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Response of foliar fertilization of B and N on growth, yield and oil content of false flax (*Camelina sativa*) under protected condition

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ABSTRACT

False flax [*Camelina sativa* (L.) Crantz], popularly known as gold-of-pleasure a proposed biofuel species, is an oilseed crop. It has been recently introduced in India from Austria and has potential of large scale production of the biofuel. *C. sativa* cv. Calena was grown in low cost naturally-ventilated polyhouse, and sprayed with boric acid at 150 and 300 ppm and urea at 1% and 2% alone or combined together at pre-bloom stage at Defence Institute of Bio-Energy Research, Field Station- Pithoragarh, Uttarakhand, India during 2010-11. Application of boric acid at 150 ppm provided higher yield (962.50 kg/ha) over control and combination of boric acid at 300 ppm plus urea at 2% increased oil content by 37.12 %. Thus, the foliar application of boric acid at 150 ppm and combination of boric acid at 300 ppm plus urea at 2% is recommended for higher production and oil enhancement, respectively for *C. sativa* under polyhouse conditions.

Key words: Biofuel, Boron, *Camelina*, Foliar fertilization, Nitrogen

Global energy demand and an emphasis on sustainable system have recently renewed interest in agriculturally produced biofuels. Oilseed crops are the efficient way to produce biofuel, with a net energy gain of up to 93% after all production processes are completed. With reference to current scenario of demand for fuel and to realize self-reliance in energy, India is stepping up the National Biofuel Policy proposing a blending of 20% biofuels with petrol-diesel by 2017. *Camelina sativa* (L.) Crantz., is an oil seed crop recently introduced in India from Austria as a potential biodiesel plant.

C. sativa, a Brassicaceae plant, known as false flax, gold-of-pleasure, wild flax, linseed dodder, German sesame, and Siberian oilseed is a biofuel species originated in the Mediterranean to Central Asia. It is a short season crop 85-100 days, tolerant to frost, withstands drought, and gives higher seed oil (320-480 g/kg) and yields up to 2 800 kg/ha. Presence of high cholesterol (200 mg/kg) and eicosenoic acid (15%) pose a hurdle for it's approval as food oil but can be used for biofuel. Thus, *Camelina* is a promising crop for use in biofuel sector without interfering the edible oil trade and competition for available resources (Agarwal *et al.* 2010).

Hill regions having varied agro-climatic conditions and most of the introduced crops such as *C. sativa* can be produced in greenhouse structures in one or other parts to avoid crop failure, multiplication and continuous supply of necessary raw stock for running the oil extraction plants year-round. Even the mid hills of Shivalik Himalayas are experiencing hail storming in the month of April and May. In these areas greenhouse cultivation is the only alternative and economic necessity offering crop diversification. Although *C. sativa* is capable of growing with fewer inputs than other oilseeds (Frohlich and Rice 2005), Urbaniak *et al.* (2008) found that *C. sativa* yield increases with fertilization rate.

During the last few decades, foliar fertilization of nutrients has become an established procedure to increase yield and improve the quality of crop products by better nutrient utilization and lowering of the environmental pollution through reducing the amount of fertilizers added to soil (El Nour 2002). Nitrogen (N) is being one of the most important element in metabolism of plant nutrition and urea is considered the most suitable form of N for foliar application to increase the yield and crop quality (Yildirim *et al.* 2007). Rashid and Ryan (2004) stated that boron (B) is a non-metal micronutrient results in the successful fruit setting and ultimately improves the yield. The absorption rate of mineral nutrients by above ground plant parts considerably differs not only among plant species but also among varieties within

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the same species. Research on *C. sativa* for present day agriculture production is relatively limited; there is an urgent need to develop technologies which can prove effective across soil and agro-climatic conditions besides being cost effective. Since meagre information is available on physiological and agronomical aspects of *C. sativa,* therefore, the current research was designed to evaluate the effectiveness of spraying with different levels of boron (B) and urea on yield, yield components and oil enhancement of *C. sativa* under protected condition of Central Western Himalayas.

