



Original Research Article

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Effect of Nitrogen Application Rate and its Scheduling on Productivity and Economics of a Newly Introduced Biofuel Crop *Camelina sativa* L. in Malwa Plateau Region of Madhya Pradesh, India

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ABSTRACT

Keywords

Camelina sativa, Economics, Growth, Nitrogen dose, Nitrogen scheduling, Yield

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A field experiment was conducted at Defence Institute of Bio-Energy Research (DRDO) HQ Haldwani Project Site Military Farm - Mhow, Indore during the winter (*rabi*) season of 2010-11 and 2011-12 to study the effect of nitrogen dose and its scheduling on productivity and economics of *Camelina sativa*. Application of 150 kg N/ha, being at par with 120 kg N/ha, significantly recorded highest seed yield (858 kg/ha) and oil yield (292 kg/ha) of *Camelina sativa* over 60 and 90 kg N/ha. There was no difference in benefit-cost ratio (0.8) either with the application of 120 or 150 kg N/ha. The crop under three equal splitting ($\frac{1}{3}$ as basal + $\frac{1}{3}$ at 25 DAS + $\frac{1}{3}$ at 50 DAS) of N significantly recorded highest seed yield (812 kg/ha) and oil yield (288 kg/ha) over other splits viz., $\frac{1}{2}$ N as basal + $\frac{1}{2}$ N at 25 DAS, $\frac{1}{2}$ N as basal + $\frac{1}{4}$ N at 25 DAS + $\frac{1}{4}$ N at 50 DAS. Application of three equal splitting of N recorded 15.1 per cent increase in yield over two equal splitting of N with a benefit-cost ratio of 0.8. Thus application of 120 kg N/ha in three equal splitting proved effective in yield enhancement and economical for growing *Camelina sativa* in Malwa plateau region of Madhya Pradesh, India.

Introduction

Fossil fuel availability is of definite quantity and its depleting very fast due to its reckless consumption. The world is now caught between two growing problems arising out of rapid depletion of fossil fuel reserves as well as environmental degradation due to exhaust emission.

Biodiesel, an efficient and 100% clean natural energy alternative to petroleum fuels, is one such fuel, which is capable of providing a ready solution to these twin problems. India is

one of the largest petroleum consuming and importing countries. 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 upto 93% after all production process is completed (Anuja Kumari *et al.*, 2012). 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 (Singh *et al.*, 2014). *Camelina sativa*, false flax, gold of

pleasure or Siberian mustard [*Camelina sativa* (L.) Cz. et Coss.] is an under-exploited oilseed crop of origin Mediterranean to Central Asia and family Brassicaceae with agronomic low-input features (Putnam *et al.*, 1993) and an unusual fatty acid composition with high levels of alpha-linolenic acid (Budin *et al.*, 1995) vis-à-vis unusually high cholesterol and brassica sterol content (188 and 133 ppm respectively) than other vegetable oils (Shukla *et al.*, 2002). It has been an important oil crop during Bronze and Iron ages and was gradually replaced with modern Brassica cultivar in the Middle Ages and thereafter (Vollmann *et al.*, 1996). Recently interest in *Camelina sativa* has been renewed mainly due to the demand for alternative low-input crops with a potential for non-food industrial utilization specially biofuel without interfering the food security (Agarwal *et al.*, 2013). Although presence of omega-3 fatty acids makes its oil unique and nutritionally rich but presence of high cholesterol and eicosenoic acid (15%) pose a hurdle for its approval as food oil (Leonard, 1998; Lu, 2008) and thus making it suitable raw material for biofuel.

Camelina sativa reportedly grows well on marginal soils, is drought tolerant, early maturing and requires fewer inputs than other oilseed species. It is short season crop (85-100 days), tolerant to frost, contains higher seed oil (320-480 g/kg) and yields up to 600-1700 kg/ha (Urbaniak *et al.*, 2008). *Camelina sativa* has been recently introduced in India from Austria as a potential biodiesel crop that does not interfere the edible oil trade and compete for available resources (Agarwal *et al.*, 2010). The presence of certain phytochemicals gives *Camelina sativa* a natural resistance to diseases such as blackspot (*Alternaria brassicae*) and insect pests such as the crucifer flea beetle (*Phyllotreta cruciferae*). These attributes suggest that the production of *Camelina sativa* may be more sustainable than other oilseed crops.

