ISSN: 2581-3749 (online) Advanced Agricultural Research & Technology Journal ▪ Vol. II ▪ Issue 2 ▪ JULY 2018

Effect oF Dirernt Irrigation Regimes and Row Spacings on Growth and Yield of Isabgol (*Plantago ovata*) during Rabi Season

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Abstract

A field investigation entitled "Effect of different irrigation regimes and spacings on isabgol (Plantago ovata) during rabi season" was carried out on black soil of Nagarjun Medicinal plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the summer season of 2014-2015. The experiment was laid out in factorial Randomized block design with nine treatments and three replications in order to study the effect of irrigation regimes and spacings and their integration effect on growth, yield attributes and productivity for isabgol

The main plot consisted three irrigation levels viz., 0.6 IW CPE^{-1}, 0.8 IW CPE^{-1} and 1.0 IW CPE^{-1} while the sub plot treatments consisted of spacings *viz.*, 30 cm, 22.5 cm and 15 cm. Experimental results revealed that growth characters were significantly higher with irrigation scheduled at 1.0 IW CPE^{-1} followed by 0.8 IW CPE^{-1} and 0.6 IW CPE^{-1}. Yield attributes and seed yield were significantly higher with irrigation scheduling 1.0 IW CPE^{-1}. Water Use Efficiency was higher with, irrigation scheduling 0.6 IW CPE^{-1}. The economic analysis *viz.* GMR and NMR was higher with irrigation scheduled at 1.0 IW CPE^{-1}, but B:C ratio was higher in irrigation scheduled at 0.6 IW CPE^{-1}.Uptake of nutrient increase marginally with irrigation scheduled at 1.0 IW CPE^{-1}. Spacing of 30 cm recorded increased growth characters compared to 15 cm and 22.5 cm. Seed yield increased due to spacing of 15 cm. Nutrient uptake of crop was notably higher with spacing of 30 cm followed by 22.5 cm and 15 cm. Spacing of 30 cm also produced higher GMR, NMR and 15 cm spacing recorded highest B:C ratio.

Keywords: Isabgol, Irrrigation regimes, medicinal plants, yield

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Received Date: 10.3.2017; Accepted Date: 15.1.2018

Introduction

Isabgol *(Plantago ovata)* is known as Psyllium, Isabgol, Ispaghula. Isabgol is the Rabi season crop of 30-35 cm tall, short-stemmed annual herb. The seed husk is the commercial part and is separated by physical process. It contains colloidal mucilage (30%), mainly consisting xylose, arabinose, galacturonic acid with rhamnose, galactose etc. The husk has the property of absorbing and retaining water. The husk (epicarp) is used against constipation, irritation of digestive tract etc. In addition, these are also used in food industries for preparation of ice cream, candy etc.

Isabgol is an irrigated *rabi* crop, which grows well on light to medium soils with good drainage. It is traditionally grown in light sandy to sandy loam soils; however, recently it has been cultivated successfully on clay loam, medium black, black cotton and also on heavy black soils. It is grown in the month of November-December and is harvested in the month of March-April. It requires cool and dry weather for its growth and maturity. For getting higher yield of Isabgol, proper spacing and optimum irrigation level are required to be identified for the Vidarbha region. Medicinal crops are grown by the marginal farmers on relatively poor lands in variable stress condition. The present research is undertaken to find out irrigation requirement for Isabgol.To find out suitable spacing for Isabgol and cost economics. The present investigation is very effective for assessing the growth and yield of isabgol under different irrigation regime and spacing treatments. The study will be helpful to see the effect of irrigation and spacing on *rabi* isabgol. It will be beneficial for farmers and also to the research worker to carry out the research on isabgol.

Material and Methods

A field experiment entitled "Effect of irrigation regime and spacing on growth and yield of isabgol (*Plantago ovata*) during *rabi* season" was conducted during 2014-15.

Details of treatments

Factor A: Irrigation level	Factor B: Spacing
I_1 - 0.6 IW/CPE	S1 - 15 cm between Rows
I_2 - 0.8 IW/CPE	S2 - 22.5 cm between Rows
I_3 - 1.00IW/CPE	S3 - 30 cm between Rows

Table 1. Detail of irrigation treatment

Treatments	Number of irrigation	Dates of irrigation
I_1	6	22-12-2014, 11-01-2015, 28-01-2015, 11-02-2015, 28-02-2015, 16-03-2015.
I_2	8	17-12-2014, 30-12-2014, 16-01-2015, 28-01-2015, 08-02-2015, 20-02-2015, 04-03-2015, 16-03-2015.
I_3	10	14-12-2014, 25-12-2014, 06-01-2015, 19-01-2015, 28-01-2015, 06-02-2015, 15-02-2015, 24-02-2015, 15-03-2015.

The experiment was laid out in Factorial Randomized Block Design with two factor nine treatments each replicated three times. The treatments were allotted randomly in each replication. The plot size was 4.00 x 3.60 m. Details of the treatments along with symbols used in plan of layout are given follows.

Irrigation

Irrigation was given as per the schedule of irrigation treatment (Table 1). A common irrigation was given before planting for good emergence. Later, irrigation was given as per the treatment. The discharge of water through pipe in the plot was measured by the volume methods.

