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Assessment of integrated nutrient management, irrigation and moisture conservation on yield attributes, yield and economics of garden cress (*Lepidium sativum* L.)

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Abstract
A field experiment was conducted during winter season of 2015-16 and 2016-17 to assessed the integrated nutrient management, irrigation and moisture conservation practices on yield attributes, yield and economics of chandrasur at Soil Conservation and Water Management Farm of C.S.A.U.A & T., Kanpur. Results revealed that significantly higher yield attributes viz., length of pod, number of pods plant^{-1}, weight of pods plant^{-1}, seed weight plant^{-1}, and 1000-seed weight, yield viz., seed, stover, biological and oil yield and economics viz., gross and net returns and benefit : cost ratio of chandrasur was produced with irrigation applied at 35 and 70 days after sowing as compared to irrigation given at 35 and 60 days after sowing and irrigation applied at 35 days after sowing during both the years of experimentation. Application of 75% N through fertilizer + 25% N through vermicompost + PSB produced significantly higher yield and yield attributes and economics of chandrasur than 75% N through fertilizer + 25% N through FYM and 100% N through fertilizer (60 kg ha^{-1}) in the respective years. Yield and yield attributes and economic of chandrasur was significantly increased with weeding and hoeing + organic residue mulch @ 4 t ha^{-1} as compared to organic residue mulch @ 4 t ha^{-1} and without moisture conservation practices (control) during both the years of study.

Keywords: chandrasur, benefit: cost ratio, gross and net returns, integrated nutrient management

1. Introduction
Garden cress (*Lepidium sativum* L) is commonly known as chandrasur in hindi, ahliva in Marathi and shargundai in Punjabi. Chandrasur grown mainly in Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat and Maharashtra. Apart from India, it is also cultivated in North America and parts of Europe (Gokavi *et al*., 2004) [1]. Garden cress is a highly nutritious medicinal herb. Mainly its leaves and seeds are used. The seeds are strong antioxidant. They have anti-diabetic, cholesterol lowering, blood pressure lowering, anti-spasmodic, liver protective, antipyretic and it has good anti cancer property. The seed morphologically resemble some of the oil seed, with the dicotyledonous endosperm accounting for 80 to 85 percent of the seed matter, where as the seed coat and embryo account for 12 to 17 percent and 2 and 3 percent of seeds, respectively. The seed coat is brick red to cream coloured, the endosperm has yellow colour. The seed contain alkaloids lepidin, glucotropaeolin, besides sinapin, sinapic acid, mucilaginous matter (5%) and uric acid (0.108 g kg^{-1}). Seeds contain vitamin–C and vitamin B group. The seed also contain 5.69 percent moisture, 23.5 percent protein, 15.9 percent fat, 5.7 percent ash, phosphorus (1.65 %), calcium (0.31 %) and sulphur (0.9 %). These seeds are good source to enhance the milk percentage in cattle as wall as in nursing mother. Fresh leaves and young seedlings are mainly used as spice and are rich source of glucosinolates and also used as salad. They are beneficial in promoting digestion and growth of children. Seed oil is externally used in rheumatism. The extracts of seed have hypotensive effect with transient respiratory stimulation.
Presently, cultivation of garden cress is mainly confined to North Indian states. However, due to increase in its usage, besides an assured remuneration, there is a need to expand the area under this valuable medicinal crop. Hence, there is a need to do research on integrated nutrient management, irrigation and moisture conservation practices for obtaining the quantity and quality seed of garden cress.