Nitrogen (N) is one of the most important nutrients involved in the production of oilseed crops. There are inconclusive and varying results in reference to *Camelina sativa* production in different regions of the world. Nitrogen is component of most organic compounds, only in lower quantities than C, H and O (Fageria, 2007). Thus, nitrogen is one of the most important food elements; its adequate supply enhances the vigorous vegetative growth, being the integral part of the chlorophyll molecule. Its supply associates with synthesis of amino acids, protein, nucleic acid and carbohydrate metabolism. Further, splitting of nitrogen dose plays an important role in production potential and improving quality of crop. It is well established fact that absorption of nutrients by plants, particularly nitrogen increases at various critical physiological growth stages. Being a highly mobile element, losses of N in soil takes place through various paths. Therefore, it is necessary to apply this vital element at critical physiological growth stages by appropriate scheduling of total nitrogen required by plants. Thus, scheduling of nitrogen at sowing, 25 and 50 DAS may have positive influence in increasing productivity of this crop. This suggests that research evaluating rate and time of N application is pertinent in determining the success of this crop in a particular area. Meagre information is available on agronomical and physiological aspects of *Camelina sativa* (Anuja *et al.*, 2013). Hence, keeping the above facts in view, an experiment was conducted to determine nitrogen dose and its splitting for higher productivity of *Camelina sativa* in Malwa plateau region of Madhya Pradesh, India.

Materials and Methods

A field experiment was conducted at Defence Institute of Bio-Energy Research (DRDO) HQ Haldwani Project Site Military Farm-Mhow, Indore (22.55°N and 75.76°E; 556 m

altitude) during the winter (*rabi*) seasons of 2010–11 and 2011–12. The soil was medium black with pH-7.0, organic carbon-0.71%, nitrogen-266.0 kg/ha, phosphorus-11.2 kg/ha and potassium-700.0 kg/ha. Twelve treatment combinations comprising 4 nitrogen application rates (60, 90, 120 and 150 kg/ha) and 3 nitrogen scheduling ($\frac{1}{2}$ N as basal + $\frac{1}{2}$ N at 25 DAS, $\frac{1}{2}$ N as basal + $\frac{1}{4}$ N at 25 DAS + $\frac{1}{4}$ N at 50 DAS and $\frac{1}{3}$ N as basal + $\frac{1}{3}$ N at 25 DAS + $\frac{1}{3}$ N at 50 DAS) were replicated thrice in factorial randomized block design with plot size of 2.5 × 3.0 m.

The *Camelina sativa* cv. calena (EC-643910) was sown in rows, 20 cm apart, with seed rate of 4 kg/ha on 7 November 2010 and 27 October 2011. The crop was fertilized as per treatment combinations with a uniform basal dose of phosphorus and potassium @ 60 and 30 kg/ha, respectively. The crop was grown with 3 protective irrigations and harvested on 18 February 2011 and 10 February 2012. Days to flowering and pod formation were determined as the number of days from date of seeding to approximately 50% of the plants in a plot having open 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% of the pods had changed colour and the seeds were firm, representing a moisture of about 25% (Guggel and Falk, 2006).

At maturity, data on plant height, primary branches/plant, dry matter accumulation/plant, pods/plant, seeds/pod, 1000-seed weight, biological yield and seed yield were recorded, and plant samples collected at harvest were analysed for oil content in seed and N content in seed and straw. The data collected on growth, yield and quality parameters were statistically analysed as per analysis of variance procedure outlined for factorial randomized block design (Gomez and Gomez, 1984).

Results and Discussion

Nitrogen application rate

A perusal of pooled data of 2 years (Tables 1 and 2) revealed that application of 150 kg N/ha, being at par with 120 kg N/ha, recorded highest values for plant height, days to flowering, pod formation and maturity, dry matter accumulation/plant, pods/plant, 1000-seed weight, seed yield and oil yield of *Camelina sativa*. Seeds/pod was also found significantly higher with 150 kg N/ha, being at par with 90 and 120 kg N/ha. However, application of 150 kg N/ha recorded significantly highest number of primary branches/plant, biological yield and total N uptake over 60, 90 and 120 kg N/ha. Harvest index and oil content did not exhibit any marked difference due to varying N levels.