Absolute growth rate (AGR)

Absolute growth rate of total dry matter weight was calculated by following formula and expressed as g day^{-1} plant^{1}.

AGR for height

$$AGR = \frac{H_2 - H_1}{T_2 - T_1}$$

AGR for dry matter

$$AGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

H_2 and H_1 and W_2 and W_1 refer repectively to height and total dry matter of plant at T_2 and T_1 time.

Relative growth rate (RGR)

This rate of increment is called as relative growth rate (RGR), which was worked out as per formula and expressed in g^{-1} day^{-1} plant^{-1}.

Net assimilation rate (NAR)

Net assimilation rate is defined as the rate of increase in plant dry matter per unit of assimilatory surface per unit time.

Post harvest studies

Important yield attributing characters were studied after the harvest of crop.

Number of spike plant^{-1}

The spikes from randomly selected five plants were measured per plant.

Spike length plant

The spike from the randomly selected five plants and length of spike was measured with scale in cm.

Swelling Factor

All the spikes of the sampled plants were threshed separately and the swelling factor was measured separately. Swelling of seeds were recorded treatment wise by adopting the procedure described in Biannual Report (1978-80),on Medicinal and Aromatic plants which is mentioned as follows.

Take 1 g seed in 25 ml graduated stopper cylinder. Add 20 ml distilled water (up to 20 ml mask). Agitate for through wetting. Allow to stand for 20 min. Again agitate for uniform distribution. Allow to stand for 6 hrs. Volume of swelling capacity of seed recorded in cc g^{-1}.

Seed yield per hectare

The plants harvested from net plot were threshed, cleaned and seed weight plot^{-1} was recorded separately. The seed yield was then converted into hectare yield (kg ha^{-1}).

Soil Moisture studies

Moisture studies

Moisture tubes were used for moisture studies.

Water use efficiency

Water use efficiency for various treatment was calculated on the basis of grain yield and consumptive use of water in a given irrigation treatment. It indicates that amount of grain yield produced unit^{-1} of water consumed, unit^{-1} of land.

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Yield (kg ha}^{-1})}{\text{Evapotranspiration (mm)}}$$

Where,

WUE = Water use efficiency (kg ha^{-1} mm^{-1})

Y = Economic yield (kg ha^{-1}) in a particular treatment

ET = Total evapotranspiration (mm) i.e. CU in the Concerned treatment

Consumptive use

Consumptive use of water under each irrigation treatment was calculated by considering following components.

1. The potential evapo-transpiration during the period of 72 hours after irrigation.
2. Soil moisture depletion by the crop from a concerned profile.
3. Effective rainfall during the period of two consecutive sampling, at the time of irrigation

$$Cu = \sum_{K=1}^{\cdot\cdot} \text{EK x K} + \sum \frac{n(\text{Mai} - \text{Mbi})}{100} \text{x ASI x Di} + \text{ER}$$

Where

Cu = Consumptive use of water in mm, for the period between two Consecutive irrigation

Ek = Actual evaporation from USWB open pan, for the period of 72 hrs (After irrigation to the time till sampling in wet soil become possible)

K = A constant for potential evapotranspiration, for Dec., Jan (0.6) and Feb., March (0.7) in Akola region.

Mai = Soil moisture (%) after irrigation

Mbi = Soil moisture (%) just before irrigation

n = Number of soil layer

Asi = Bulk density of the ith layer (g cc^{-1})

Di = Soil depth of the ith layer two consecutive sampling period

Thus consumptive use during the given irrigation interval was worked out by adding all the above component together and all such consumptive use figures were added together to get the total consumptive use during the season of the crop.

Chemical studies

Nutrient uptake by plant (kg ha^{-1})

The nutrient uptake by seed and straw after harvest were calculated in kg ha^{-1} and g ha^{-1}

Results and Discussion

The results obtained from the field experimentation are presented and discussed under various heads.

Plant height

Data on plant height at various growth stages as influenced by different treatments are presented in Table 2. Mean plant height was increased progressively and reached to its maximum at harvest. The rate of increase in height rapid in between 45 to 90 DAS and it hastened between 90 DAS to harvest may be due to Spike formation. The plant attained mean height of 32.16 cm at harvest. The effect of different irrigation levels and spacing's was observed to be significant at 45, 60, 90 DAS and at harvest.

Effect of irrigation level

The plant height was significantly influenced due to the scheduling of irrigation at 45 and 60 DAS. Significantly higher plant height was observed at 1.0 IW/CPE, irrigation scheduling recorded significantly superior over 0.6 IW/CPE, However it was at par with irrigation scheduled at 0.8 IW/CPE.

At 90 DAS and at harvest, maximum plant height was observed at 1.0 IW/CPE over 0.6 IW/CPE and 0.8 IW/CPE irrigation regimes. The treatment 0.6 IW/CPE and 0.8 IW/CPE were statistically at par with each other, while treatment 0.6 IW/CPE and 0.8 IW/CPE were statistically at par with each other.

