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RESEARCH ARTICLE :

Yield parameters and economic feasibility of safflower (*Carthamus tinctorius* L.) influenced by different management practices in northern dry zone of Karnataka

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SUMMARY : A field experiment on "yield parameters and economic feasibility of safflower influenced by different management practices in northern dry zone of karnataka" was conducted at Agriculture Research Station, Annigeri, UAS, Dharwad during *kharif* and *rabi* seasons of 2014-15 under rainfed condition. The total annual rainfall between April 2014 to May 2015 was 841.7 mm with 52 rainy days which was 175.8 mm higher than the average of 35 years (1978-2013). The experiment was laid out in a split-split plot design replicated thrice with 18 treatment combinations. Main plots consisted of three treatments, greengram for green manuring and greengram as a dual purpose both grown during *kharif* and one fallow. Succeeding safflower was sown during *rabi* season with two spacing of 45 cm x 20 cm and 60 cm x 30 cm as sub plots and three nitrogen levels 20, 30 and 40 kg N/ ha as sub-sub plot. Among the green manure treatments greengram as a dual purpose recorded significantly highest net returns (35362.60 Rs/ha) and B:C ratio (2.53). This indicates the possibility of growing safflower at wider spacing with application of only nitrogen with *in situ* green manuring without affecting its productivity and profitability under normal or above normal rainfall years.

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BACKGROUND AND OBJECTIVES

Safflower (*Carthamus tinctorius* L.) belongs to the family Compositae or Asteraceae. It is predominantly grown in black soils (medium and deep black soils) as a rainfed oilseed crop in the Deccan plateau region of India during *rabi* season (post rainy season) (Vishwanath *et al.*, 2006). In India, the crop has traditionally been grown in the *'rabi'* or winter dry season in mixtures (inter-crop) with other *'rabi'* crops, such as wheat, chickpea and sorghum. As a sole crop (yearly rotation) it is also rotated with wheat, chickpea, cotton and sorghum. Being deep rooted with spiny leaves it is considered a drought tolerant crop, and it responds well to residual moisture,

nutrients and management practices in dryland conditions. In Northern Dry Zone of Karnataka (Zone-3) farmers practice fallow-safflower cropping system. In this system land is kept fallow during the *kharif*. It gives a chance to take up *in-situ* green manure in fallow land. These *in-situ* green manures produce an average 15-22 tonnes of green biomass which add about 5-7 tonnes of dry matter to the soil and enhance the soil fertility. This in turn increase the availability of nutrients in soils and crop productivity (improves the physical, chemical and biological properties of soil) (Hiremath and Patil, 1996).

Green manures are proven to be a viable input for crop production for sustaining the production system under irrigation system. The same role under dry land system needs to be elaborated to check possibility of using green manures for their ability to supplement the nutrients in comparison to recommended inorganic nutrients to achieve comparative yields (Yogesh, 2013). Therefore, in order to achieve enhanced and sustained yield through improvement of soil productivity and to produce high quality oil of safflower, there is a need to work out proper management techniques to grow the green gram as a green manure crop in *kharif in-situ* and application of different levels of nitrogen and different spacing of safflower during *rabi* in assured rainfed conditions.

RESOURCES AND METHODS

The field study was conducted during *kharif* and *rabi* seasons of 2014-15 under rainfed conditions at the Agricultural Research Station, Annigeri, Dharwad. The experiment was laid out in a split-split plot design and replicated thrice. Main plot consist of three treatments, greengram as a green manuring (GM_1) and greengram as a dual purpose (GM_2) grown during *kharif* and one fallow (GM_3). Succeeding safflower was sown during *rabi* season. Two sub treatments spacings (S_1: 45 cm x 20 cm and S_2: 60 cm x 30 cm) and nitrogen levels (N_1: 20, N_2: 30 and N_3: 40 kg N/ha) were applied to succeeding safflower.

The greengram crop was sown with the onset of monsoon (12th June 2014) at row spacing of 30 cm with seed rate of 12.5 kg/ha. Greengram crop was given a common dose of fertilizer of 25:50:25 kg N: P_2O_5: K_2O/ ha at the time of sowing. Green manure GM_1 *i.e.* incorporation of greengram as a green manure at full bloom stage (45-50 DAS) in field was done on 1st August 2014. And GM_2 greengram as a dual purpose *i.e.* incorporation after picking of pods was carried out on (20.08.2014).

