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EFFECT OF SPACING, FERTILIZERS AND IRRIGATION ON *CAMELINA SATIVA* PRODUCTION UNDER TROPICAL CONDITIONS OF MHOW, MALWA REGION OF MADHYA PRADESH, INDIA

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ABSTRACT

Camelina sativa (L) Crantz is an oil yielding crop of *Brassicaceae*. Experiments were conducted at DIBER Project Site, Mhow (Madhya Pradesh) to study the effect of spacing (20 and 30 cm) between rows, fertilizer application ½ dose (25:15: 10: N:P: K) and Full Dose (50:3:20::N:P:K) and irrigations (1, 2, 3) alone and in combinations on the crop production during 2013 and repeated in 2014-15 for confirmatory data. Combined effect of 30 cm row to row distance, full dose application of the fertilizers and three irrigations resulted in higher production (2385 ± 56 kg/ha). Sowing season also effect the productivity very significantly. October month was found best suitable for sowing *Camelina sativa* for getting highest production.

***Key words*:** *Camelina sativa*, Spacing, Fertilizers, Irrigation

Introduction

Camelina (*Camelina sativa* (L.) Crantz) is an ancient oil and food crop that has gained renewed interest for its high n-3 fatty acid content and for its potential for biodiesel and ATF production. *Camelina sativa* is adapted to various climatic conditions. It has low nutrient requirements and good resistance to diseases and pests. Due to its extremely high content (about 70%) of polyunsaturated fatty acids.

(PUFA), Camelina seeds and their by-products have considerable industrial potential: food, animal feeds, nutraceuticals, paints, dyes, cosmetics, bio-fuel, etc. (Rode, 2002). However, in the late 2000s, *Camelina* had undergone little research and its full agronomic and breeding potential was unexplored (Francis *et al*., 2009).

Camelina is an annual or overwintering herb, which grows to a height of 30-60 cm. The stems are single, usually branched above, glabrous, sometimes with few simple and branched hairs. The leaves are alternate, sessile, lanceolate, entire or slightly toothed, 2.0-8.0 cm long x 1.0-2.0 cm wide, glabrous or sparsely hairy. The inflorescences are elongated racemes borne on ascending pedicels. The flowers are tetramerous, light yellow or greenish-yellow in colour. The pods are leathery, pear-shaped and contain many seeds that are oblong, brown, deeply grooved and 2-3 mm long (Francis *et al*., 2009). The seeds contain between 36 and 47% oil. *Camelina* oil meal, the by-product of camelina oil extraction, is a protein-rich and often oil-rich feed with potential in livestock feeding (Almeida *et al*., 1978). *Camelina* is thought to have originated in south-eastern Europe and south-western Asia. It could have been introduced as a weed in flax and other crops (Knorzer, 1978). *Camelina* is adapted to cool temperate semi-arid zones on dry prairies or steppes. It is rarely found in Mediterranean or coastal climates, except in the North Sea periphery in Europe (Jalas *et al*., 1996). It is grown in Europe, Canada (Alberta, Saskatchewan, Maritime Provinces) and in the Northern USA, where it is also a prospective possibility for bio-fuel production (Francis *et al*., 2009).

Camelina can survive early-season water deficits and minor frosts in spring (Cherian, 2012). In Northern France, winter-sown annual *camelina* can tolerate temperatures of -10°C to -14°C over a period of several days without snow cover (Bonjean *et al*., 1999). In the Northern Corn Belt of the USA, autumn-seeded camelina can survive 3 consecutive months below -10°C. *Camelina*

is a fast-growing plant (85-100 days to maturity) (Przybylski, 2005). In Minnesota (upper Corn Belt), winter *Camelina* was harvested early enough to allow the production of a second crop (Gesch *et al*., 2011). *Camelina* does well on poor marginal soils provided they are well-drained. For this reason, it compares favourably with other oil crops such as soybean, sunflower or rapeseed, which are not suitable in low moisture, low fertility and saline conditions (Nolte, 2010).

Yields of *Camelina* seed are in the 1.5-3.0 t/ha range (Singh *et al.*, 2014). One hectare can yield more than 370 L of oil and 1 t of oil meal (Enjalbert *et al*., 2011). Both winter and spring annual genotypes exist. In Northern America, annual winter *Camelina* gives optimal yields when sown from early to mid-October (Gesch *et al*., 2011). In Europe, annual spring *Camelina* gives better yields when sown in early spring (ITAB, 2009). In India *Camelina* has been introduced as a biodiesel feedstock production (Agarwal *et al.*, 2010.)