Increase in plant height might be due to optimum soil

Table 2. Plant height (cm plant^{-1}) as influenced by different irrigation levels and spacings

Treatments	45 DAS	60 DAS	90 DAS	At harvest
Irrigation levels				
I1 (0.6 IW/CPE)	16.97	20.64	29.84	31.38
I2 (0.8 IW/CPE)	17.87	22.25	29.99	31.73
I3 (1.0 IW/CPE)	18.01	22.93	30.95	33.38
SE (m)±	0.27	0.28	0.29	0.21
CD (P= 0.05)	0.82	0.83	0.88	0.62
Spacing				
S1 (15cm)	18.54	22.93	30.38	31.88
S2 (22.5cm)	17.28	21.56	30.28	32.04
S3 (30cm)	17.03	21.34	30.12	32.58
SE (m)±	0.27	0.28	0.29	0.21
CD (P= 0.05)	0.82	0.83	NS	NS
Interaction				
I x S				
SE (m)±	0.47	0.48	0.51	0.36
CD (P= 0.05)	NS	NS	NS	NS
GM	17.62	21.94	30.26	32.16

moisture availability favouring the nutrient uptake, resulting in better growth as against scheduling irrigation through 0.6 IW/CPE and 0.8 IW/CPE. The irrigation scheduling at 50 CPE of 1.0 IW/CPE provides higher soil moisture availability due to which plant absorbed more water and resulted in higher plant height as compared to other levels.

Effect of spacing

The effect of spacing on plant height was observed significantly at 45, 60. While non-significant at 90 DAS and at harvest.

At 45 & 60 DAS, maximum plant height were observed with spacing of S_3 (30 cm) which was significantly superior over S_1(15 cm) and S_2(22.5) cm. While S_1 (15cm) and S_2(22.5) were statistically at par with each other.

The spacing of S_1 (30 cm) produced higher growth parameters plant^{-1} which was mainly due to better resource availability and reduction in interplant competition in plant community.

The above results are in conformity with the findings reported by Patel *et al.* (2011) and Siddaraju *et al.* (2010).

Interaction effect was found to be non significant in respect of plant height at all the crop growth stages.

Chlorophyll content

Data on chlorophyll content plant^{-1} as influenced by various treatments at different growth phases are shown in Table 3.

Effect of irrigation level

The irrigation scheduling at 50 CPE provides higher soil moisture availability due to which plant absorbed more water and resulted in higher chlorophyll content as compared to other levels. This might be due to more and frequent irrigations resulted in better green leaves, synthesizing activity and assimilation rate leading to increase in chlorophyll content.

The irrigation scheduling significantly influenced the chlorophyll content plant^{-1} at all the stages of crop growth except at 90 DAS.

At 45 and 60 DAS, maximum chlorophyll content observed with irrigation scheduling at 1.0 IW/CPE and it

Table 3. Chlorophyll content plant^{-1} (%) as influenced by different irrigation levels and spacings

Treatments	45 DAS	60 DAS	90 DAS
Irrigation levels			
I1 (0.6 IW/CPE)	9.21	15.59	6.54
I2 (0.8 IW/CPE)	9.36	15.75	7.47
I3 (1.0 IW/CPE)	10.49	16.41	8.26
SE (m)±	0.32	0.21	3.23
CD (P= 0.05)	0.97	0.62	NS
Spacing			
S1 (15cm)	9.54	15.70	7.43
S2 (22.5cm)	9.75	15.97	7.39
S3 (30cm)	9.77	16.09	7.44
SE (m)±	0.32	0.21	3.23
CD (P= 0.05)	NS	NS	NS
Interaction			
I x S			
SE (m)±	0.56	0.36	5.59
CD (P= 0.05)	NS	NS	NS
GM	9.69	15.92	7.42

was significantly higher over other levels. However, 0.6I W/CPE and 0.8 IW/CPE at par with each other.Irrigation level at 1.0 IW/CPE recorded highest chlorophyll content at all the crop growth stages. The chlorophyll content after 90 DAS decreased due to drying of leaves.

Effect of spacing

The effect of spacing had no significant influence on the chlorophyll content. However, at all the growth stages spacing of 30 cm recorded numerically higher values.

Interaction effect

Interaction effect was found to be non significant in respect of chlorophyll content at all the crop growth stages.

Total Dry matter plant^{1} (g)

Data in respect of total dry matter plant^{-1} as influenced by various treatment of irrigation regime and spacing at all the crop growth stages are presented in Table 4.

In general total dry matter was increased continuously up to harvest. Maximum mean dry matter plant^{-1} was

Table 4. Total dry matter accumulation per plant^{-1} (g) as influenced by different irrigation levels and spacings

Treatments	45 DAS	60 DAS	90 DAS	At harvest
Irrigation levels				
I1 (0.6 IW/CPE)	1.53	3.27	7.79	8.65
I2 (0.8 IW/CPE)	1.65	3.46	7.88	8.66
I3 (1.0 IW/CPE)	2.05	3.95	8.49	9.21
SE (m)±	0.08	0.09	0.16	0.32
CD (P= 0.05)	0.25	0.26	0.49	NS
Spacing				
S1 (15cm)	1.65	3.44	7.80	8.56
S2 (22.5cm)	1.67	3.49	7.94	8.97
S3 (30cm)	1.93	3.75	8.42	9.00
SE (m)±	0.08	0.09	0.16	0.32
CD (P= 0.05)	0.25	0.26	0.49	NS
Interaction				
I x S				
SE (m)±	0.14	0.15	0.29	0.56
CD (P= 0.05)	NS	NS	NS	NS
GM	1.74	3.56	8.05	8.84

recorded at harvest. Mean total dry matter was increased from 0.60 g at 30 DAS, 1.15 g at 45 DAS, 3.56 g at 60 DAS, at 90 DAS and 8.84 g at harvest.

