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Cost economics studies in seed production of alfalfa (*Medicago sativa* L.) cv. RL-88

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Abstract
An experiment was carried out at the department of Seed Science and Technology (E-block) Eastern Dry Zone of College of Agriculture, UAS, GKVK, Bengaluru to find out the efficacy of different spacings and bio-inoculants treatment on cost benefit ratio of alfalfa (*Medicago sativa* L.) cv. RL-88 seed production. The results revealed that higher economic return to cost bear recorded higher in (30 x 10 cm) close spacing (1.92 and 2.59) over other combinations during *kharif* and *rabi* seasons respectively. Whereas the higher fertilizer dose in consortia with bio-consortia seed treatment 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM (1.73 and 2.45) over other combinations during *kharif* and *rabi* season. Whereas, among the interaction of closer spacing accompanying the 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM recorded (3.07 and 3.79) during *kharif* and *rabi* seasons respectively, over other treatments.

Keywords: Alfalfa, benefit cost ratio, bio-consortia

Introduction

Alfalfa (*Medicago sativa* L.) is popularly known as Lucerne and rightly called as "Queen of Forage". In India, it occupies an area of one million hectares and provides 60 to 130 t ha^{-1} of green forage, and seed yield. In Karnataka, it occupies an area of 3121.23 ha which accounts for 0.03% of the net cropped area (Elumalai Kannan, 2012) [3].

The non-availability of good quality seed is one of the major constraints in popularizing the seed production practice for most forage crop species. Hence, the production and supply of high quality seeds of these crops at a reasonable price is very much necessary. Seed production in alfalfa requires high expertise, timeliness and conducive climate conditions. The high plant density of flowers influence the activity of wild pollinators, particularly bumble bees and large solitary bees that are physically capable of tripping the flower. Among the different pollinators recommended in forage crops, alfalfa leaf cutter bee is the world's most effectively used and intensely managed solitary bee because of their gregarious nature, presence of trichomes at lateral surface of the abdomen which facilitates the pollen dispersal in turn results in effective pollination (Theresa *et al.*, 2011) [6].

One of the major constraints encountered in seed production is the lack of technology to carry over the seeds until the next planting season of the several factors which affect the yield & seed quality. Alfalfa normally considered to be cross pollinated crop known for *shy* seed production. In India, an average seed yield ranges from 50-250 kg ha^{-1} as compared to 800 to 1000 kg ha^{-1} in Lebanon as reported by Abu-Shakra *et al.* (1969) [1]. Hence there is a wide gap between requirement and availability of seeds in the country. The successful seed production involves acceptable variety, adequate pollination, proper fertigation, and proper insect pest management and fitting of cultural management practices under local conditions. In order to achieve these, proper seed production technological practices are important tools.

Materials and Methods

An experiment was conducted under irrigated conditions during the *kharif* and *rabi*, 2015-16 at E-6 block of the Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bengaluru. The Field experiment is laid out in Factorial Randomized Block Design with three replication with gross plot size: 2.1 m x 2.0 m=4.20 m^2. The experimental plot soil is of red sandy clay loam with slightly acidic (pH 6.26) and the electrical conductivity was normal (0.12 m mhos/cm at 25 °C). The nitrogen (240 kg ha^{-1}) was low, whereas the phosphorus was high (62.83 kg ha^{-1}) and the potash was medium (190.83 kg ha^{-1}).

During the previous season of *kharif* -2014, the site was grown with red gram crop for seed purposes with the recommended package of practices and, in the previous season of *rabi* - 2014, sunflower was grown for seed purposes with normal agronomic practices.
The seeds of alfalfa were sown @ 5 kg per hectare, with the line spaced 30 cm apart and 10 cm between the plant-to-plant seeds was sown at a shallow depth of 2-3 cm. After sowing light irrigation was given to maintain the optimum moisture for uniform seed germination.

