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Anupam Pariari
Professor and Head, Department of Plantation, Spices, Medicinal and Aromatic Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India

Sayantan Roy
Ph.D., Research Scholar, Department of Plantation, Spices, Medicinal and Aromatic Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India

CS Karthik
Ph.D., Research Scholar, Department of Plantation, Spices, Medicinal and Aromatic Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India

Sarthak Bhattacharya
Ph.D., Research Scholar, Department of Plantation, Spices, Medicinal and Aromatic Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India

Correspondence
Anupam Pariari
Professor and Head, Department of Plantation, Spices, Medicinal and Aromatic Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India

Effect of Irrigation intervals under the influence of N-Triacontanol on growth and seed yield of Nigella (*Nigella Sativa* L.)

Anupam Pariari, Sayantan Roy, CS Karthik and Sarthak Bhattacharya

Abstract
A field investigation was carried out during 2016-17 and 2017-18 at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to study the effect of irrigation intervals under the influence of N-triacontanol on growth and seed yield of Nigella (*Nigella sativa* L.). The experiment was conducted in Strip plot design with eight treatments of irrigation intervals *viz.*, I_{10} (irrigation at 10 days interval), I_{16} (irrigation at 16 days interval), I_{22} (irrigation at 22 days interval), and I_{28} (irrigation at 28 days interval). Each treatment had two sub treatments *i.e*., with (T_1) and without (T_0) application of N-triacontanol which were randomly replicated six times. The study revealed that irrigation at shortest interval produced maximum vegetative growth in terms of plant height, number of primary branches as well as seed yield of the crop (828.25 kg/ha). However, treatments with irrigation at longer interval enhanced earlier reproductive phase *viz.*, first bud initiation, flower initiation, pod initiation and pod maturity. Application of N-triacontanol (T_1) showed significantly superior influence on yield attributes and seed yield (674.46 kg per ha) over control (T_0) (609.21 kg/ha). Among all the treatment combinations, the interaction effects between irrigation frequency and N-triacontanol regarding of growth and seed yield was found superior in $I_{10}T_1$. With longest frequency of irrigation (I_{28}) the variation in yield between T_1 and T_0 was maximum (25.38 %) in comparison to 2.30 % at shortest interval. It clearly shows that water stress in black cumin severely effects growth and seed yield of the crop. However, N-triacontanol was found more effective particularly in the stress condition by delaying the reproductive phase to prolong normal vegetative growth for higher seed yield.

Keywords: Nigella, irrigation intervals, n-triacontanol, yield

Introduction

Nigella (*Nigella sativa* L.) belonging to the family *Ranunculaceae* is one of the important seed spices. It is called '*Kalgira*' in Bengali, '*Kalongi*' in Hindi or '*Kalagira*', and '*Karun jiragam'* in Sanskrit. This family contains about 70 genera and about 300 species. The genus *Nigella* contains about 20 species of annual herb. It is originated from Eastern Mediterranean region, but it is now widely distributed in Eastern Africa specially Ethiopia, where it is used as fish poison. In India it is generally cultivated in the states of Punjab, Himachal Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Assam, Bihar and West Bengal. It is grown in India as a rabi crop with irrigation. Time of sowing generally extends from first week to last week of November. Black cumin seed is an expensive spice, common in Indian kitchen, extensively used for culinary purpose and for flavoring foods and beverages. The seeds have been used since long to protect health and combat different diseases in countries specially in different parts of Middle East and South East Asia. It is reported that whole black cumin seeds or their extracts contain antidiabetic, antihistaminic, antihypertensive, anti-inflammatory, antimicrobial, antitumor, galactagogic and insect repellent compounds (Riaz *et al.* 1996; Siddiqui and Sharma, 1996) [14, 16]. Bio-chemical analysis of black cumin reveals that it contents 3.8-5.3% total ash, ash insoluble in acid 0-0.5%, volatile oil 0.5-1.6%, crude oil 35.6-41.6% and oleic acid 3.4-6.3%.