Effect of irrigation level

Data in respect of mean dry matter accumulation (g plant^{-1}) shows significant differences at all the stages of crop growth except at 15 DAS. At 45 DAS, significantly higher dry matter accumulation plant^{-1}was observed in irrigation scheduling at 1.0 IW/CPE over 0.6 IW/CPE, however, it was at par with 0.8 IW/CPE. The growth parameters showed a decreasing trend with decreasing IW/CPE ratio up to 0.6.

At 60 and 90 DAS significantly higher dry matter accumulation was observed under irrigation scheduling at 1.0 IW/CPE and it was significantly higher over 0.8 IW/CPE and 0.6IW/CPE. While 0.8 IW/CPE and 0.6IW/CPE were at par with each other.

The dry matter accumulation plant^{-1}is the resultant of photosynthesis activity. Increase in irrigation frequency increased dry matter accumulation (g) plant^{-1}. Irrigation scheduled at 1.0 IW/CPE, increased the number of leaves, leaf area which increases the production of photosynthets produced and accumulated at a higher rate and quantity through process of plant metabolism which ultimately replaced in dry matter production at higher rate. These results are in accordance with the findings of Singh *et al.* (2014) and Yadav *et al.* (2012).

Effect of spacing

Total dry matter accumulation g^{-1} plant^{-1} was influenced significantly by various spacing except at harvest.

At 45 and 60 maximum dry matter accumulation plant^{-1} under spacing of 30 cm and was significantly higher over pacing of 22.5 cm and 15 cm. While 22.5 cm and 15 cm were at par to each other.

At 90 DAS, maximum dry matter accumulation plant^{-1}was observed in spacing of 30 cm which was significantly higher over spacing of 15 cm, however it was at par with spacing of 22.5 cm.

Interaction effect was found to be non significant in respect of total dry matter at all the crop growth stages.

Light interception (%)

Data on light interception affected by various treatments at different growth stages are given in Table 5.

Effect of irrigation level

Irrigation scheduling at 1.0 IW/CPE recorded highest light interception followed by irrigation scheduling at 0.8 IW/CPE and minimum 0.6 IW/CPE.

Effect of spacing

The highest light interception was recorded with spacing 30 cm followed by 22.5 cm and 15 cm.

Growth analysis

Data on height of plant, leaf area per plant and total dry matter production per plant were further subjected to growth function *viz*. AGR, RGR and NAR at various growth stages of crop and are exhibited on mean basis.

Absolute growth rate (AGR) for dry matter

Data on AGR for dry matter as affected by various treatments at different growth stages are given in Table 6.

Effect of irrigation level

The AGR for dry matter was significantly influence at 60-75 DAS and non significant at all other stages.

At 60-75 DAS, irrigation scheduling at 1.0 IW/CPE recorded highest values of AGR which was significantly higher over 0.8 IW/CPE and 0.6 IW/CPE. Irrigation regime 0.6 IW/CPE and 0.8 IW/CPE were at par to each other.

Effect of spacing

The AGR for dry matter at all growth stage was found non significant. But numerically higher value was recorded fewer than 30 cm spacing.

Interaction effect

Interaction effect was found to be non significant in respect of AGR for dry matter at all the crop growth stages.

Relative growth rate (RGR) for dry matter

Data on Relative growth rate (RGR) for dry matter as affected by various treatments at different growth stages are given in Table 7.

Effect of irrigation level

It is evident from the data presented in table 7 that, RGR for dry matter, did not differ significantly due to irrigation levels.

The effect of spacing and interaction had no significant influence on the RGR for dry matter at all crop growth stages.

Net assimilation rate (NAR)

Data on Net Assimilation Rate (NAR) as affected by various treatments at different growth stages is given in Table 8.

Effect of irrigation level

Table 5. Light interception as influenced by different irrigation levels and spacings.