2. Materials and Methods

A field experiment was conducted during two consecutive years of 2015-16 and 2016-17 to study the response of integrated nutrient management and irrigation on yield attributes, yield and economics of garden cress (Lepidium sativum L.) under different moisture conservation practices at Soil Conservation and Water Management Farm of C.S.A.U.A & T., Kanpur. Geographically Kanpur is located of 26.30° N Longitude of 80.15° E and 125.9 meters above mean sea level. The treatment combination consisting three irrigation scheduling viz., irrigation given at 35 DAS, irrigation given at 35 and 60 DAS and irrigation given at 35 and 70 DAS, three integrated nutrient management viz., 100% N (60 kg ha^{-1}) through fertilizer, 75% N through fertilizer + 25% N through FYM and 75% N through fertilizer + 25% N through vermicompost + PSB and three moisture conservation practices viz., control, organic residue mulch @ 4 t ha^{-1} and weeding and hoeing + organic residue mulch @ 4 t ha^{-1}. The experiment was laid out in split plot design with three replications with irrigation scheduling in main plots, integrated nutrient management in sub plots and moisture conservation practices in sub-sub plots. The seed of chandrasur @ 4 kg ha^{-1} was sown in furrow by desi plough keeping row to row distance of 30 cm and plant to plant 15 cm. The crop of garden cress was sown on 19.11.2015 and 25.11.2016 and harvesting was done on 02.04.2016 and 06.04.2017 during first and second year of investigation. The crop of chandrasur was fertilized with 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}. The half dose of nitrogen and full dose of phosphorus and potash was applied at the time of sowing, remaining half dose of nitrogen was top dressed at 30 days after sowing. The nitrogen was applied as a organic and inorganic sources as per treatments. The winter rainfall was received 49.9 and 32.8 mm in 2015-16 and 2016-17, respectively. The collected data on yield attributes, yield and economics was analyzed using the Fischer's method of analysis variance technique as given by Panse and Sukhatme (1967). For estimation of oil content, 100 (g) of seeds were taken from each plot and were uniformly dried and analyzed using NMR spectroscopy and was expressed is percentage.

3. Results and Discussion

i. Yield attributing characters

Data pertaining to yield attributing characters viz., length of pod (cm), number of pods $plant^{-1}$, weight of pods $plant^{-1}$, seed weight $plant^{-1}$ and 1000-seed weight of chandrasur as affected by different irrigation scheduling, integrated nutrient management and moisture conservation practices during 2015-16 and 2016-17 have been presented in Table (1).

Yield attributing characters viz., length of pod (0.50 and 0.51 cm), number of pods $plant^{-1}$ (945.04 and 995.10), weight of pods $plant^{-1}$ (18.36 and 21.50 g), seed weight $plant^{-1}$ (13.72 and 16.23 g) and 1000-seed weight (2.01 and 2.14 g) was significantly increased with irrigation applied at 35 and 70 days after sowing as compared to irrigation given at 35 and 60 days after sowing and irrigation given at 35 days after sowing during 2015-16 and 2016-17, respectively (Table-1). Irrigation given at 35 and 60 days after sowing also significantly increased yield attributing characters of chandrasur than irrigation given at 35 days after sowing during both the years of study. Minimum yield attributing characters of chandrasur was recorded in irrigation given at 35 days after sowing in the respective years. The increase in yield attributing characters of chandrasur with irrigation scheduling might be due to increase in water availability throughout the crop growth period. The increase in yield attributes with irrigation scheduling has also been corroborated with the findings of Kumari and Patel (2013) [2]

Application of 75% N through fertilizer + 25% N through vermicompost + PSB produced significantly higher yield attributing characters viz., length of pod (0.51 and 0.52 cm), number of pods $plant^{-1}$ (878.69 and 932.83), weight of pods $plant^{-1}$ (17.53 and 20.13 g), seed weight $plant^{-1}$ (13.44 and 15.57 g) and 1000-seed weight (1.99 and 2.13 g) of garden cress than the application 75% N through fertilizer + 25% N through FYM and 100% N through fertilizer in the respective years of study (Table-1). Yield attributing characters of garden cress was also significantly increased with the application 75% N through fertilizer + 25% N through FYM than 100% N through fertilizer during both the years. Application of *et al* 100% N through fertilizer recorded minimum yield attributes of garden cress during both the years of study. The increase in yield attributing of chandrasur with the application of organic and inorganic sources of nutrients might be due to increase in availability of plant nutrients. Similar results were earliar noticed by Santosh *et al* (2010) [5] and Saraswathi *et al* (2014) [6] in garden cress.

It is evident from the data (Table-1) that weeding and hoeing + organic residue mulch @ 4 t ha^{-1} increased yield attributing characters viz., length of pod (0.51 and 0.52 cm), number of pods $plant^{-1}$ (922.54 and 967.09), weight of pods $plant^{-1}$ (18.50 and 20.83 g), seed weight $plant^{-1}$ (14.12 and 16.03 g), and 1000-seed weight (2.03 and 2.17 g) as compared to organic residue mulch @ 4 t ha^{-1} and control during 2015-16 and 2016-17, respectively. The increase in yield attributing of garden cress with different moisture conservation practices might be due to continuous availability of soil moisture through out the life cycle of crop. Similar results has also been reported by Sharma and Jain (2011).

Table 1: Yield attributing characters of garden cress as affected by different irrigation scheduling, integrated nutrient management and moisture conservation practices.