MATERIALS AND METHODS

The present investigation was carried out to study the effect of foliar spray on *C. sativa* cv. Calena (EC 643910), during 2010-11 at Defence Institute of Bio-Energy Research (DIBER) Field Station Pithoragarh (Uttarakhand), situated in Central Western Himalayas of India, which extends from 29º 29' - 30º49'N latitude to 85º05'- 81º31'E longitude and 5500 ft altitude.The annual rainfall is around 1250 mm and temperature ranges from 35ºC in the summer to –2ºC in the winter. The black forest soil of the experimental site belongs to the Agro-Ecological Zone (AEZ) of "Hill agriculture - Central Himalayas". The soil was gravel sandy - clay loam in texture, pH 6.1-7.5, organic carbon (0.92 %), available N- 280.5 kg/ha, P- 20.1 kg/ha and K - 96.2 kg/ha, respectively. The crop was sown in May, using a seed rate of 4.5 kg/ha in low cost naturally ventilated polyhouse and sprayed with boric acid at 150 and 300 ppm and urea at 1% and 2% alone or combined together at pre-bloom stage and harvested at the end of August. The net plot size measured 10.80 m^2 and was fed with 5 tonnes/ha of well rotten farmyard manure before sowing with a spacing of 30 cm × 10 cm for row to row and plant to plant. Four irrigations were given to the crop during the complete growth phase .Two hoeing were given to keep the crop free from weeds. All data were collected on plot basis. Days to flower and pod were determined as the number of days from date of seeding to approximately 50 % flowering and pod formation, respectively. Days to maturity was determined as the number of days from date of seeding to physiological maturity, i.e. when about 95 per cent of the pods had changed colour and the seeds were firm, representing a moisture of about 25 per cent. Biological yield (kg/ha) was obtained by summing pod yield and stover yield from net plots. Thirty plants were taken out randomly from each plot to collect data on plant characters and yield attributes. The oil content, reported as percent of whole seed on a dry weight (zero moisture) basis, was determined by Soxhlet method. The experiment was designed and laid out in randomized complete block design (RCBD) and replicated four times. The pooled data were subjected to Analysis of Variance (ANOVA) using the online statistical analysis package (OPSTAT, Computer section , CCS HAU Hisar, Haryana, India) and treatment means were compared by using the least significant difference test at P=0.05.

RESULTS AND DISCUSSION

The data pertaining to different agronomic traits and seed oil (Table 1) indicates that the foliar fertilization significantly influenced the physiological behaviour, yield and oil per cent of *C. sativa*.

Average pod formation was delayed with various foliar treatments and took lesser time of 70 days in control (sprayed with tap water) compared to 96 days in 2% urea treatment. This reveals that the foliar spray had altered the physiological and reproductive growth of the crop through enhanced activities of enzymes and photosynthetic activity (Sarkar and Pal 2006). C/N ratio is maintained in the control treatment which could have promoted early pod formation.

The data revealed that foliar application of urea resulted in a significant increase in plant height (Table 1). Maximum plant height of 116.29 cm was recorded where 2% urea solution was sprayed while the minimum height of 75.80 cm was recorded in control. Nitrogen is a major constituent of chlorophyll and protein and its adequate supply through urea encouraged the photosynthesis, thereby resulting in stem elongation, i.e. height (Sarkar and Mallick 2009). The result corroborates with Sharma and Jain (2002) in mustard.

The branches/plant and seeds/pod does not differ significantly by foliar application of boron and urea alone or in combination and were found maximum 9.40 and 14.45, respectively in the treatment (T-8), i.e. boric acid at 300 ppm plus urea at 1%.

It is clear from the data that spraying of B at 150 ppm significantly increased the number of pods/plant (174.24) and 1 000 seed weight (1.416 g) in *C. sativa*. This may be attributed to Boron's role in enhancing reproductive phase of the plant, i.e. in the promotion of flowering by enhancing the pollen germination and growth resulting in better pollination and fertilization of flowers. Thus, ultimately adding to the setting of more number of pods/plant with higher test weight of the seeds (Usenik and Stampar 2007, Erdogan and Aygaun 2009).

Physiological maturity, adjudged by all the earliness was found earlier in control (111 days) and it rises with various foliar applications and took maximum time with urea at 2 % (126 days). N-fertilization beyond the optimum limit delayed the crop and promoted the excess vegetative growth by prolonging the life cycle of plants (Prasad and Siddique 2004).

Maximum biological yield, i.e. total dry matter was produced by 300 ppm boric acid spray (4 629.62 kg/ha) followed by 150 ppm boric acid spray (4 259.25 kg/ha), while minimum biological yield was recorded in the combination of boric acid at 300 ppm plus urea 2% (1 504.62 kg/ha). B affects the relative values of individual elements, but it also affects the balance among certain nutrient elements within the plants causing either an increase or decrease of dry matter production (Hellal *et al.* 2009).

Significantly, the higher seed yield of 962.50 kg/ha was

Table 1 Effect of foliar fertilization of B and N on growth, yield and oil content of *C. sativa*.