Treatments	90 DAS	At harvest
Irrigation		
I1 (0.6 IW/CPE)	71.50	55.10
I2 (0.8 IW/CPE)	76.40	59.10
I3 (1.0 IW/CPE)	81.20	63.20
Spacing		
S1 (15cm)	68.24	51.58
S2 (22.5cm)	76.46	60.41
S3 (30cm)	84.40	65.41
GM	76.36	59.13

Table 6. Absolute growth rate (AGR) for dry matter ($g^{-1} day^{-1}$ plant) as influenced by different irrigation levels and spacings

Treatments	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS	90- At harvest
Irrigation levels					
I1 (0.6 IW/CPE)	0.062	0.124	0.126	0.134	0.044
I2 (0.8 IW/CPE)	0.064	0.126	0.127	0.139	0.046
I3 (1.0 IW/CPE)	0.067	0.156	0.174	0.180	0.071
SE (m)±	0.012	0.013	0.011	0.021	0.014
CD (P= 0.05)	NS	NS	0.033	NS	NS
Spacing					
S1 (15cm)	0.062	0.135	0.147	0.134	0.039
S2 (22.5cm)	0.063	0.135	0.149	0.139	0.050
S3 (30cm)	0.067	0.137	0.151	0.160	0.072
SE (m)±	0.012	0.013	0.011	0.021	0.014
CD (P= 0.05)	NS	NS	NS	NS	NS
Interaction					
I x S					
SE (m)±	0.022	0.023	0.019	0.036	0.023
CD (P= 0.05)	NS	NS	NS	NS	NS
GM	0.064	0.135	0.149	0.144	0.054

It was evident from the data presented in Table 8 that, value of NAR did not differ significantly due to irrigation levels at all stages of observation.

The effect of spacing and interaction had no significant influence on the values of NAR at all crop growth period.

Soil moisture studies

Data in respect of consumptive use and water use efficiency based on mean values influenced by various treatments are presented in Table 9

Total water requirement

From the data represented in Table 9, it is observed that mean total water requirement was 451.30 mm.

Effect of irrigation

Data indicated that with increase in irrigation total water requirement also increases. Highest total water requirement of 500 mm was recorded by 1.0 IW/CPE followed by 0.8 IW/CPE (437.39 mm), 0.6 IW/CPE (416.50 mm).

Effect of spacing

The spacing treatment showed difference in total water requirement. The spacing of 22.5 cm recorded highest water requirement (451.33 mm) followed by spacing of 15 cm (451.23). Spacing of 30 cm (451.22 mm) recorded minimum total water requirement.

Water use efficiency

From the data presented in Table 9, the mean value of water use efficiency was observed to be 3.10kg ha^{-1} mm.

Effect of irrigation

Irrigation scheduling at 0.6 IW/CPE recorded highest water use efficiency (3.71 kg ha^{-1}mm) followed by irrigation scheduling at 0.8 IW/CPE (2.99 kg ha^{-1}mm) and minimum at 1.0 IW/CPE (2.56 kg ha^{-1} mm). The above findings agree with those reported by Behera *et al*. (2015), Singh *et al.* (2014) and Kumar *et al.* (2015).

Effect of spacing

The highest water use efficiency was recorded with spacing 22.5 cm (3.14 kg ha^{-1} mm) followed by 30 cm

Table 7. Relative growth rate (RGR) for dry matter (g $^{-1}$ day^{-1} plant) as influenced by different irrigation levels and spacings

Treatments	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS	90 - At harvest
Irrigation levels					
I1 (0.6 IW/CPE)	0.057	0.055	0.031	0.017	0.006
I2 (0.8 IW/CPE)	0.057	0.058	0.033	0.018	0.006
I3 (1.0 IW/CPE)	0.063	0.059	0.033	0.028	0.007
SE (m)±	0.009	0.008	0.002	0.003	0.003
CD (P= 0.05)	NS	NS	NS	NS	NS
Spacing					
S1 (15cm)	0.059	0.056	0.031	0.021	0.005
S2 (22.5cm)	0.059	0.057	0.032	0.021	0.007
S3 (30cm)	0.061	0.059	0.034	0.022	0.007
SE (m)±	0.009	0.008	0.002	0.003	0.003
CD (P= 0.05)	NS	NS	NS	NS	NS
Interaction					
I x S					
SE (m)±	0.016	0.014	0.004	0.006	0.006
CD (P= 0.05)	NS	NS	NS	NS	NS
GM	0.059	0.057	0.032	0.021	0.006

Table 8. Net assimilation rate (NAR) (g cm^{-2} $plant^{-1}$) as influenced by different irrigation levels and spacings

Treatments	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS	90 - At harvest
Irrigation levels					
I1 (0.6 IW/CPE)	0.0032	0.005	0.0017	0.0002	0.0066
I2 (0.8 IW/CPE)	0.0042	0.0049	0.0016	0.0006	0.0073
I3 (1.0 IW/CPE)	0.0042	0.0051	0.0018	0.0008	0.0077
SE (m)±	0.0003	0.0001	0.0001	0.0001	0.0005
CD (P= 0.05)	NS	NS	NS	NS	NS
Spacing					
S1 (15cm)	0.0036	0.0052	0.0018	0.0004	0.0075
S2 (22.5cm)	0.0043	0.0053	0.0015	0.0009	0.0073
S3 (30cm)	0.0037	0.0047	0.0017	0.0005	0.0074
SE (m)±	0.0002	0.0002	0.0001	0.0002	0.0004
CD (P= 0.05)	NS	NS	NS	NS	NS
Interaction					
I x S					
SE (m)±	0.0005	0.0003	0.0003	0.0003	0.0009
CD (P= 0.05)	NS	NS	NS	NS	NS
GM	0.0039	0.0051	0.0017	0.0006	0.0074

Table 9. Total Water Requirement and Water Use Efficiency as influenced by different irrigation levels and spacings

