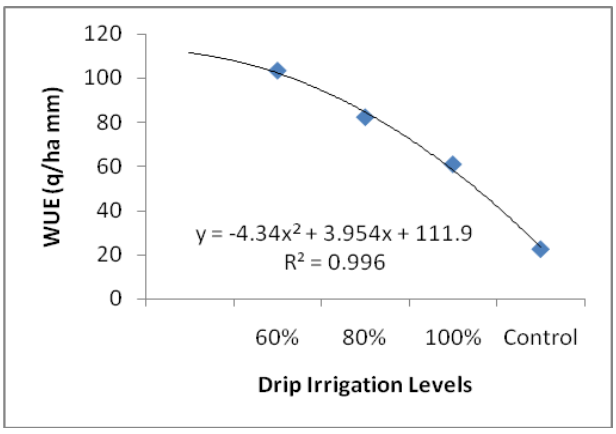

Fig.2 Relationship between irrigation levels and WUE

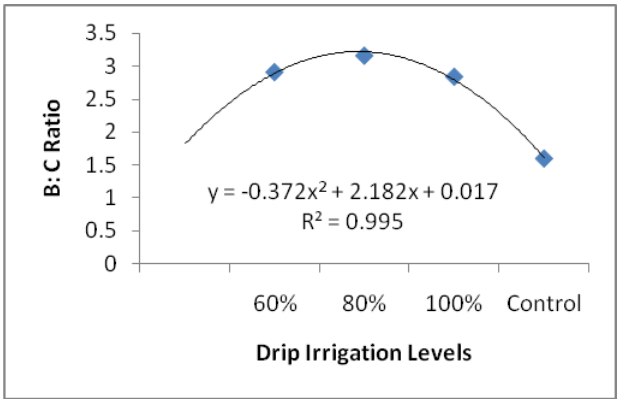

Fig.3 Relationship between irrigation levels and B:C Ratio

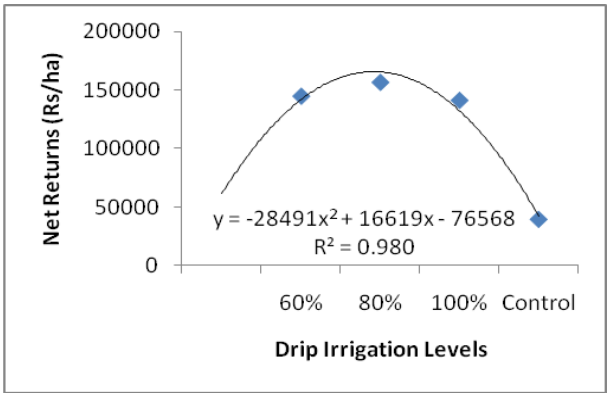

Fig.4 Relationship between irrigation levels and net return

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