OBSERVATIONS AND ANALYSIS

The seed yield of safflower was substantially influenced by incorporation of green manures. Incorporation of greengram as a green manure resulted significantly highest seed yield (12.92 q/ha). While the lowest seed yield was recorded in fallow (11.09 q/ha), however the greengram as a dual purpose was on par with greengram as a green manuring (12.04 q/ha). Safflower yield was 16.50 per cent in GM_1 and 8.57 per cent in GM_2 higher compared to fallow- safflower system (Table 2). Seed yield is a function of yield contributing characters of safflower. The improvement in seed yield of safflower in greengram as green manuring as well as greengram as a dual purpose crop was due to yield attributes *viz.*, number of capsules per plant (24.56 and 22.69, respectively), number seeds per capsules (26.11 and 25.00, respectively), seed weight per plant (15.07 g and 13.07 g, respectively) and test weight (5.91 g and 5.88 g, respectively) (Table 1). All these yield components were significantly higher with greengram as a green manuring crop than fallow. Similar increase in yield attributes with incorporation of green manure was reported in safflower by Nooli *et al.* (2001), Karle *et al.* (2007) and Biradar (2008).

The performance of safflower was significantly influenced by adopting two different spacings. Between the spacings treatments, significantly higher seed yield was observed in 60 cm x 30 cm (12.77 q/ha) than the 45 cm x 20 cm (11.26 q/ha), which was 13.41 per cent higher in 60 cm x 30 cm compared to 45 cm x 20 cm (Table 2). Wide spacing produced the highest number of capsules per plant (24.09), number of seeds per capsules (25.85), test weight (5.95) and seed weight per plant (14.26) as compared with narrow one (Table 1). due to the better environmental conditions in wide spacing and less competition between plants as well as increased light penetration within plant canopy which increased assimilation rate and oil formation. These results are in line with those obtained by Babak *et al.* (2011), Roqiyeh *et al.* (2012) and Ahmed and Mohammad (2013).

Nitrogen fertilization positively affected seed yield. Seed yield showed significant increase with increase in levels of nitrogen. Among the different nitrogen levels,

Table 1: Effect of green manuring, spacing and nitrogen levels on yield attributing characters of safflower

Treatment		Number of capsules per plant				Number of seeds per capsules				Seed weight per plant (g)				Test weight (g)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
GM_1	S_1	20.00	23.00	25.00	22.67	21.00	23.00	28.67	24.22	12.57	13.34	16.93	14.28	5.37	5.96	6.23	5.85
	S_2	22.67	27.00	29.67	26.44	24.00	27.67	32.33	28.00	15.44	16.37	15.76	15.86	5.59	5.73	6.60	5.97
	Mean	21.33	25.00	27.33	24.56	22.50	25.33	30.50	26.11	14.01	14.85	16.34	15.07	5.48	5.85	6.41	5.91
GM_2	S_1	18.50	20.00	24.67	21.06	22.00	26.67	26.00	24.89	10.57	11.34	14.93	12.28	4.86	5.77	6.88	5.84
	S_2	23.33	23.67	26.00	24.33	21.33	26.00	28.00	25.11	13.44	14.37	13.76	13.86	5.44	5.89	6.42	5.92
	Mean	20.92	21.83	25.33	22.69	21.67	26.33	27.00	25.00	12.01	12.85	14.34	13.07	5.15	5.83	6.65	5.88
	S_1	18.08	19.75	24.22	20.68	19.00	21.67	25.33	22.00	11.33	11.90	12.53	11.92	4.26	5.31	5.76	5.11
Fallow	S_2	15.92	22.28	26.30	21.50	22.33	24.67	26.33	24.44	12.38	13.08	13.74	13.07	4.96	5.38	6.18	5.51
	Mean	17.00	21.02	25.26	21.09	20.67	23.17	25.83	23.22	11.86	12.49	13.14	12.49	4.61	5.35	5.97	5.31
Mean of S	S_1	18.86	20.92	24.63	21.47	20.67	23.78	26.67	23.70	11.49	12.19	14.80	12.83	4.83	5.68	6.29	5.60
	S_2	20.64	24.32	27.32	24.09	22.56	26.11	28.89	25.85	13.75	14.61	14.42	14.26	5.33	5.67	6.40	5.80
Mean		19.75	22.62	25.98		21.61	24.94	27.78		12.62	13.40	14.61		5.08	5.67	6.34	
For comparison of means		S.E. ±		C.D. (P=0.05)		S.E. ±		C.D. (P=0.05)		S.E. ±		C.D. (P=0.05)		S.E. ±		C.D. (P=0.05)	
Green Manuring (GM)		0.64		2.50		0.77		2.41		0.49		1.94		0.18		0.89	
Spacing (S)		0.71		2.47		0.67		2.02		0.29		1.01		0.11		NS	
Nitrogen (N)		0.54		1.58		0.57		1.67		0.41		1.21		0.12		0.34	
GM x S		1.24		NS		1.16		NS		0.51		NS		0.19		NS	
GM x N		0.94		NS		0.99		NS		0.72		NS		0.20		NS	
S x N		0.77		NS		0.81		NS		0.59		1.63		0.17		NS	
GM x S x N		1.33		NS		1.40		NS		1.01		NS		0.29		NS	