Treatments	Yield (kg ha^{-1})	Total Water Requirement (mm)	WUE (kg ha^{-1} mm)
Irrigation levels			
I1 (0.6 IW/CPE)	718.37	416.50	3.71
I2 (0.8 IW/CPE)	750.54	437.39	2.99
I3 (1.0 IW/CPE)	829.32	500.00	2.56
Spacing			
S1 (15cm)	784.65	451.23	3.02
S2 (22.5cm)	765.22	451.33	3.14
S3 (30cm)	748.36	451.22	3.09
GM	766.08	451.30	3.10

Table 10. No. of spike, spike length, seed yield and swelling factor as influenced by different irrigation levels and spacings

Treatments	No of spike plant^{-1}	Spike	Seed yield (kg ha^{-1})	Swelling factor cc g^{-1}
Irrigation levels				
I1 (0.6 IW/CPE)	25	2.95	718	10.49
I2 (0.8 IW/CPE)	26	3.06	751	11.23
I3 (1.0 IW/CPE)	27	3.47	829	11.87
SE (m) ±	0.4	0.11	8	0.38
CD (P= 0.05)	1	0.32	23	NS
Spacing				
S1 (15 cm)	25	3.20	785	11.23
S2 (22.5 cm)	26	3.11	765	11.32
S3 (30 cm)	27	3.17	748	11.03
SE (m)±	0.4	0.11	8	0.38
CD (P= 0.05)	NS	NS	23	NS
Interaction				
I x S				
SE (m) ±	0.6	0.18	13	0.66
CD (P= 0.05)	NS	NS	NS	NS
GM	26	3.16	766	11.19

(3.09 kg ha^{-1}) mm and 15 cm (3.02 kg ha^{-1}mm).

Yield attributes and yield

The data in respect of no. of spike plant^{-1}, spike length cm, swelling factor, seed yield as affected by various treatments are shown in Table 10.

Mean value of spike plant^{-1}, spike length (cm), swelling factor, seed yield (kg plant^{-1}) were, 8.50, 7.71, 33.50 and 7.20 respectively which were significantly influenced due to irrigation levels and spacing.

Number of Spike plant^{-1}

The data presented in Table 10 revealed that number of spike plant^{-1} was affected significantly due to various treatments and mean number of spike was 26.

Effect of Irrigation level

Irrigation scheduling at 1.0 IW/CPE recorded 27 number of spike which was significantly superior over other irrigation levels. Similarly, 0.8 IW/CPE recorded 26 number of spike which was significantly superior over 0.6 IW/CPE, Because of frequent irrigation at 1.0 IW/CPE, this treatment might have created favorable moisture conditions for the crop growth consequently increased the values of the yield attributes than other treatments

Spacing and interaction effect was found to be non significant in respect of number of spike plant^{-1} at all the crop growth stages.

Spike length (cm)

The data presented in Table 10 revealed that spike length was affected significantly due to various treatments and mean spike length was 3.16

Effect of irrigation level

Spike length was significantly influenced due to irrigation scheduling 1.0 IW/CPE recorded 3.47spike length which was significantly superior over 0.8 and 0.6 IW/CPE.

Because of frequent irrigation under at 1.0 IW/CPE treatment might have created favorable moisture conditions for the crop growth consequently increased the values of the yield attributes than other treatments. Similar trend was reported by Yadav *et al.* (2012)

Spacing and interaction effect was non-significant during investigation.

Swelling factor cc g^{-1}

The data presented in Table 10 in respect of swelling capacity of seeds in isabgol due to effect of different treatments was found non-significant.

Effect of irrigation level

The data from table revealed that maximum swelling capacity of seeds was recorded under the irrigation treatment 1.0 IW/CPC.

Spacing and interaction effect was non-significant during investigation.

Seed Yield (q ha^{-1})

The data presented in Table 10.revealed that seed yield of isabgol affected significantly due to various treatments. Mean seed yield was 7.66 q ha^{-1}.

Effect of irrigation level

Irrigation scheduling significantly influenced the seed yield of isabgol. Irrigation scheduled at 1.0 IW/CPE produced maximum seed yield (829 kg ha^{-1}) which was significantly higher over other levels. Irrigation scheduling at 0.8 IW/CPE recorded significantly higher seed yield over 0.6 IW/CPE. The increased seed yield was mostly attributed to more spike bearing and dry matter accumulation in the treatments. The lowest values of the yield attributes were observed in case of IW/CPE of 0.6.

In *rabi* season, large amount of water was lost through evaporation from soil and transpiration from vegetation which exerted more pressure on water demand and this demand was fulfilled due to frequent irrigation at 1.0 IW/CPE resulting in higher number of spikes. The increase in all growth attributes under the treatment 1.0 IW/CPE might be due to additional moisture supply due to application of frequent irrigation which helps in promoting the growth and cell multiplication activities, better availability of nutrients enhance the vegetative and reproductive growth. Favourable plant water balance maintained through irrigation might have resulted in better translocation of photosynthates and maintenance of cell turgidity, consequently leading to higher yield traits. Same trend was reported by Yadav *et al.* (2012).