Materials and Methods

This study was conducted at DIBER Bio-fuel Park (100ha area) at Harshola, Mhow (MP). For spacing trial line to line distance of 20 cm and 30 cm were used and for fertilizer dose (½ dose) N:P:K were used in 25:15:10 and for Full Dose they were used in 50: 30:20 ratio respectively. Urea, single super phosphate, Muriate of potash and Zinc sulphate (25kg/acre) were also applied. Three irrigations trials were conducted, in first trial one irrigation was provided to the crop only at the time of sowing. In second trail two irrigations were provided one at the time of seed germination one at the time of flowering. In third trial three irrigations were provided one each at the time of germination, flowering and fruiting. Trials of *Camelina sativa* cultivation were conducted in 2013 and repeated during 2014-15 to confirm the results.

Data regarding germination date, incidence of insect pests, irrigation, flowering initiation date, days taken in 50 % flowering, pod setting date, days taken for 50 % Pod setting , days taken for maturity, no. of pods/plant and seed yield/plot were recorded. Data were also recorded for flowering date, fruiting date and crop maturity duration. Data were also recorded for plant height, number of branches per plant, stem and root biomass, number of pods per plant, number of seeds per pod and 1000 seed weight were also recorded.

Fig. 1: *Camelina sativa* as intercrop in *Jatropha* Plantation.

For each trial plot size was 1m^2, number of plots per replicate were 8 and number of replicates were 3. Crop was sown in open field conditions. Both line sowing and broadcast method were tried. Sowing of seeds was done manually. Seed rate for 1m^2 plot was 12.3g. Trials were conducted from Jan to Dec months on monthly basis and all the data were collected in replicates of three. Biomass was calculated as whole plant weight by uprooting the plants after maturity (10 plants/plot, 1×1m^2 area) Fresh weight and sun-dried weight. The data of all three years were pooled and analyzed as per standard statistical procedures (Panse and Sukhatme).

Results and Discussion

Detailed data of the experiments conducted from 2012 to 2014 are given in Table. 1. The resulted revealed that row to row spacing has influence on the vegetative growth, yield and oil% of *Camelina* at 5% level of significance. Wider spacing resulted in higher vegetative growth (taller plants & a greater number of side branches), a greater number of branches, higher seed yield per plant and thus higher yield/hectare. Plant growth was comparatively less in 20 cm row to row distance plants this may be because of completion between the plants for light (Rana and Pachauri, 2001) and space for root activity. Flowering takes place first in plants of 30cm row to row distance. Earlier flower formation in more

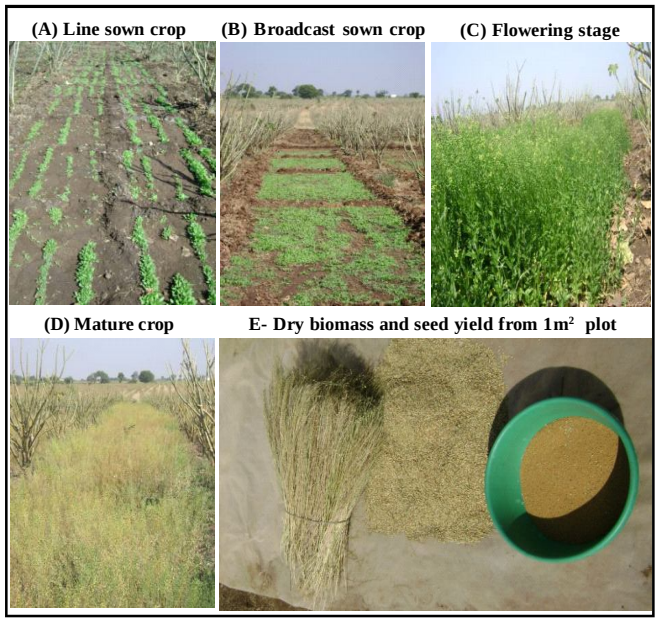

Fig. 2: (A-E) *Camelina* as intercrop in *Jatropha* plantation.

Table 1: *Camelina sativa* experimental trial-I Data.