Gross return (₹ 40111), gross expenditure (₹ 22288) and net return (₹ 17823) were also recorded highest with 150 kg N/ha but benefit-cost ratio was found 0.8 either with 120 or 150 kg N/ha. It is well emphasized that increasing rate of nitrogen application markedly improved overall growth of crop in terms of plant height and dry matter accumulation/plant upto 120 kg N/ha; primary branches upto 150 kg N/ha by virtue of its impact on morphological and photosynthetic components coupled with accumulation of nutrients. This suggests greater availability of nutrients and metabolites for growth and development of reproductive individual plants. The increased availability of nutrients and photosynthesis might have enhanced number of flowers and their fertilization resulting in higher number of grains/pod. Further in most of the oilseeds, greater assimilating surface at reproductive stage resulted in better grain formation because adequate production of metabolites and their translocation towards grain was evident from nutrient concentration and their uptake (Fig. 1 and 2).

Table.1 Growth and yield attributes of false flax (*Camelina sativa* L.) as affected by nitrogen application rate and its scheduling (pooled data of 2 years)

| Treatment | Plant height (cm) | Branches/plant | Days to flowering | Pod formation | Days to maturity | Dry matter accumulation/plant (g) | Pods/plant | Seeds / pod | Test weight (g) |
|--|-------------------|----------------|-------------------|---------------|------------------|-----------------------------------|------------|-------------|-----------------|
| Nitrogen application rate (kg/ha) | | | | | | | | | |
| 60 | 73.0 | 8.3 | 39.3 | 53.8 | 96.5 | 6.0 | 203.1 | 7.9 | 1.10 |
| 90 | 79.3 | 10.4 | 42.6 | 57.3 | 99.9 | 7.4 | 246.4 | 8.6 | 1.19 |
| 120 | 84.3 | 11.7 | 46.0 | 60.5 | 102.9 | 8.1 | 283.9 | 8.9 | 1.25 |
| 150 | 87.5 | 12.4 | 47.8 | 62.2 | 104.8 | 8.4 | 294.2 | 9.0 | 1.26 |
| SEm± | 1.3 | 0.2 | 0.8 | 1.4 | 1.4 | 0.1 | 3.7 | 0.2 | 0.02 |
| CD (P=0.05) | 3.8 | 0.5 | 2.2 | 3.9 | 4.0 | 0.4 | 10.9 | 0.6 | 0.07 |
| Nitrogen scheduling | | | | | | | | | |
| ½ N as basal + ½ N at 25 DAS | 75.8 | 10.0 | 43.1 | 57.6 | 99.3 | 6.9 | 237.7 | 8.3 | 1.17 |
| ½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS | 81.5 | 10.7 | 44.1 | 58.6 | 101.3 | 7.5 | 260.4 | 8.6 | 1.20 |
| ⅓ N as basal + ⅓N at 25 DAS + ⅓N at 50 DAS | 85.9 | 11.9 | 44.5 | 59.2 | 102.5 | 8.0 | 272.5 | 8.9 | 1.23 |
| SEm± | 1.1 | 0.2 | 0.6 | 1.2 | 1.2 | 0.1 | 3.2 | 0.2 | 0.02 |
| CD (P=0.05) | 3.3 | 0.6 | NS | NS | NS | 0.4 | 9.4 | NS | NS |

DAS, Days after sowing

Table.2 Productivity and economics of false flax (*Camelina sativa* L.) as influenced by nitrogen application rate and its scheduling (pooled data of 2 years)