Effect of spacing

Improvement in different yield attributes due to optimum space and more plant population at 15 cm spacing.

Maximum seed yield was recorded with spacing of 15 cm which was significantly superior over 30 cm but at par with 22.5 cm. This was due to more plant population with spacing 15cm compared to other treatment.

Interaction effect between irrigation scheduling and spacing was non significant in respect to seed yield.

Nutrient uptake

Nitrogen uptake (kg ha^{-1})

Nitrogen uptake in seed and straw is presented in Table 11.

Effect of irrigation level

Irrigation levels at different growth stages significantly influenced the nitrogen uptake of isabgol crop.

Successive increase in number of irrigations significantly increased the nitrogen uptake by isabgol crop. The significantly high uptake of nitrogen by seed and straw of nitrogen by plant were 35 recorded by irrigation scheduled at 1.0 IW/CPE which was significantly superior over 0.6 IW/CPE and 0.8 IW/CPE. Higher uptake of nitrogen in straw at irrigation scheduled 1.0IW/CPE over 0.8 IW/CPE.

Uptake of N, P and K was the highest when the crop was irrigated at IW/CPE ratio of 1.0. This might be due to optimal air and water balance in the soil, which consequently increased the mobilization of the nutrients along with the absorbed water through well developed root system. At lower irrigation frequency insufficient soil moisture might not have facilitated mass flow, root interception and diffusion processes to mobilize the nutrients for uptake. The uptake pattern mostly followed the biomass yield trend due to different irrigation regimes. Similar result was found Tripathy *et al.*(2012).

Effect of spacing

Spacing at different growth stages non significantly influenced the nitrogen uptake of isabgol crop.

Interaction effect

Interaction effect between irrigation scheduling and spacing in respect of nitrogen content in isabgol due to different treatment was found non significant.

Phosphorus uptake (kg ha^{-1})

Phosphorus uptake in seed and straw is presented in Table 11.

Effect of irrigation level

Phosphorus uptake by seed and straw was significantly influenced by irrigation scheduling. Irrigation scheduled at 1.0 IW/CPE recorded maximum phosphorus uptake by seed and straw which was significantly superior over0.6 IW/CPE and 0.8 IW/CPE. Similar result was

Table 11. NPK uptake as influenced by different irrigation levels and spacings.

Treatments	N (Kg ha^{-1})		P uptake (Kg ha^{-1})		K (kg ha^{-1})	
	Seed	Straw	Seed	Straw	Seed	Straw
Irrigation levels						
I1 (0.6 IW/CPE)	32.1	23.1	10.4	11.5	10.2	23.2
I2 (0.8 IW/CPE)	32.6	23.4	10.3	11.6	11.2	23.8
I3 (1.0 IW/CPE)	35.3	25.8	11.6	12.9	11.9	24.8
SE (m) ±	0.8	0.8	0.4	0.4	0.4	0.4
CD (P = 0.05)	2.5	2.3	1.1	1.2	1.2	1.3
Spacing						
S1 (15 cm)	33.1	23.4	10.7	11.9	10.9	23.0
S2 (22.5 cm)	32.8	24.2	10.3	11.5	11.1	24.0
S3 (30 cm)	34.2	24.9	11.3	12.7	11.3	24.8
SE (m) ±	0.8	0.8	0.4	0.4	0.4	0.4
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Interaction						
I x S						
SE (m)±	1.5	1.3	0.7	0.7	0.7	0.7
CD (P= 0.05)	NS	NS	NS	NS	NS	NS
GM	33.4	24.2	10.7	12.0	11.1	23.9

found Singh *et al.* (2014).

Effect of irrigation level

Phosphorus uptake by seed and straw was significantly influenced by irrigation scheduling. Irrigation scheduled at 1.0 IW/CPE recorded maximum phosphorus uptake by seed and straw which was significantly superior over0.6 IW/CPE and 0.8 IW/CPE. Similar result was found Singh *et al.* (2014).

Spacing and interaction effect did not reach to the level of significance.

Potassium uptake (Kg ha^{-1})

The data in respect of potassium uptake by seed and straw are presented in Table 11.

Effect of irrigation level

Potassium uptake by seed and straw was significantly influenced by irrigation scheduling. Irrigation scheduled 1.0 IW/CPE recorded maximum potassium uptake by straw and seed which was significantly superior over 0.6 IW/CPE but it was at par with 0.8 IW/CPE. Potassium uptake by seed and straw was significantly influenced by irrigation scheduled. The treatment 1.0 IW/CPE recorded maximum potassium uptake which was significantly superior over all other levels. Similar result was found Tripathy *et al.*(2012).

Spacing and interaction effect did not reach to the level of significance.