Treatments	Length of pod (cm)		No. of pods $plant^{-1}$		Weight of pods $plant^{-1}$ (g)		Seed weight $plant^{-1}$ (g)		1000-seed weight (g)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation Scheduling										
Irrigation at 35 DAS	0.48	0.50	674.74	731.90	14.30	15.87	10.43	11.86	1.75	1.87
Irrigation at 35 and 60 DAS	0.49	0.51	842.73	894.78	16.70	19.10	12.55	14.55	1.92	2.08
Irrigation at 35 and 70 DAS	0.50	0.51	945.04	995.10	18.36	21.50	13.72	16.23	2.01	2.14
SE (d)	0.02	0.02	12.82	14.01	0.32	0.42	0.33	0.37	0.02	0.01
CD (P=0.05)	N.S	N.S	35.60	38.90	0.89	1.17	0.92	1.04	0.05	0.04
Integrated Nutrient Management										
100% N (60 kg ha^{-1}) through fertilizer	0.48	0.49	747.27	800.59	15.16	17.35	10.80	12.62	1.78	1.91
75% N through fertilizer + 25% N through FYM	0.50	0.51	836.56	888.35	16.66	18.99	12.45	14.46	1.91	2.05

75% N through fertilizer + 25% N through vermicompost + PSB @ 2.5 kg ha^{-1} in soil	0.51	0.52	878.69	932.83	17.53	20.13	13.44	15.57	1.99	2.13
SE (d)	0.02	0.02	11.45	11.40	0.26	0.35	0.26	0.31	0.03	0.02
CD (P=0.05)	N.S	N.S	24.94	24.85	0.56	0.77	0.58	0.67	0.07	0.05
Moisture Conservation Practices										
Control	0.48	0.49	704.80	763.54	14.08	16.50	10.15	12.11	1.73	1.84
Organic residue mulch @ 4 t ha^{-1}	0.49	0.50	835.19	891.14	16.77	19.14	12.42	14.50	1.92	2.08
Weeding and hoeing + Organic residue mulch @ 4 t ha^{-1}	0.51	0.52	922.54	967.09	18.50	20.83	14.12	16.03	2.03	2.17
SE (d)	0.02	0.02	11.02	12.19	0.30	0.34	0.27	0.32	0.04	0.03
CD (P=0.05)	N.S	N.S	22.16	24.51	0.60	0.68	0.55	0.64	0.09	0.06

ii. Yield

The data on seed, stover and biological yield (q ha^{-1}) and oil yield (kg ha^{-1}) of chandrasur as influenced by different irrigation scheduling, integrated nutrient management and moisture conservation practices during 2015-16 and 2016-17 have been presented in Table (2).

Seed (14.20 and 15.22 q ha^{-1}), stover (48.28 and 46.77 q ha^{-1}) and biological yield (62.48 and 61.98 q ha^{-1}) and oil yield (377.97 and 408.26 kg ha^{-1}) of chandrasur was significantly increased with irrigation applied at 35 and 70 days after sowing as compared to irrigation given at 35 and 60 days after sowing and irrigation given at 35 days after sowing during 2015-16 and 2016-17, respectively. The increase in seed, stover, biological and oil yield of chandrasur with irrigation given at 35 and 70 days after sowing to the tune of 40.30, 31.84, 33.70 and 25.03 percent in 2015-16 and 34.93, 28.99, 30.37 and 22.03 percent in 2016-17 than irrigation given at 35 days after sowing, respectively. Irrigation given at 35 and 60 days after sowing also produced significantly more seed, stover and biological yield and oil yield of chandrasur than irrigation given at 35 days after sowing during both the years of experimentation. Similar results have also been reported by Patnaik *et al* (2016) [4] and Kumari and Patel (2015).

Application of 75% N through fertilizer + 25% N through vermicompost + PSB produced significantly higher seed (13.55 and 14.60 q ha^{-1}), stover (45.56 and 45.02 q ha^{-1}) and biological yield (60.12 and 59.62 q ha^{-1}) and oil yield (371.59 and 393.79 kg ha^{-1}) of chandrasur as compared to 75% N through fertilizer + 25% N through FYM and 100% N through fertilizer during 2015-16 and 2016-17, respectively. Seed, stover, biological and oil yield of chandrasur was increased to the extent of 26.52, 21.44, 22.57 and 20.21 percent in 2015-16 and 24.89, 20.37, 21.48 and 12.42 percent in 2016-17 with the *et al* application of 75% N through fertilizer + 25% N through vermicompost + PSB than *et al*100% N through fertilizer, respectively. The minimum yield of chandrasur was recorded with the *et al* application of *et al*100% N through fertilizer during both the years of experimentation. The increase in yield of chandrasur might be due to better growth and yield attributes with the use of organic and inorganic sources of plant nutrient. Similar results has also been reported by Santosh *et al* (2010) [5].