In the gangetic alluvial plains of West Bengal, the crop is grown in a small scale basis. But, it has a great potentiality as well. Water is most often the limiting factor for Nigella production especially in the rabi season due to scanty rainfall. Therefore, irrigation should be scheduled centering on such critical stages of water requirement. Mozzafari *et al.* (2000) [11] and Bannayan *et al.* (2008) [2] have reported that black cumin is able to tolerate moderate levels of water stress. Some researchers have also focused on response of black cumin to different irrigation intervals (Mozzafari *et al.* 2000) [11] and irrigation scheduling based on developmental stage (Bannayan *et al.* 2008) [2]. N-triacontanol (plant growth regulator) shows its effects by influencing mineral uptake, enhancing the activity of the naturally available enzymes and plant hormones, increasing the rate of photosynthesis and enhancing the synthesis of protein and also increasing permeability. Experiments showed that it increases the yield of grains, the dry matter content, height of plants, earlier and stronger tillering, longer and better spread of roots, and uniform and early maturity in crops (Shrivastava 2001) [15]. Hence, keeping in view the above, an attempt has been made to study the effect of irrigation intervals under the influence of N-triacontanol on the growth and seed yield of Nigella.

Material and Methods

The present experiment was undertaken during the rabi (winter) season for two consecutive years *i.e.,* 2016-17 and 2017-18 at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (23.5oN and 89oE longitude, with an altitude of 9.75 m above the mean sea level). The soil of the experiment field was Entisol with sandy clay loam texture (54.2 5% sand, 30.20 % silt and 14.30 % clay), slightly acidic to neutral in reaction (pH 6.9) and with good water holding capacity, well drained with moderate soil fertility status. The maximum and minimum temperature during the crop growing season was 29.9 and 11.6°C during 2016-17 and 33.8 and 12.7°C during 2017-18 respectively. The total rainfall received during the crop growing season of 2016-17 and 2017-18 was 12.8 and 0.00 mm respectively. The experiment was conducted in Strip plot design with eight treatments of irrigation intervals *viz.*, I_{10} (irrigation at 10 days interval), I_{16} (irrigation at 16 days interval), I_{22} (irrigation at 22 days interval), and I_{28} (irrigation at 28 days interval). Each treatment had two sub treatments *i.e*., with (T_1) and without (T_0) application of N-triacontanol which were randomly replicated six times. N- triacontanol was applied twice (30 DAS-after thinning and 45 DAS-before flowering) at the rate of 0.5ml/L of water. Seeds were sown with a spacing of 30 x 10 cm in a plot size of $3m^2$. The land is fertilized with 15 tonnes of well rotten Farm Yard Manure (FYM) and NPK @ 40:30:45 Kg/ha. Half dose of N and full amount of P and K were applied before sowing. The remaining dose were applied in two splits at 30 and 60 DAS.The data were recorded on the morphological, yield and yield attributing parameters. Statistical analysis and interpretation of data were done as described by Panse and Sukhatme (1985) [12]. For comparison of 'F' and ’t’ table values for determination of critical differences, Fisher and Yates tables (1979) [5] were consulted.

Results and Discussion

The growth and seed yield of Nigella recorded were shown significant differences among the treatments. The effect of irrigation intervals under the influence of N-triacontanol on the various growth parameters of Nigella are briefly discussed.

Growth parameters

Days required for germination, first leaf initiation and fifth leaf initiation

In case of days taken for germination (Table 1), it is found that all the treatments are statistically at par with each other. The mean duration for germination was found at 8.38 DAS. Further, there was no significant difference among the treatments regarding days taken for first leaf initiation. From the mean data it is seen that first leaf initiation was noticed at 11.26 DAS (Table 1). However, data from the Table-1 revealed that irrigation intervals has significant influence on days taken for fifth leaf initiation in different treatment combinations. Here I_{10} showed earlier (26.38 DAS) fifth leaf initiation among all. Second earlier fifth leaf initiation was noticed in I_{16} (27.78 DAS). The maximum time (31.76 DAS) was taken for fifth leaf initiation by I_{28}.