TRIAL –I (Oct sown crop)															
PLOTS →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**	**STD DEV**	**CD(p=0.05)**
Biomass (g) (10plants/Plot)	219	211	208	198	162	140	181	169	180	172	162	108	175.83	31.62	20.23
Root mass (g) (10plants/Plot)	36	32	28	21	18	12	19	17	18	16	14	11	20.16	7.86	4.11
No of Pods per plant	458	423	314	298	163	57	84	176	189	178	75	56	205.91	138.06	72.42
No of seeds/pod	14	16	19	12	10	6	12	10	8	11	9	10	11.41	3.55	1.86
1000 seed weight (g)	1.2	1.1	1.0	1.2	1.1	0.9	1.1	1.0	1.1	1.2	1.1	0.9	1.075	0.105	0.07
Yield (g)	227	279	371	302	238	173	269	279	193	221	181	130	238.58	65.83	21.00
Total Yield	(No. of branches per plant 8 to 20) (plant height 62-99 cm) **0.238 Kg/ 1m² plot i.e. 2385 kg/ha** (112 days from sowing to harvesting)														
*Data are mean values of three years trials															

Table 2: *Camelina sativa* experimental trial-II Data.

TRIAL –II (Nov sown crop)															
PLOTS →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**	**STD DEV**	**CD(p=0.05)**
Biomass (g) (10plants/Plot)	167	183	192	111	109	108	78	98	89	78	79	83	114.58	41.97	21.94
Root mass (g) (10plants/Plot)	22	18	17	22	19	18	19	21	14	13	18	15	18	2.92	1.59
No of Pods per plant	268	174	170	226	346	182	192	296	189	261	269	146	226.58	60.92	31.81
No of seeds/pod	11	07	12	10	09	06	06	09	08	12	10	06	9	2.25	0.74
1000 seed weight (g)	1.1	1.1	1.0	1.2	1.0	1.1	1.0	1.1	1.1	1.2	1.1	0.9	1.075	0.086	0.06
Yield (g)	132	140	142	128	127	114	112	129	124	141	137	87	126.66	16.38	8.22
Total Yield	(No. of branches per plant 7 to 17) (plant height 52-84 cm) **0.126 Kg/ 1m² plot i.e. 1266 kg/ha** (107 days from sowing to harvesting)														
*Data are mean values of three years trials															

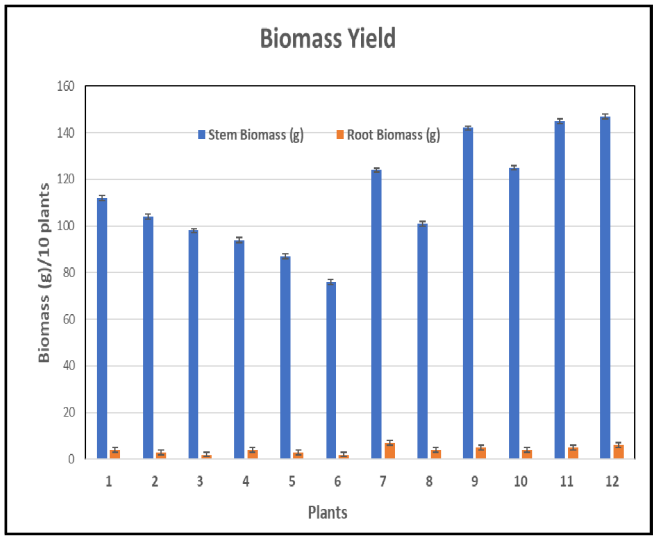

Fig. 3: Biomass yield data of *Camalina. sativa*

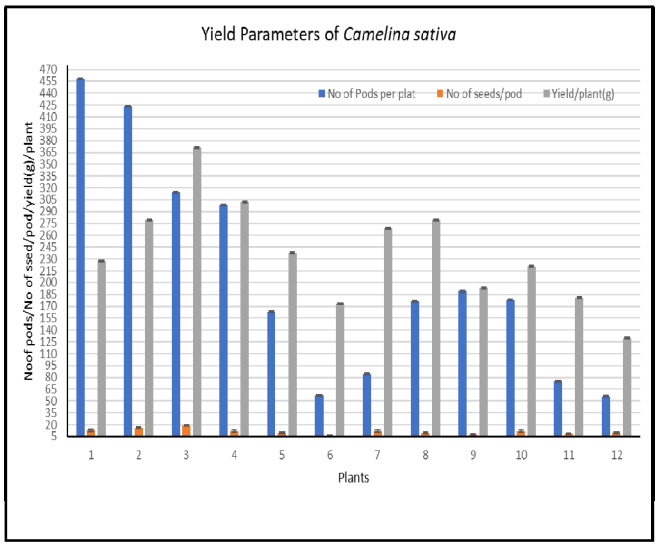

Fig. 4: Yield parameters of *Camalina sativa.*

Table 3: *Camelina sativa* experimental trial-III Data.