	Treatment	Pod formation (days)	Plant height (cm)	Branch/ plant	Pod/plant	Seed/pod
T-1	Control (tap water)	70.00	75.80	9.20	128.32	10.00
T-2	Boric acid @ 150 ppm	73.46	96.60	8.80	174.24	12.00
T-3	Boric acid @ 300 ppm	75.00	94.98	8.00	146.40	11.00
T-4	Urea @ 1%	92.11	104.12	7.20	101.71	13.20
T-5	Urea @ 2%	95.85	116.29	7.20	104.10	12.60
T-6	Boric acid @ 150 ppm + urea @ 1%	79.59	88.21	7.00	108.08	13.00
T-7	Boric acid @ 150 ppm + urea @ 2%	85.48	83.65	6.60	115.04	13.72
T-8	Boric acid @ 300 ppm + urea @ 1%	84.01	98.75	9.40	116.95	14.45
T-9	Boric acid @ 300 ppm + urea @ 2%	86.00	101.95	6.74	120.54	14.20
	CD @ 5 %	8.99	8.22	NS	10.58	NS
	CV	6.25	4.92	13.75	4.86	1.02
	Sem	2.97*	2.71**	1.08	3.49**	14.03
		1000 seed wt (gm)	*Maturity duration (days)*	*Biological yield (kg/ha)*	*Yield (kg/ha)*	*Oil %*
T-1	Control (tap water)	1.094	111.00	3472.22	787.50	36.13
T-2	Boric acid @ 150 ppm	1.416	115.00	4259.25	962.50	36.74
T-3	Boric acid @ 300 ppm	1.256	117.00	4629.62	841.89	36.83
T-4	Urea @ 1%	1.112	123.11	4166.67	346.75	35.68
T-5	Urea @ 2%	1.009	125.98	2083.35	220.13	35.61
T-6	Boric acid @ 150 ppm + urea @ 1%	1.142	119.00	3373.69	365.04	35.81
T-7	Boric acid @ 150 ppm + urea @ 2%	1.128	120.45	2893.51	352.08	36.89
T-8	Boric acid @ 300 ppm + urea @ 1%	1.152	121.90	2314.81	247.68	36.29
T-9	Boric acid @ 300 ppm + urea @ 2%	1.289	122.00	1504.62	168.51	37.12
	CD @ 5 %	00.69	0.75	7.93	10.31	0.326
	CV	3.32	1.36	1.14	1.83	0.513
	Sem	00.23*	0.251*	2.62**	5.06**	0.108*

*Significant, ** highly significant

recorded with B (150 ppm), followed by 841.89 kg/ha in 300 ppm B spray, while the lowest yield (168.51 kg/ha) was recorded in combination of B at 300 ppm plus urea 2%. The positive effect of B application on *C.sativa* yield and yield components is in harmony with Nasef *et al.* (2006) that pods yield and some yield components, i.e. number of pods/plant, weight of pods/plant and seed weight/plant were significantly increased with foliar application of B as compared with control in peanut. The response of B spray may be attributed to its essential role in plant metabolism and in the synthesis of nucleic acid, enhancement of the chlorophyll content and photosynthetic intensity of the leaves, increased dry matter accumulation of plants, advancing their flowering and promoting the transport of the photosynthates from the vegetative organs to the reproductive organs, thus resulting in significant improvement of the yield (Quiong *et al.* 2002). However, the combination of B and N exerted adverse effects on yield and it may be due to negative effect on pod set by permitting the egg to be fertilized by a weaker sperm resulting in a weak embryo that is aborted and causing the drop of pod during early pod development (Lovatt and Ohr 1993). It was noticed that a proper B and N balance was beneficial to the growth of the plants.

C. sativa showed a significant variation of oil content to various foliar spray, and combination of boric acid at 300 ppm plus urea at 2% was found to be efficient in providing higher oil (37.12 %) while the lowest oil (35.61 %) noticed in urea at 2%. N being a constituent of amino acids favors the formation of protein precursors and therefore protein formation competes more strongly for photosynthates; resulting in the reduction of oil percentage in the crop. Agegnehu and Honermeier (1997) also found negative correlation between N and oil content.

According to the results, it may be concluded that foliar fertilization significantly affects the physiological traits, yield and oil changes associated with *Camelina*. The foliar application of boric acid at 150 ppm and combination of boric acid at 300 ppm plus urea at 2% is recommended for better yield and oil enhancement, respectively for protected crop of *Camelina*.

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