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EFFECT OF SPACING ON *CAMELINA SATIVA*: A NEW BIOFUEL CROP IN INDIA

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ABSTRACT

Camelina sativa (L.) Crantz (Gold of Pleasure) is a proposed biofuel species introduced in India from Austria in 2009. The experiment was conducted during 2010-2012 at the Defence Institute of Bio-Energy Research, Field station- Pithoragarh, Uttarakhand to study the effect of spacing between rows (20, 25, 30 and 35cm) on the growth, yield and oil content of *C. sativa* cv calena. The row spacing of 30cm showed a significantly higher threshing percentage (93.60), harvest index (11.78%), seed yield (458.89 kg/ha) and oil content in seed (38.71%) on applying least significant difference test at P=0.05. The study will be beneficial to optimize the cultivation of *Camelina* crop for large scale production of biofuel.

INTRODUCTION

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. 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.) Crtz., of origin Mediterranean to Central Asia belongs to Brassicaceae family. It is also known as gold-of-pleasure, false flax and Siberian mustard and is short season crop 85-100 days, tolerant to frost, contains higher seed oil (320-480g/kg) and yields up to 600-1700kg/ha. Presence of high cholesterol (200mg/kg) and eicosenoic acid (15%) pose a hurdle for its approval as food oil and is recently introduced in India from Austria as a potential bio diesel crop that don't interferes the edible oil trade and competes for available resources (Agarwal *et al*., 2010). Among various agronomic practices, proper spacing is one of the major factor exploring the high yielding and better oil potential of a particular crop. The space available for individual plant growing in community of row affects the yield and quality of produce. So, maintaining the optimum row spacing is more important for growth factor of plant responsible for better vegetative and productive phases.Being a new crop in the country, meager information is available on its physiological and agronomical aspects. Keeping above facts in view, the present study was carried out to standardize the row spacing of *C. sativa* (L.) under Central Western Himalayas of India for large scale cultivation for the biofuel production.

MATERIALS AND METHODS

A field study was carried out to determine the effect of row spacing on *C. sativa* cv calena (EC-643910), during the winter (rabi) season of 2010-2011 and 2011-12 at Defence Institute of Bio-Energy Research (DIBER) Field station Pithoragarh (Uttarakhand), situated in Central Western Himalayas of India, which extends from 29°29′ – 30°49′N L to 85°05′- 81°31′E L and at 5500 ft altitude. The annual rainfall is around 1250mm and temperature ranges from 35°C in summer to -2°C in winter. The soil was gravel sandy - clay loam in texture, organic carbon (0.36%), N (250kg/ha), P (11kg/ha), K (115 kg/ha) and soil pH varies from 6.1-7.5. The row spacing was 20, 25, 30 and 35cm. The plant-plant (10cm) distance was maintained. The plot size measured 6m^2. The crop was sown on October using a seed rate of 4.5 kg/ha and harvested on February. Two irrigations (protective input) were given at early seeding and flowering stage. All data were collected on plot basis. Days flower and pod 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. Biological yield (kg/ha) was obtained by summing pod yield and stover yield from net plots. Threshing per cent is calculated by seed yield/pod yield X 100 and Harvest index is defined as the ratio of seed yield to biological yield and expressed in percentage. 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) Fifteen plants were taken out randomly from each plot to collect data on plant characters and yield attributes. The oil content, reported as percent 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) and treatment means were compared by using the least significant difference test at p = 0.05.

RESULTS AND DISCUSSION

Pooled analysis of the experiment conducted (2010-12) on the effect of spacing on *Camelina* agronomic traits and seed oil is given in Table 1. The results revealed that the row spacing had significantly influenced the physiological behaviour, yield and oil % of *C. sativa* cv calena at 5 % level of significance. The flowering was found much earlier in 35cm(63.69 days) and this trend keep on increasing towards narrower spacing, revealing maximum duration to flower (71 days) in 20cm. Wider spacing resulted higher rates of flowering as reported by Harrington and Debell, 1995. Average pod formation took lesser time in 35cm (74.15 days), followed by 75.36 days in 30 cm and maximum (77.40 days) in 20cm of spacing. This is because of early flowering in wider spacing ultimately leads to earlier pod formation. Significantly the taller plants (82.72cm) were observed in row spacing of 35cm over 20cm (Table 1). This was mainly due to higher plant population in closer spacing that might be attributed to reduction in magnitude of competition for light (Rana and Pachauri, 2001) and resources (Sher *et al.,* 2001) under closer spacing as compared to wider spacing leading to taller plants as a result of malnutrition. The branch/plant does not differ significantly due to spacing and found maximum (8.10) in 30cm and minimum (6.18) in 35cm. The number of pod/plant (96) found higher in 35cm, followed by 92.74 in 30cm of spacing and lowest (85.18) in 20cm of narrower spacing. Gupta (1988) obtained higher number of siliquae/plant in mustard at lower plant density. The 20cm spacing produced the lowest number of pod/plant, because mutual shading reduced the light interception. As a result, photosynthesis was affected and pod formation was hampered. The widest spacing produced more number pod/plant than closer row spacing because of the fact that wider spacing facilitates maximum utilization of solar energy by providing sufficient space to intercept light as well as other environmental resources that helped photosynthesis and ultimately produced more dry matter that eventually partitioned towards sink (pod). This result was corroborated with Angadi