Table 1: Effect of irrigation intervals and N-triacontanol on time of germination, first leaf initiation and fifth leaf initiation of Nigella

	Germination (DAS)			first leaf initiation (DAS)			Fifth leaf initiation (DAS)		
Irrigation (I)	Treatments (T)			Treatments (T)			Treatments (T)		
	T_0	T_1	MEAN	T_0	T_1	MEAN	T_0	T_1	MEAN
I_{10}	8.58	8.53	8.56	11.03	11.10	11.07	26.17	26.60	26.38
I_{16}	8.17	8.32	8.24	11.47	11.28	11.38	27.78	27.78	27.78
I_{22}	8.25	8.43	8.34	11.25	11.47	11.36	30.68	30.52	30.60
I_{28}	8.33	8.43	8.38	11.18	11.27	11.23	31.70	31.82	31.76
MEAN	8.33	8.43	8.38	11.23	11.28	11.26	29.08	29.18	29.13
	I	T	I XT	I	T	I XT	I	T	I XT
S.Em (±)	0.1284	0.0836	0.1564	0.0868	0.0492	0.1139	0.0191	0.1386	0.1034
CD (0.05)	NS	NS	NS	NS	NS	NS	0.0575	NS	NS

Plant height

Plant height at different DAS (Days after sowing) has been presented in Table 2, It was recorded at 40 DAS, 80 DAS and 120 DAS. Comparing irrigation intervals only, from the data recorded in the table it is clear that height of plant appeared significantly higher in I_{10} (21.63 cm in 40 DAS, 55.10 cm in 80 DAS, 60.06 cm in 120 DAS). It was followed by I_{16} at 40 DAS with plant height of 20.76 cm, 80 DAS with plant height of 49.37 cm and at 120 DAS with plant height 54.35 cm. Significantly lowest plant height was recorded in I_{28} at 40 DAS, 80 DAS and 120 DAS with plant height of 16.36 cm, 35.42 cm and 44.72 cm respectively. Comparing N-triacontanol treatment from the Table 2, it is evident that T_1 resulted significantly more height than T_0 at all three different stages *viz.*, 40 DAS, 80 DAS and 120 DAS. At 120 DAS T_1 showed plant height of 54.27 cm whereas it was 50.03 cm in case of T_0. Between intervals of irrigation and N-triacontanol treatment interaction, $I_{10}T_1$ treatment combination did not show significant variation from $I_{10}T_0$ treatment combination at any stage. But after this all other T_1 treatments showed significant superiority in plant height than T_0 at same irrigation interval. These findings are in conformity with Lakpale *et al*. (2007) [10] where irrigation at highest frequency (0.8 IW/CPE) produced maximum plant height of 40.7 cm at harvest, while it was found lowest (32.4 cm) with no irrigation and Shrivastava *et al.* (2001) [15] where N-triacontanol (Miraculan) application resulted higher (51.85 cm) plant height and then control (48.20 cm) in the experiment on chick pea (*Cicer arietinum*) *cv.* JG 315 respectively.

Table 2: Effect of irrigation intervals and N-triacontanol on plant height (cm)

Irrigation (I)	40 DAS			80 DAS			120 DAS		
	Treatments (T)			Treatments (T)			Treatments (T)		
	T_0	T_1	MEAN	T_0	T_1	MEAN	T_0	T_1	MEAN
I_{10}	21.58	21.68	21.63	54.97	55.23	55.10	59.87	60.25	60.06
I_{16}	20.60	20.92	20.76	47.13	51.60	49.37	51.47	57.23	54.35
I_{22}	18.13	19.50	18.82	41.00	44.73	42.87	46.88	52.07	49.47
I_{28}	15.53	17.18	16.36	33.46	37.38	35.42	41.92	47.52	44.72
MEAN	18.96	19.82	19.39	44.14	47.24	45.69	50.03	54.27	52.15
	I	T	I XT	I	T	I X T	I	T	I X T
SEm(±)	0.141	0.071	0.222	0.204	0.062	0.282	0.218	0.277	0.349
CD(0.05)	0.4268	0.2588	0.67	0.6163	0.5907	0.8499	0.6564	1.0083	1.0528