Table 12. Gross monetary return (GMR), Net monetary return (NMR) and B:C ratio as influenced by different irrigation levels and spacings

Treatments	Cost of Cultivation (COC)	GMR (₹ ha)	NMR (₹ ha)	B:C Ratio
Irrigation levels				
I1 (0.6 IW/CPE)	17170	31633	14463	2.01
I2 (0.8 IW/CPE)	16120	32352	16233	1.89
I3 (1.0 IW/CPE)	17832	34725	16893	1.82
SE (m)±	149	695	546	-
CD (P= 0.05)	447	2085	1637	-
Spacing				
S1 (15cm)	17336	32151	14815	2.02
S2 (22.5cm)	16119	31838	15719	1.94
S3 (30cm)	17667	34722	17055	1.75
SE (m) ±	149	695	546	-
CD (P = 0.05)	447	2085	1637	-
Interaction				
I x S				
SE (m) ±	258	1205	946	-
CD (P = 0.05)	NS	NS	NS	-
GM	17041	32903	15863	-

Gross Monetary Returns, Net Monetary Returns and B: C ratio

The data emerged in respect of gross monetary returns, net monetary returns and B:C ratio as affected by various treatment are presented in Table 12.

Effect of irrigation level

Gross monetary returns and net monetary returns were significantly influenced by irrigation scheduling.

Irrigation scheduled 1.0 IW/CPE had recorded significantly higher gross monetary returns and net monetary returns than other irrigation scheduling. Significantly lowest gross monetary returns and net monetary returns were registered under 0.6 IW/CPE. The higher gross monetary returns and net monetary returns might be due to the differences in the seed yield that might have reflected in the higher gross monetary returns and net monetary returns. But Irrigation scheduled at 0.6 IW/CPE had recorded higher B:C ratio than at 1.0 and 0.8 IW/CPE. The irrigation scheduled 0.6 IW/CPE had highest B:C ratio due to less cost of cultivation than other treatments. Similar result was found Singh *et al.* (2014).

Effect of spacing

Gross monetary returns and net monetary returns was significantly influenced by spacing. Spacing 30 cm had recorded significantly higher gross monetary returns and net monetary returns than other spacing. Significantly lowest gross monetary returns and net monetary returns was registered under spacing 15 cm. The higher B:C ratio was recorded with spacing at 30 cm. The higher gross monetary returns, net monetary returns and B:C ratio might be due to the differences in the seed yield that might have reflected in the higher gross monetary returns, net monetary returns and B:C ratio. A similar result was also reported by Singh *et al*. (2006).

Interaction effect was found to be non significant.

Reference

Akhter L. H., Bukhari S., S. Salah-ud-Din and Minhas 2012. Response of new guar strains to various row spacings. Pak. J. Agri. Sci., 49:469-471.

Behera B. S., Das M., Behera A. C. and Behera R. A. 2015. Weather based irrigation scheduling in summer groundnut in odisa condition. *I*nternational J. Agric. Sci. and Res., 5:247-260.

Kumar M., Patel J. J., Umale A., Prasad R. D. and Patel H. K. 2015. Performance of cultivar and irrigation scheduling (IW:CPE ratio) on yield, water use efficiency, consumptive use of water and economics of summer clusterbean (*Cymopsis tetragonoloba* L.) under middle Gujarat conditions. Res. Env. Life Sci., 8:599-602.

Patel D. M., Shah K. A. and Sadhu A.C. 2011. Response of summer cluster bean (*Cyamopsis tetragonoloba* L.Taub) to irrigation scheduling and integrated nutrient management. Int. J. Forestry & Crop Impro., 2:8-11

Pawar D. D., Dingre S. K., and Nanaware D. M. 2013. Yield and quality of summer groundnut under different irrigation scheduling through micro sprinkler in clay loam soils of western Maharashtra*.* J. Agric. Res. and Techno, 38:102-106.

Singh R. J., Idnani L. K. and Rai R. K. 2006. Grain yield, water use efficiency, economics and soil moisture extraction pattern of summer green gram as influenced by planting and irrigation methods; irrigation schedules and VAM inoculation. Ann. Agric. Res., 27:306-310.

Siddaraju R., Naryanswamy S., Ramegowda S., Rajendra Prasad, 2010. Studies on Growth, Seed Yield and Yield Attributes as Influenced by Varieties and Row Spacings in Clusterbean (*Cyamopsis tetragonoloba*L. Taub.). Mysore J. Agric. Sci., 44:16-21.

Singh A. K., Singh A. K, Jaiswal A., A. Singh, Upadhyay P. K. and Choudhary S.K. 2014. Effect of irrigations and phosphorus fertilization on productivity, water use efficiency and soil health of summer mungbean (*Vigna radiata* L.). International j. Envr. Sci. 8:185-191.

Sounda G., A. Mandal, G. Moindduin and S. K. Mondal 2006. Effect of irrigation and mulch on yield, consumptive use of water and water use efficiency of summer groundnut. J. crop and weed, 2:29-32.

Tripathy S. and Bastia D. K. 2012. Irrigation and nutrient management for yield augmentation of summer sesame (*Sesamum indicum* L.). J. Crop and Weed, 8:53-57.

Trivedi G. P., Salava D. T. and Patel D. W. 2004. Effect of irrigation scheduling and fertilizer management on growth and yield attributes of summer green gram. Fertilizer News. 41:39-43.

Yadav S. and Singh B. N. 2012. Effect of irrigation schedules and planting methods on growth, productivity and WUE of green gram (*Phaseolus radiate* L.) under rice-wheat-green gram cropping system. Plant Archives. 14:211-213.