Weeding and hoeing + organic residue mulch @ 4 t ha^{-1} produced significantly highest seed (13.47 and 14.56 q ha^{-1}), stover (46.74 and 45.38 q ha^{-1}) and biological yield (60.21 and 59.94 q ha^{-1}) and oil yield (369.81 and 401.24 kg ha^{-1}) of chandrasur than organic residue mulch @ 4 t ha^{-1} and control during 2015-16 and 2016-17, respectively. The increase in seed, stover, biological and oil yield of chandrasur with weeding and hoeing + organic residue mulch @ 4 t ha^{-1} to the tune of 23.69, 21.12, 21.69 and 18.32 percent in 2015-16 and 22.66, 21.01, 21.41 and 17.91 percent in 2016-17 than control, respectively. Significantly higher seed, stover and biological yield and oil yield of chandrasur was also recorded in organic residue mulch @ 4 t ha^{-1} and control during both the years of study. The increase in seed, stover, biological and oil yield of chandrasur with different moisture conservation practices might be due to more availability of soil moisture throught out the crop growth. The similar results has also been corroborated with the findings of Sharma and Jain (2011).

Table 2: Yield of garden cress as affected by different irrigation scheduling, integrated nutrient management and moisture conservation practices.

Treatments	Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Biological yield (q ha^{-1})		Oil yield (kg ha^{-1})	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation Scheduling								
Irrigation at 35 DAS	10.12	11.28	36.62	36.26	46.73	47.54	302.30	334.55
Irrigation at 35 and 60 DAS	11.99	12.85	42.12	40.45	54.10	53.30	349.41	378.67
Irrigation at 35 and 70 DAS	14.20	15.22	48.28	46.77	62.48	61.98	377.97	408.26
SE (d)	0.47	0.46	0.96	0.88	1.44	1.37	3.51	4.32
CD (P=0.05)	1.33	1.29	2.67	2.45	4.00	3.81	9.75	11.99
Integrated Nutrient Management								
100% N (60 kg ha^{-1}) through fertilizer	10.71	11.69	38.34	37.40	49.05	49.08	309.13	350.29
75% N through fertilizer + 25% N through FYM	12.04	13.06	42.11	41.05	54.16	54.12	348.97	377.40
75% N through fertilizer + 25% N through vermicompost + PSB @ 2.5 kg ha^{-1} in soil	13.55	14.60	46.56	45.02	60.12	59.62	371.59	393.79
SE (d)	0.55	0.55	1.01	0.94	1.53	1.43	3.08	3.63
CD (P=0.05)	1.20	1.21	2.21	2.06	3.34	3.32	6.73	7.90
Moisture Conservation Practices								
Control	10.89	11.87	38.59	37.50	49.48	49.37	312.54	340.13
Organic residue mulch @ 4 t ha^{-1}	11.94	12.93	41.68	40.58	53.63	53.51	347.34	380.11
Weeding and hoeing + Organic residue mulch @ 4 t ha^{-1}	13.47	14.56	46.74	45.38	60.21	59.94	369.81	401.24
SE (d)	0.41	0.46	1.05	0.99	1.54	1.46	3.09	3.41
CD (P=0.05)	0.83	0.92	2.14	2.01	3.14	2.98	6.20	6.85

iii. Economics

The data on economic viz., gross and net returns (Rs ha^{-1}) and benefit: cost ratio of chandrasur as affected by different irrigation scheduling, integrated nutrient management and moisture conservation practices during 2015-16 and 2016-17 have been presented in Table (3).

Data exhibited that gross (146850.33 and 164451.55 Rs ha^{-1}) and net return (112373.77 and 129383.33 Rs ha^{-1}) and benefit : cost ratio (3.25 and 3.68) was fetched by irrigation given at 35 and 70 days after sowing followed by irrigation given at 35 and 60 days after sowing and irrigation given at 35 days after sowing during 2015-16 and 2016-17, respectively. Minimum gross (104828.35 and 122077.18 Rs ha^{-1}) and net returns (71473.79 and 88156.96 Rs ha^{-1}) and benefit: cost ratio (2.13 and 2.59) was obtained when irrigation given at 35 days after sowing in the respective years of study. The increase in gross and net return and benefit: cost ratio with irrigation given at 35 and 70 days after sowing might be due to increase in seed and stover yield of garden cress. Similar results have also been reported by several workers (Patnaik *et al*, 2016 and Kumari and Patel, 2013) [4, 2].