Number of Primary branches

Yield of Nigella varies with the variation in number of Primary branches. In this experiment number of branches was recorded at 40 DAS, 80 DAS and 120 DAS and showed in Table 3. It is evident from the Table 3that both irrigation interval and N-triacontanol has significant influence on number of primary branches. Comparing irrigation intervals only, it is clear that number of primary branches was recorded significantly higher in I_{10}, 6.53 in 40 DAS, 8.36 in 80 DAS and 9.32 in 120 DAS respectively. This treatment was followed by I_{16} at 40 DAS with 5.76 no. of primary branches, 80 DAS with 7.03 no. of primary branches and at 120 DAS with 8.03 no. of primary branches. Least number of primary branches was recorded significantly in I_{28} at 40 DAS, 80 DAS and 120 DAS with number of primary branches 4.65, 5.73 and 6.55 respectively. Comparing N-triacontanol treatment, T_1 resulted significantly more primary branches than T_0 at all three different stages of observation. Highest difference was found at 40 DAS by 12.98 %. It is also noted that in the interaction effect of intervals of irrigation and N-triacontanol treatment, $I_{10}T_1$ treatment combination and $I_{10}T_0$ treatment combination were statistically at par at all stages. But, other than these at same irrigation intervals all T_1 treatments showed significant variation than T_0. Highest variation has been observed between $I_{28}T_1$ and $I_{28}T_0$ at 40 DAS by 30.76 %. This is in accordance with the findings of Lakpale *et al*. (2007) [10] where maximum no. of primary branches (5.38) are recorded with irrigation at 0.8 IW/CPE and minimum (3.89) without irrigation. Bannayan *et al.* (2008) [2] also reported the same result on black cumin. The no. of primary branches was also found highest (22.50) in N-triacontanol (Miraculan) application and lowest (16.70) in control. This may be due to higher number of greener leaves which increased photosynthesis as a result of increased metabolism of the absorbed plant nutrients and higher number of shoots. Baruah *et al.* (1997) [3] also reported the similar trend in their experiment in tea respectively.

Table 3: Effect of irrigation intervals and N-triacontanol on number of primary branches

Irrigation(I)	40 DAS			80 DAS			120 DAS		
	Treatments (T)			Treatments (T)			Treatments (T)		
	T_0	T_1	MEAN	T_0	T_1	MEAN	T_0	T_1	MEAN
I_{10}	6.38	6.68	6.53	8.18	8.53	8.36	8.98	9.32	9.15
I_{16}	5.37	6.15	5.76	6.37	7.70	7.03	7.30	8.75	8.03
I_{22}	4.85	5.23	5.04	6.57	6.87	6.72	7.58	7.83	7.71
I_{28}	4.03	5.27	4.65	5.05	6.42	5.73	5.87	7.23	6.55
MEAN	5.16	5.83	5.50	6.54	7.38	6.96	7.43	8.28	7.86
	I	T	I X T	I	T	I X T	I	T	I X T
SEm(±)	0.1796	0.0700	0.1666	0.1450	0.0530	0.2511	0.0990	0.0780	0.1663
CD(0.05)	0.5413	0.2545	0.5021	0.4370	0.1927	0.7568	0.2984	0.2835	0.5012

Days required for First bud initiation

Data from the Table 4 revealed that irrigation intervals had significant influence on initiation of bud. Here it is clear that I_{10} took maximum time for first bud initiation (56.21 DAS), followed by I_{16} (56.01 DAS), I_{22} (54.76 DAS). I_{28}resulted significantly earlier first bud initiation (53.64 DAS) than all others. This result shows that in stress condition *viz.* irrigation in 28 days interval bud initiates earlier. Whereas, it was delayed with shorter interval of irrigation due to normal vegetative growth. Comparing N-triacontanol treatment effect, it is evident from the Table 4 that T_0 (54.09 DAS) resulted significantly earlier first bud initiation than T_1 (56.72 DAS). Unlike the individual effects, the interaction effect of intervals of irrigation and N-triacontanol treatment were also not found significant. However, the range was varied from earliest at $I_{28}T_0$ (52.13 DAS) and last of all at $I_{28}T_1$ (57.15 DAS).

Days required for First flower initiation

It is clear from the data in the Table 4 that irrigation frequency has significant influence on initiation of flower. Comparing the effects of irrigation intervals, it is found that I_{10}took maximum time to initiate flower (63.77 DAS), followed by I_{16} and I_{22}.Whereas, I_{28} resulted significantly earlier first bud initiation (62.21 DAS) than all others. The effect of N-triacontanol in this case was seen that T_0 initiated first flower significantly earlier (62.18 DAS) than T_1 (63.83 DAS). The interaction effects of intervals of irrigation and N-triacontanol treatment also showed non significance.