| Treatment | Seed yield (q/ha) | Biological yield (q/ha) | Harvest index (%) | Oil content (%) | Oil yield (kg/ha) | Total N uptake (kg/ha) | Gross return (₹ /ha) | Cost of cultivation (₹ /ha) | Net return (₹ /ha) | Benefit - cost ratio |
|--|-------------------|-------------------------|-------------------|-----------------|-------------------|------------------------|----------------------|-----------------------------|--------------------|----------------------|
| Nitrogen application rate (kg/ha) | | | | | | | | | | |
| 60 | 6.00 | 59.90 | 10.01 | 35.7 | 214 | 58.5 | 28246 | 21064 | 7183 | 0.3 |
| 90 | 7.41 | 74.87 | 9.91 | 35.3 | 262 | 71.1 | 34897 | 21453 | 13453 | 0.6 |
| 120 | 8.27 | 80.87 | 10.24 | 35.2 | 291 | 84.2 | 38730 | 21914 | 16816 | 0.8 |
| 150 | 8.58 | 84.98 | 10.04 | 34.9 | 292 | 88.3 | 40111 | 22288 | 17823 | 0.8 |
| SEm± | 0.12 | 1.34 | 0.09 | 0.3 | 5 | 1.3 | - | - | - | - |
| CD (P=0.05) | 0.37 | 3.92 | NS | NS | 14 | 3.8 | - | - | - | - |
| Nitrogen scheduling | | | | | | | | | | |
| ½ N as basal + ½ N at 25 DAS | 7.05 | 69.94 | 10.07 | 35.1 | 248 | 70.5 | 33125 | 21638 | 11488 | 0.5 |
| ½ N as basal + ¼ N at 25 DAS + ¼ N at 50 DAS | 7.49 | 75.56 | 9.90 | 35.3 | 264 | 74.9 | 35308 | 21701 | 13614 | 0.6 |
| ⅓ N as basal + ⅓N at 25 DAS + ⅓N at 50 DAS | 8.12 | 79.94 | 10.16 | 35.4 | 288 | 81.2 | 38055 | 21701 | 16355 | 0.8 |
| SEm± | 0.11 | 1.16 | 0.08 | 0.2 | 4 | 1.1 | - | - | - | - |
| CD (P=0.05) | 0.32 | 3.40 | NS | NS | 12 | 3.3 | - | - | - | - |

The price of seed was taken ₹ 3500/q in 2011 and ₹ 4000/q in 2012 while the price of straw was considered ₹ 100/q in 2011 and ₹ 110/q in 2012.

Fig.1 60 kg N/ha in 2 equal splits



Fig.2 120 kg N/ha in 3 equal splits



This might have resulted in increased weight of individual grain expressed in terms of test weight and ultimately increased seed yield. The results are in close conformity with the findings of Urbaniak *et al.*, (2008) and Malhi *et al.*, (2014).

Nitrogen scheduling

Averaged over 2 years (Tables 1 and 2) the crop under three equal splitting ($\frac{1}{3}$ as basal + $\frac{1}{3}$ at 25 DAS + $\frac{1}{3}$ at 50 DAS) of nitrogen significantly improved plant height, primary branches/plant, dry matter accumulation/plant, seeds/pod, seed yield, biological yield, oil yield and total N uptake over other splits viz., $\frac{1}{2}$ N as basal + $\frac{1}{2}$ N at 25 DAS, $\frac{1}{2}$ N as basal + $\frac{1}{4}$ N at 25 DAS + $\frac{1}{4}$ N at 50 DAS. However, scheduling of nitrogen did not influence days to flowering, pod formation and maturity, seeds/pod, test weight, harvest index and oil content significantly. Gross return (₹ 38055), net return (₹ 16355) and benefit-cost ratio (0.8) were recorded highest with the crop under three equal splitting ($\frac{1}{3}$ as basal + $\frac{1}{3}$ at 25 DAS + $\frac{1}{3}$ at 50 DAS) of nitrogen but gross expenditure was found equal (₹ 21701) with $\frac{1}{2}$ N as basal + $\frac{1}{4}$ N at 25 DAS + $\frac{1}{4}$ N at 50 DAS. Application of three equal splitting of nitrogen recorded 15.1 and 8.4 per cent increase in yield over other splits viz. $\frac{1}{2}$ N as basal + $\frac{1}{2}$ N at 25 DAS,

$\frac{1}{2}$ N as basal + $\frac{1}{4}$ N at 25 DAS + $\frac{1}{4}$ N at 50 DAS, respectively.

This may be due to leaching and volatilization losses of nitrogen in soil resulting in low availability of nitrogen in basal application which might be unable to fulfill the supply of N at critical growth stages of plants. Increase in yield parameters of *Camelina sativa* by reducing basal dose of N and its splitting might be due to the prevented losses of N through leaching and volatilization; and as a result crop was benefited through adequate supply of N at different growth stages which helped in increasing seed yield (Narolia *et al.*, 2013). The findings of the present study elucidates that application of 120 kg N/ha in three equal splitting ($\frac{1}{3}$ as basal + $\frac{1}{3}$ at 25 DAS + $\frac{1}{3}$ at 50 DAS) proved effective in yield enhancement and economical for growing *Camelina sativa* L. in Malwa plateau region of Madhya Pradesh, India.

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