GM_1: Green gram (green manuring) S_1: 45 cm x 20 cm N_1: 20 kg N/ha (50% RDN)
GM_2: Green gram (dual purpose) S_2: 60 cm x 30 cm N_2: 30 kg N/ha (75% RDN)
N_3: 40 kg N/ha (100% RDN) NS=Non-significant

Table 2: Effect of green manuring, spacing and nitrogen levels on seed yield, stalk yield, harvest index and equivalent yield of safflower

Treatments		Seed yield (q/ha)				Stalk yield (q/ha)				Harvest index				Equivalent yield (q/ha) of safflower			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
GM_1	S_1	11.07	11.80	13.90	12.26	40.86	43.83	49.52	44.74	0.27	0.27	0.28	0.27	11.07	11.80	13.90	12.26
	S_2	11.73	13.27	15.73	13.58	47.98	51.06	59.80	52.95	0.25	0.26	0.26	0.26	11.73	13.27	15.73	13.58
	Mean	11.40	12.53	14.82	12.92	44.42	47.45	54.66	48.84	0.26	0.26	0.27	0.26	11.40	12.53	14.82	12.92
GM_2	S_1	9.76	10.17	13.50	11.14	33.83	42.36	49.96	42.05	0.27	0.22	0.25	0.25	20.20	20.61	23.95	21.59
	S_2	10.86	12.46	15.51	12.94	41.43	45.44	56.67	47.85	0.24	0.25	0.26	0.25	21.30	22.91	25.96	23.39
	Mean	10.31	11.31	14.51	12.04	37.63	43.90	53.31	44.95	0.26	0.24	0.26	0.25	20.75	21.76	24.95	22.49
	S_1	8.15	9.39	13.59	10.37	35.82	39.04	44.58	39.81	0.21	0.22	0.29	0.24	8.15	9.39	13.59	10.37
Fallow	S_2	10.37	10.75	14.27	11.80	38.69	45.86	56.05	46.87	0.25	0.21	0.23	0.23	10.37	10.75	14.27	11.80
	Mean	9.26	10.07	13.93	11.09	37.26	42.45	50.31	43.34	0.23	0.22	0.26	0.23	9.26	10.07	13.93	11.09
Mean of S	S_1	9.66	10.45	13.66	11.26	36.84	41.74	48.02	42.20	0.25	0.24	0.27	0.25	9.66	10.45	13.66	11.26
	S_2	10.99	12.16	15.17	12.77	42.70	47.46	57.51	49.22	0.25	0.24	0.25	0.25	10.99	12.16	15.17	12.77
Mean		10.32	11.31	14.42		39.77	44.60	52.76		0.25	0.24	0.26		10.32	11.31	14.42	
For comparison of means		S.E. ±		C.D. (P=0.05)		S.E. ±		C.D. (P=0.05)		S.E. ±		C.D. (P=0.05)		S.E. ±		C.D. (P=0.05)	
Green manuring (GM)		0.24		0.95		0.97		3.79		0.004		0.017		0.24		0.95	
Spacing (S)		0.24		0.82		0.93		3.21		0.005		NS		0.24		0.82	
Nitrogen (N)		0.29		0.85		0.97		2.83		0.008		NS		0.29		0.85	
GM x S		0.41		NS		1.61		NS		0.009		NS		0.41		NS	
GM x N		0.51		NS		1.68		NS		0.014		NS		0.51		NS	
S x N		0.41		NS		1.37		NS		0.011		NS		0.41		NS	
GM x S x N		0.72		NS		2.38		NS		0.019		NS		0.72		NS	

GM_1: Green gram (green manuring) S_1: 45 cm x 20 cm N_1: 20 kg N/ha (50% RDN)
GM_2: Green gram (dual purpose) S_2: 60 cm x 30 cm N_2: 30 kg N/ha (75% RDN)
N_3: 40 kg N/ha (100% RDN) NS=Non-significant