Table 4: Effect of irrigation intervals and N-triacontanol on time of first bud initiation and flowering of Nigella:

	First bud initiation (DAS)			**First flower initiation (DAS)**		
Irrigation(I)	**Treatments(T)**			**Treatments(T)**		
	T_0	**T_1**	**MEAN**	**T_0**	**T_1**	**MEAN**
I_{10}	55.80	56.63	56.21	63.75	63.80	63.77
I_{16}	55.25	56.77	56.01	63.00	63.70	63.35
I_{22}	53.17	56.35	54.76	61.87	63.53	62.70
I_{28}	52.13	57.15	53.64	60.12	64.30	62.21
MEAN	54.09	56.72	55.41	62.18	63.83	63.00
	I	T	I X T	I	T	I X T
SEm(±)	0.2484	0.1208	0.3696	0.0986	0.0560	0.1729
CD(0.05)	0.7486	0.4391	NS	0.2972	0.2035	NS

Days required for First pod initiation

Data from Table 5 reveals that both irrigation and N-triacontanol treatments has significant influence on time taken for initiation of pod. Comparing the effect of irrigation intervals on the initiation of pod, it is found that I_{10} (80.26 DAS) took significantly maximum time for first pod initiation followed by I_{16}. Earlier days taken for initiation of pod was found in I_{28} (77.92 DAS) which was statistically at par with I_{22} (77.75 DAS). Whereas, comparing N-triacontanol treatments it is clear that T_0 resulted significantly earlier first pod initiation (77.75 DAS) than T_1 (79.71 DAS). Unlike the individual effects, the interaction effect of intervals of irrigation and N-triacontanol treatment, was found non significant as depicted in the Table 5. Though, the range had been found from 76.43 DAS (earliest in $I_{22}T_0$) to 80.52 DAS (last of all in $I_{10}T_1$).

Days required for Pod maturity

From the Table 5, it is noted that both irrigation and N-triacontanol treatments has significant influence on days required for pod maturity. Comparing the effect of irrigation intervals, it was found that I_{28} resulted significantly earlier fruit maturity (126.71 DAS) than all others. It was followed by I_{22} (127.31 DAS). Maximum time taken for fruit maturity was observed in I_{10} (129.19 DAS). On comparing the effect of N-triacontanol treatments, it is evident that T_0 (127.55 DAS) resulted significantly earlier fruit maturity than T_1 (128.42 DAS). However, the result from the Table 5 shows that the interaction effect of intervals of irrigation and N-triacontanol treatment on time taken for pod maturity was found non significant.

Table 5: Effect of irrigation intervals and N-triacontanol on time of first bud initiation and pod maturity of Nigella

	1st pod initiation (DAS)			**Pod maturity (DAS)**		
Irrigation(I)	**Treatments (T)**			**Treatments (T)**		
	T_0	**T_1**	**MEAN**	**T_0**	**T_1**	**MEAN**
I_{10}	80.00	80.52	80.26	129.22	129.17	129.19
I_{16}	77.98	79.98	78.98	129.30	128.15	128.72
I_{22}	76.43	79.07	77.75	126.08	128.55	127.31
I_{28}	76.57	79.28	77.92	125.60	127.83	126.71
MEAN	77.75	79.71	78.73	127.55	128.42	127.98
	I	T	I X T	I	T	I X T
SEm(±)	0.1574	0.1147	0.1562	0.2036	0.1121	0.2929
CD(0.05)	0.4744	0.4169	NS	0.6136	0.4074	NS

Yield and yield attributing parameters

Number of pods per plant

Pod yield is directly contributed to the total yield of a crop. It is evident from the data in Table 6 that number of pods per plant was influenced by both irrigation and N-triacontanol. I_{10} (81.63) resulted significantly higher number of pods per plant than all others when we compare irrigation intervals only. It was followed by I_{16} (70.89) and I_{22} (55.87). I_{28} showed significantly least number of pods per plant (43.50). Comparing N-triacontanol treatment, T_1 (67.42) resulted significantly higher number of pods per plant than T_0 (58.52). However, interaction effect of intervals of irrigation and N-triacontanol treatment also not found to be differ significantly from each other, though having a range from 82.98 ($I_{10}T_1$) to 38.33 ($I_{28}T_0$).This experimental results are in reality with Shrivastava *et al.* (2001) [15] whose experimental results also showed the same trend of maximum (54.40) no. of pods per plant over 48.40 in control with the application of N-triacontanol (*Miraculan*) on chick pea respectively.