Application of 75% N through fertilizer + 25% N through vermicompost + PSB recorded highest gross (140189.60 and 157813.35 Rs ha^{-1}) and net (102128.71 and 119164.46 Rs ha^{-1}) return followed by 75% N through fertilizer + 25% N through FYM and 100% N through fertilizer during 2015-16 and 2016-17, respectively. Minimum gross (110933.96 and 126438.22 Rs ha^{-1}) and net returns (79148.07 and 94079.33 Rs ha^{-1}) was fetched with the application of 100% N through fertilizer in the respective years of study. Benefit : cost ratio (2.83 and 3.26) of chandrasur was recorded highest with the application 75% N through fertilizer + 25% N through FYM followed by 75% N through fertilizer + 25% N through vermicompost + PSB (2.67 and 3.07) and *et al* 100% N through fertilizer (2.48 and 2.89) during 2015-16 and 2016-17, respectively. Similar results has also been reported by Verma *et al* (2011) [8].

Highest gross (139396.24 and 157371.78 Rs ha^{-1}) and net returns (103118.69 and 120576.89 Rs ha^{-1}) and benefit : cost ratio (2.83 and 3.27) of garden cress was fetched with weeding and hoeing + organic residue mulch @ 4 t ha^{-1} followed by organic residue mulch @ 4 t ha^{-1} and control during 2015-16 and 2016-17, respectively. Minimum gross (112748.14 and 128338.61 Rs ha^{-1}) and net returns (80813.58 and 95707.72 Rs ha^{-1}) and benefit: cost ratio (2.52 and 2.92) was recorded in control plots in the respective years of study. The increase in gross and net return and benefit: cost ratio with moisture conservation practices might be due to increase in seed and stover yield of garden cress. Similar results has also been reported by Sharma and Jain (2008) [7].

Table 3: Economics of garden cress as affected by different irrigation scheduling, integrated nutrient management and moisture conservation practices.

Treatments	Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		Benefit : Cost ratio	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Irrigation Scheduling						
Irrigation at 35 DAS	104828.35	122077.18	71473.79	88156.96	2.13	2.59
Irrigation at 35 and 60 DAS	124078.48	138981.61	89601.92	103913.38	2.58	2.95
Irrigation at 35 and 70 DAS	146850.33	164451.55	112373.77	129383.33	3.25	3.68
SE (d)	555.13	691.39	491.36	505.96	0.07	0.06
CD (P=0.05)	1541.04	1919.31	1364.03	1404.55	0.19	0.18
Integrated Nutrient Management						
100% N (60 kg ha$^{-1)}$ through fertilizer	110933.96	126438.22	79148.07	94079.33	2.48	2.89
75% N through fertilizer + 25% N through FYM	124633.59	141258.78	92172.70	108209.89	2.83	3.26
75% N through fertilizer + 25% N through vermicompost + PSB @ 2.5 kg ha^{-1} in soil	140189.60	157813.35	102128.71	119164.46	2.67	3.07
SE (d)	483.48	555.85	422.31	504.76	0.06	0.05
CD (P=0.05)	1053.51	1212.21	920.22	1099.88	0.14	0.12
Moisture Conservation Practices						
Control	112748.14	128338.61	80813.58	95707.72	2.52	2.92
Organic residue mulch @ 4 t ha^{-1}	123612.78	139799.96	89517.22	105169.07	2.61	3.03
Weeding and hoeing + Organic residue mulch @ 4 t ha^{-1}	139396.24	157371.78	103118.69	120576.89	2.83	3.27
SE (d)	437.83	535.11	362.17	434.43	0.03	0.04
CD (P=0.05)	880.48	1076.11	728.32	873.64	0.07	0.08

4. Conclusion

On the basis of above results, it may be concluded that integration of irrigation given at 35 and 70 days after sowing, application of 75% N through fertilizer + 25% N through vermicompost + PSB and weeding and hoeing + organic residue mulch @ 4 t ha^{-1} is most remunerative and profitable to chandrasur during 2015-16 and 2016-17.

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