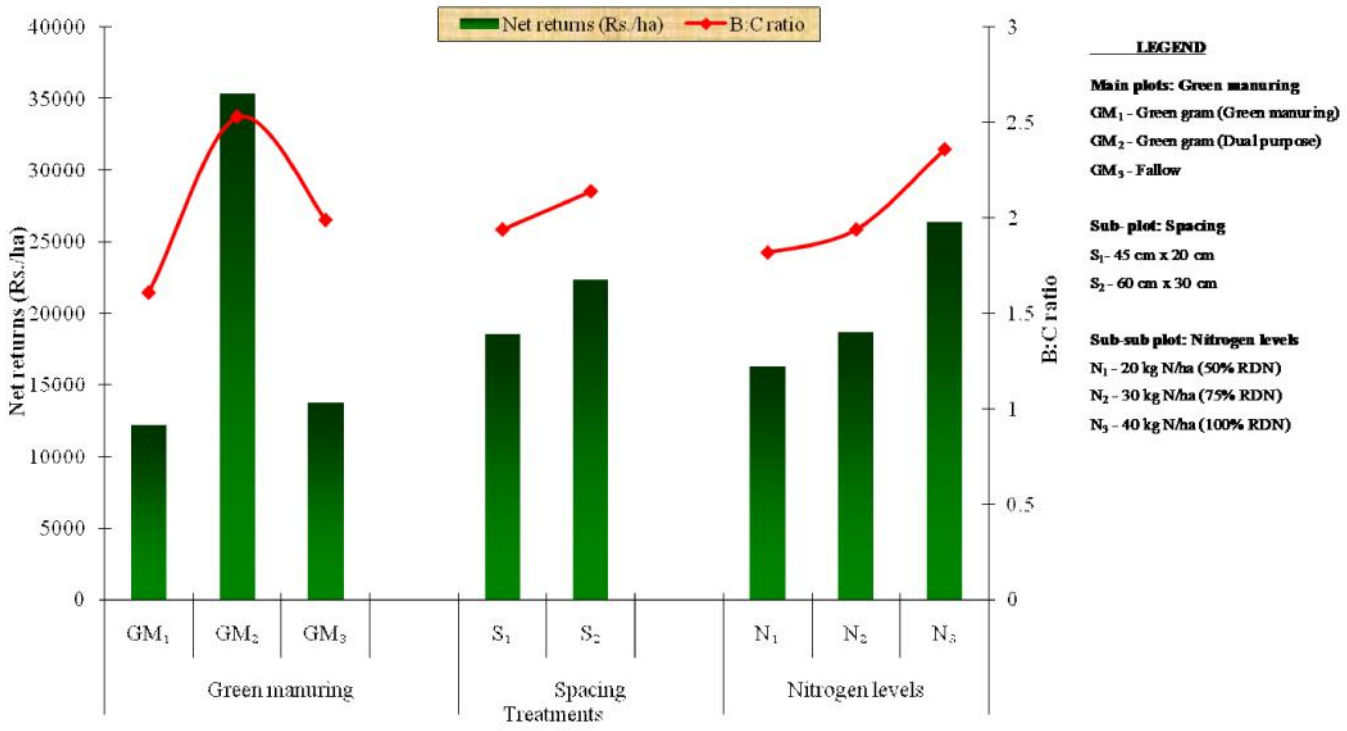

Fig. 1 : Effect of green manuring, spacing and nitrogen levels on net returns and B.C. ratio of safflower

significantly the highest seed yield was observed at 40 kg N/ha (14.42 q/ha) over the 30 kg N/ha (11.31 q/ha) and 20 kg N/ha (10.32 q/ha). And this was 39.72 per cent in GM_1 and 9.6 per cent in GM_2 higher compared to fallow (Table 2). These results conformed with the following findings of Mundel *et al.*, 2004; Gawand *et al.*, 2005; Vishwanath *et al.*, 2006; Dordas and Sioulas, 2008.

Differences in seed yield of safflower were mainly due to differences in yield contributing characters. The improvement in seed yield with application of 40 kg nitrogen per ha (100 % RDN) was due to increase in yield attributing characters of safflower such number of capsules per plant (25.98), number seeds per capsules (27.78), seed weight per plant (14.61) and test weight (6.62) (Table 1). All these yield components recorded significantly higher value at 40 kg nitrogen per ha (100 % RDN) than the 20 kg nitrogen per ha (50 % RDN). Similar increases in yield attributes with increasing levels of nitrogen were reported in safflower by Dordas and Sioulas, 2008; Golzarfar *et al.*, 2011; Zareie *et al.*, 2011 and Mohamed *et al.*, 2012.

Economics :

Among the green manure treatments GM_2 recorded significantly higher net returns (35363 Rs./ha) and B : C ratio (2.53), respectively, as compared to rest of the green manure treatments GM_1 and fallow (12191 Rs./ha and 137945 Rs./ha, respectively) and (1.61 and 1.99, respectively) (Fig. 1). The higher net returns and B : C ratio of safflower was due to higher equivalent yield of safflower. (Table 2) These results are in line with the findings of Devaranavadgi *et al.* (2004) and Rajshekar *et al.* (2004).

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