Number of seeds per pod

Number of seeds per pod also contributes directly on yield. Data shown in Table 6 proved that irrigation had significant influence on number of seeds per pod. Comparing irrigation intervals only I_{10} (60.23) resulted significantly higher number of seeds per pod than all others. It is followed by I_{16} (52.49). I_{28} (45.48) showed significantly least number of seeds per pod. Whereas, unlike the effect of irrigation intervals, effect of N-triacontanol showed non significant difference on the treatments, though it was found more in T_1 (52.88) and least in T_0 (51.57). Intervals of irrigation and N-triacontanol treatment interaction effect also showed non significant difference, having a range from 61.05 (maximum in $I_{10}T_1$) to 45.18 (minimum in $I_{28}T_0$).

Table 6: Effect of irrigation intervals and N-triacontanol on number pods per plant and number of seeds per pod

	Number pods per plant			Number of seeds per pod		
Irrigation (I)	Treatments(T)			Treatments(T)		
	T_0	T_1	MEAN	T_0	T_1	MEAN
I_{10}	80.27	82.98	81.63	59.42	61.05	60.23
I_{16}	65.88	75.90	70.89	51.32	53.67	52.49
I_{22}	49.60	62.13	55.87	50.37	51.02	50.69
I_{28}	38.33	48.67	43.50	45.18	45.77	45.48
MEAN	58.52	67.42	62.97	51.57	52.88	52.22
	I	T	I XT	I	T	I XT
S.Em(±)	1.2961	1.4322	2.8077	1.2130	0.4513	1.6183
CD(0.05)	3.9064	5.2060	NS	3.6559	NS	NS

1000 seed weight

It is clear from the Table 7 that 1000 seed weight was recorded to be influenced by both irrigation and N-triacontanol. Comparing irrigation intervals only, I_{10} (2.35g) produced significantly higher 1000 seed weight than all others. It is followed by I_{16} (2.22g). I_{28} (1.99g) showed significantly least 1000 seed weight. T_1 (2.21g) executed significantly higher 1000 seed weight than T_0 (2.13g) when we compared N-triacontanol treatments. Between intervals of irrigation and N-triacontanol treatment interaction, $I_{10}T_1$ treatment combination (2.36g) did not show significant variation from $I_{10}T_0$ treatment combination (2.34 g). But after this all T_1 treatments showed significant variation from T_0 at same irrigation interval which is higher in $I_{28}T_1$ (2.08 g) over $I_{28}T_0$ (1.91g) by 8.9 %. This is in evident with the results of Shrivastava *et al.* (2001) [15] on chick pea where 1000 seed weight was significantly higher (206.00 g) in N-triacontanol (Miraculan) application than it was in control (179.88 g) respectively. Bannayan *et al.* (2008) [2], Ghamarnia *et al.* (2012) [8] and Karim *et al.* (2017) [9] also reported the similar trend of significant difference in 1000 seed weight was noticed amongst different irrigation treatments for Nigella.

Seed Yield (g/plot)

Data recorded in the Table 7 reveals that both irrigation and N-triacontanol had significant influence on yield per plot. Among irrigation intervals effects, it is clear that I_{10} (124.24g) resulted significantly higher seed yield than all others. It is followed by I_{16} (107.30g). The least seed yield was significantly showed by I_{28} (66.39g). Comparing N-triacontanol treatment effects, T_1 (101.17g) resulted significantly higher seed yield than T_0 (91.38g). However, the treatment combinations showed non significant in the interaction effects of irrigation intervals and N-triacontanol, though the range was found from 125.65g (highest in $I_{10}T_1$) to 59.00g (lowest in $I_{28}T_0$). Similarly, Pariari *et al.* (2011) [13] also confirmed that application of N-triacontanol resulted higher yield of the leaves in betel vine particularly in the semi-stressed or stressed conditions respectively.