TRIAL –III (Dec sown crop)															
PLOTS →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**	**STD DEV**	**CD(p=0.05)**
Biomass (g) (10plants/Plot)	112	104	98	94	87	76	124	101	142	125	145	147	112.91	23.63	12.36
Root mass (g) (10plants/Plot)	04	03	02	04	03	02	07	04	05	04	05	06	4.08	1.50	0.88
No of Pods per plant	34	28	24	24	22	12	34	31	35	34	35	36	29.08	7.31	3.85
No of seeds/pod	05	06	03	03	03	02	05	04	07	04	05	06	4.41	1.50	0.53
1000 seed weight (g)	0.7	0.5	0.4	0.4	0.3	0.3	0.6	0.4	0.6	0.5	0.7	0.7	0.508	0.150	0.09
Yield (g)	54	43	35	34	28	22	54	37	56	41	59	59	43.5	12.68	6.64
Total Yield	(No. of branches per plant 5 to 11) (plant height 55-71 cm) **0.0435 Kg/ 1m² plot i.e. 435 kg/ha** (103 days from sowing to harvesting)														
*Data are mean values of three years trials															

spacing leads to early pod formation. Number of pods/ plant (182-458) found higher in 30 cm than 20cm (57-189). Lesser number of pods in 20cm may be due to light interception because of mutual shading by the plants. The 30 cm spacing produced a greater number of pods per plant because of 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 biomass.

These results are in accordance of Angadi *et al.*, (2003) reports that the number of pods per plant increased with decreasing plant population density in all environments. The 30 cm spacing provides higher seed yield/plot (227-302g) biological yield of 2385 kg/hectare. At 30 cm spacing, relatively competition free environment prevails hence more resources like nutrients, light, space etc. are available per plant. Hence it may be concluded the at 30cm 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. Based on the trials throughout the year, October month was found best suitable for sowing, germination, growth and optimum seed yield. Detailed data (mean values) regarding *Camelina sativa* experimental trials (2013-2015) to study the effect of spacing, fertilizer and irrigation were provided in the Tables 1-4 and Fig. 3-4.

From the above results it can be concluded that *Camelina sativa* is a good alternative oil yielding crop as total oil percentage in it is found in the range of 36.10 to 40.12 %. *Camelina sativa* is a short duration (100-115 days) oil yielding crop which can be utilised as a potential candidate for bio-fuel crop due to its high oil content and

Table 4: *Camelina sativa* experimental trial-III Data.

TRIAL –IV (Jan sown crop)															
PLOTS →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**	**STD DEV**	**CD(p=0.05)**
Biomass (g) (10plants/Plot)	121	122	120	189	140	124	105	131	154	112	104	98	126.6	25.14	13.15
Root mass (g) (10plants/Plot)	05	06	05	06	04	06	05	06	07	05	04	03	5.16	1.11	0.73
No of Pods per plant	28	27	24	26	25	42	23	19	21	24	12	13	23.66	7.70	4.05
No of seeds/pod	04	04	03	03	05	05	03	03	03	04	03	02	3.5	0.904	0.38
1000 seed weight (g)	0.4	0.7	0.6	0.7	0.6	0.7	0.5	0.7	0.7	0.5	0.5	0.4	0.58	0.11	0.08
Yield (g)	29	46	40	47	42	46	39	46	49	30	30	29	39.41	7.86	4.09
Total Yield	(No. of branches per plant 6 to 11) (plant height 53-75 cm) **0.039 Kg/ 1m² plot i.e. 394 kg/ha** (97 days from sowing to harvesting)														
*Data are mean values of three years trials															

short duration annual crop. It can be grown as intercrop in *Jatropha plantation* for better utilisation of space being a winter crop there is no problem of light interception by *Jatropha* because in winter *Jatropha* sheds leaves completely and *Camelina* can be grown easily. Thus, *Camelina* as intercrop in *Jatropha* plantation is a good model for the proper utilization of land and production of feedstock for bio-fuel production.

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