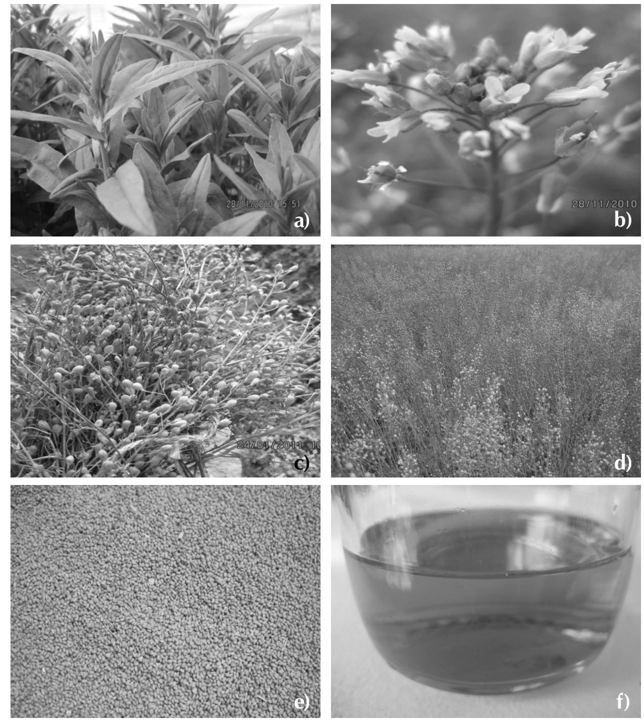

Figure 1: a) *Camelina sativa* rosettes, b) Flowering, c) pod bearing stage, d) Harvesting stage e) Seed and f) Oil.

Table 1: Effect of spacing on growth, yield and oil content of *C. sativa* (mean of two years)

S.No	Spacing (cm)	Flowering (days)	Pod formation (days)	Plant height (cm)	Branch/plant	Pod /plant	Seed/ pod	1000 seed wt (g)
1	20	71.00	77.40	72.00	6.33	85.18	7.50	1.41
2	25	68.00	76.03	73.74	6.75	89.45	8.01	1.33
3	30	67.40	75.36	78.18	8.10	92.74	8.40	1.23
4	35	63.69	74.15	82.72	6.18	96.00	7.23	1.22
CD@5 %	1.03	2.13	3.22	NS	3.51	NS	NS	
Sem	0.29	0.60	0.91	0.60	0.99	0.33	0.09	
CV	0.75	1.38	2.06	15.18	1.90	7.46	12.57	

S.No	Spacing (cm)	Seed/ plant	Biological yield(kg/ha)	Threshing %	Harvest Index (%)	Maturity Duration(days)	Seed yield(kg/ha)	Oil %
1	20	615.85	3425.55	66.34	5.76	129.65	226.66	35.86
2	25	750.48	3894.44	86.90	10.01	121.54	342.77	37.74
3	30	774.72	3935.00	93.60	11.78	119.01	458.89	38.71
4	35	710.40	3527.78	77.26	9.42	113.23	332.22	37.25
CD@5 %	09.19	10.91	5.90	2.57	2.60	10.31	0.023	
Sem	8.56	8.56	1.67	0.72	1.30	19.85	0.065	
CV	2.08	2.08	3.57	12.66	1.27	14.20	0.302	

et al. (2003) reports that the number of pods per plant increased with decreasing plant population density in all environ-ments, although the magnitude of the decline was differ-ent. The number of seeds/pod and test weight of seed does not differ significantly. The 30cm spacing provides higher seed/plant (774.72), biological yield of 3935 kg/ha, threshing (93.60%) and harvest index (11.78%) compared to other spacing tried. This was due to higher number of branch/plant (8.10), seed/pod (8.40) and seed/plant (774.72). The findings of Kumar *et al*. (1997) confirm these results. Days to physiological maturity of the crop found earlier in wider spacing of 35cm (113.23) and the maturity duration rises with narrower spacing 129.65, 121.54 and 119.01 days in 30, 25 and 20cm, respectively and can be related to better vegetative growth, plant canopy area and efficient photosynthetic activities which might have enhanced the reproductive phase resulting in earlier maturity of the crop. These results are in agreement with the findings of Johnson *et al*. (2008) and Mazumdar *et al.,* 2007. Significantly, the higher seed yield of 458.89kg/ha was recorded with row spacing of 30cm and it resulted in 202.46 % yield over 20cm row spacing (226.66kg/ha). This relates to better and efficient translocation and utilization of photosynthates, adequate availability of nutrients, moisture, light and space that has resulted in more number of seed/pod (8.40) and seed/plant (774.72) and 1000 seed weight (1.41g) as evident from the study (Table 1), which has ultimately resulted in higher seed yield in both 30cm row spacing. The results are similar to the Shivani and Kumar (2002) and Saleem *et al.,* 2001 reports that the row spacing of 30cm in various crops of *brassicaceae* family giving better seed yield but are contrary to Laffertey *et al*. (2009) suggestions of 12-15cm of row spacing. At 30cm spacing, relatively competition free environments prevail; hence more resources like nutrients, light, space etc. are available per plant. Hence, it may be concluded that at 30cm of row spacing optimum plant density is formed which made maximum utilization of nutrients, increased dry matter production and thereby resulted in higher seed yield/ha.

C. sativa showed a variation in oil content from 35.86 - 38.71 % and again row spacing of 30cm was found to be efficient in providing higher oil (38.71%) in comparison to narrower spacing of 20cm (35.86%).The higher oil per cent may be ascribed to the overall improvement in plant vigour and production of sufficient photosynthates owing to higher availability of nutrients, resulting in better seed yield at 30cm. These results are in conformity with the findings of Rana and Pachauri, 2001.

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