Table 7: Effect of irrigation intervals and N-triacontanol on 1000 seed weight and seed yield per plot:

	1000 seed weight(g)			Seeds yield(g)/plot		
Irrigation (I)	Treatments (T)			Treatments (T)		
	T_0	T_1	MEAN	T_0	T_1	MEAN
I_{10}	2.34	2.36	2.35	122.83	125.65	124.24
I_{16}	2.20	2.23	2.22	102.10	112.50	107.30
I_{22}	2.08	2.18	2.13	81.60	92.55	87.08
I_{28}	1.91	2.08	1.99	59.00	73.98	66.49
MEAN	2.13	2.21	2.17	91.38	101.17	96.28
	I	T	I XT	I	T	I XT
SEm(±)	0.0077	0.0060	0.0121	1.5268	1.7159	2.9348
CD(0.05)	0.0232	0.0218	0.0365	4.6017	6.2373	NS

Estimated Seed Yield (kg/ha)

Here also recorded data, shown in Table 8 reveals that both irrigation and N-tricontanol had significant influence on estimated seed yield (kg/ha). Comparing effects irrigation intervals, I_{10} (828.25 kg) resulted significantly higher seed yield than all others. It was followed by I_{16} (715.33 kg). I_{28} (443.25 kg) showed significantly least seed yield. So, it was evident that I_{10} resulted 86.85% higher yield than I_{28}. N-triacontanol treatment (T_1) also resulted significantly higher estimated seed yield (674.46 kg per ha.) than T_0 (609.21 kg per ha.). However, intervals of irrigation and N-triacontanol treatment interaction effects on all treatment combinations showed non significant, having the range found from 837.67 kg per ha. (highest in $I_{10}T_1$) to 393.3 kg per ha. (Lowest in $I_{28}T_0$). Whereas in another cases, Lakpale *et al.* (2007) [10] observed that highest seed yield (609 kg/ha) in black cumin was found with irrigation at 0.8 IW/CPE and lowest (226 kg/ha) was observed with one irrigation only at 35 DAS. Akbarinia *et al.* (2005) [1] found that irrigation at 7 days' interval resulted in the highest seed yield (1118 kg ha^{-1}). Datta and Chatterjee (2006) [4] reported that seed yield of fenugreek (*Trigonella foenum-graceum* L.*)* was highest with irrigation at IW/CPE ratio 1.0. Shrivastava *et al.* (2001) [15] concluded that the seed yield was recorded significantly higher (25.08 q/ha) in former while it was 22.40 q/ha in later. Straw yield also followed the same trend in miraculan application (41.79 kg/ha) over control (23.41 kg/ha). Gaikwad *et al.* (2004) [7] and Fozia *et al.* (2006) [6] had observed the same trend in their experiment on respective crops. The stimulating effect of N-triacontanol might have contributed to more absorption and translocation of nutrients and maintained better harmony between photosynthesis and translocation, and ultimately gave rise to higher yield.

Straw Yield (q/ha)

Straw yield (q/ha) was also influenced significantly by both irrigation and N-triacontanol as revealed by the data shown in Table 8. Among all irrigation intervals, I_{10} resulted significantly higher straw yield (35.98 q/ha) than all others. It is followed by I_{16} (27.38 q/ha). Least seed yield was showed significantly by I_{28} (15.78 q/ha). Comparing N-triacontanol treatment effects, T_1 (27.16 q/ha) resulted significantly higher seed yield than T_0 (23.32 q/ha.). However, intervals of irrigation and N-triacontanol treatment interaction effects on all treatment combinations were found non significant.

Table 8: Effect of irrigation intervals and N-triacontanol on estimated seed yield and straw yield per ha:

Irrigation(I)	Estimated seed yield (kg/ha)			Straw yield (q/ha)		
	Treatments (T)			Treatments (T)		
	T_0	T_1	MEAN	T_0	T_1	MEAN
I_{10}	818.83	837.67	828.25	33.73	38.23	35.98
I_{16}	680.67	750.00	715.33	25.61	29.15	27.38
I_{22}	544.00	617.00	580.50	20.38	23.26	21.82
I_{28}	393.33	493.17	443.25	13.57	18.00	15.78
MEAN	609.21	674.46	641.83	23.32	27.16	25.24
	I	T	I XT	I	T	I XT
SEm(±)	10.1787	11.4391	11.4391	0.7299	0.5060	1.6903
CD(0.05)	30.6786	41.5811	NS	2.1999	1.8393	NS

Conclusion

Therefore, from the findings of the experiment it may be concluded that irrigation at shortest interval with N-triacontanol ($I_{10}T_1$) produced maximum vegetative growth as well as seed yield of the crop. Treatments with irrigation at longer interval enhanced earlier reproductive phase, *viz.*, first bud initiation, flower initiation, pod initiation and pod maturity. N-triacontanol was found more effective particularly in the stress condition by delaying the reproductive phase to prolong normal vegetative growth for higher seed yield.

References

1. Akbarnia A, Khosravifard M, Ashoorabad ES, Babakhanlou P. Effect of irrigation interval on the yield and agronomic characteristics of black cumin (*Nigella sativa* L.). Iranian J Med. Arom. Pl. Res. 2005; 21(1):65-73.
2. Bannayan MF, Nadjafi F, Azizi M, Tabrizi L, Rastgoo M. Yield and seed quality of *Plantago ovata* and *Nigella sativa* L. under different irrigation treatments. Industrial Crops and Products. 2008; 27(1):11-16.
3. Baruah S, Saikia A, Sharma D. Effect of N-triacontanol in combination with other nutrients on growth and development of nursery tea plant. Journal of Interacademicia. 1997; 1(3):170-176.
4. Datta S, Chatterjee R. Effect of irrigation regimes on moisture extraction pattern, evapotranspiration and yield of fenugreek (*Trigonella foenum-graecum* L.). Journal of Spices and Aromatic Crops. 2006; 15(2):125-129.
5. Fisher RA, Yates F. Statistical Tables for Biological, Agricultural and Medicinal Research, *6th* Edition. Longman Publications, 1979, 63.
6. Fozia R, Sah D, Khaliq S. Response of triacontanol and nitrogen levels on growth, yield, quality and nutrient uptake of mustard (*Brassica juncea* L.). Environment and Ecology. 2006; 24S (Special 2):281-284.
7. Gaikwad SC, Nainwad RV, Kulkarni NH, Kalalbandi BM, Kothule VG. Effect of bio enzymes on growth, seed yield and quality of fenugreek, cv. RMT-1. Annals of Plant Physiology. 2004; 18(1):24-27.
8. Ghamarnia H, Jalili Z, Daichin, S. The effects of saline irrigation water on different components of black cumin (*Nigella sativa* L.). International Journal of Agri. Science. 2012; 2(10):915-92.
9. Karim M, Himel RM, Ferdush J, Zakaria M. Effect of irrigation levels on yield performance of Black Cumin. Inter. J of Envin. Agri. and Biotech. 2017; 2(2):960-966.
10. Lakpale R, Shrivastava GK, Tripathi RS. Effect of irrigation schedule on growth, yield and economics of spice crops. Indian Journal of Agricultural Sciences. 2007; 77(3):170-173.
11. Mozzafari FS, Ghorbanli M, Babai A, Faramarzi M. The effect of water stress on the seed oil of *Nigella sativa* L. Essential Oil Res. 2000; 12:36-38.
12. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, 1985.
13. Pariari A, Khan S, Singh LS. Effect of Irrigation and N-triacontanol on growth and growth and yield of Betel vine (*Piper betle* L.) cultivars. Proceedings of the 3rd International Conference on Water and Flood management (ICWFM).2:503-508 held in IWFM, Dhaka, Bangladesh during, 2011, 8-10.
14. Riaz M, Syed M, Chaudhary FM. Chemistry of the medicinal plants of the genus Nigella. Hamdard Medicus. 1996; 39(2):40-45.
15. Shrivastava T, Namdeo KN, Kumar MM, Dwivedi RK, Tiwari RK. Effect of plant growth regulators on growth, yield and nutrient uptake by chick pea (*Cicer arietinum* L.). Crop Research. 2001; 21(3):301-307.
16. Siddiqui AA, Sharma PKR. Clinical importance of *Nigella Sativa* L. A review. Hamdard Medicus. 1996; 39(2):23-26.