Economics of seed production
Information on the market price of seeds, land preparation, bullock pair, fertilizers, chemicals and labour units required for the seed production were considered in addition to the regular components of the cost of cultivation. The cost of labour was calculated taking into account the prevailing labour wages at the time of investigation. Gross returns from the alfalfa seed yield were calculated. The net returns and B: C ratio were worked out by using the following formula

Net returns: Gross return – Cost of cultivation

$$\text{Benefit cost ratio: } \frac{\text{Net returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

Results and Discussion
Seed production in alfalfa requires high expertise, timeliness, and conducive climate conditions. Among the different production technologies, sowing at optimum planting density, use of bio-fertilizers with discriminate usage of in-organic fertilizers, nutrient management and finding out the suitable season are the important aspects. These play an important role in the seed production of alfalfa to get maximum seed yield with superior quality. Judicious manipulation of plant population through planting density and mother plant nutrition with bio-fertilizers seed treatment in seed production of alfalfa will help to achieve optimum source-to-sink relationship to realize higher seed yield combined with better quality parameters.
Economics of seed production on total cost of cultivation, gross return, net income and the interaction of spacing with nutrient levels influenced cost-benefit ratios during *kharif* and *rabi/summer* 2015.
The gross income was highest in the interaction narrow spacing of 30 x 10 cm spacing with 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM (Rs. 1,28,228 and 1, 18,552 ha^{-1}), was on par with S_1T_1: 30 x 10 cm + 20:100:40 NPK kg ha^{-1} (RDF) + FYM (Rs. 97,732 and 1, 26,732 ha^{-1}) and whereas, the lowest gross income was in S_2T_3: 40 x 20 cm spacing + 10:100:40 NPK kg ha^{-1} + *Rhizobium meliloti* + FYM (Rs. 19,288 ha^{-1}) during *kharif* season & S_3T_6: 50 x 20 cm spacing + 10:50:20 NPK kg ha^{-1} + *Bacillus megaterium* + VAM Fungi + FYM (Rs. 25,528 ha^{-1}) during *rabi*/*summer* season (Table 2 & 3). The higher gross income may be due to the higher planting density along with an adequate amount of nutrition resulted in higher seed yield. These results conform with that of Siddaraju *et al*. (2010) [5] in cluster bean and Sathiya Bama *et al*. (2016) [4] in alfalfa cv. CO-1.
Among the interactions of spacing and nutrient levels (S x T), the lowest cost was noticed in interaction of S_1T_{10}: lower spacing with *Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + *Pseudomonas fluorescens* + FYM (Rs. 30,630 ha^{-1}) in both the seasons. This is because of the cheaper cost of biofertilizers used for seed treatment as compared to the inorganic fertilizer (S_1T_9: 30 x 10 cm spacing + 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM) (Rs. 41,811 ha^{-1}) during *kharif* and *rabi*/*summer* seasons (Table 2 & 3).
The highest net income was recorded in S_1T_9: 30 x 10 cm spacing + 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM (Rs. 86,417 and 1, 16,741 ha^{-1}) followed by S_1T_1: 30 x 10 cm spacing + 20:100:40 NPK kg ha^{-1} (Rs. 56,071 and 85,071 ha^{-1}) during *kharif* and *rabi* / *summer* season, respectively. This might be due to higher seed yield ha^{-1} and higher gross returns. Lower net income was recorded in S_2T_3: 40 x 20 cm spacing + 10:100:40 NPK kg ha^{-1} + *Rhizobium meliloti* + FYM (Rs. -22,384 ha^{-1}) during *kharif*. Whereas the, S_3T_6: 50 x 20 cm spacing + 10:50:20 NPK kg ha^{-1} + *Bacillus megaterium* + VAM Fungi + FYM (-10,583 ha^{-1}) during *rabi*/*summer* season (Table 2 & 3). This may be due to the lower plant population, which resulted in lower seed yield and lower net income. These results are in accordance with the results of Sathiya Bama *et al*. (2016) [4] in alfalfa.
The cost benefit ratio was highest in S_1T_9: 30 x 10 cm spacing + 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM (3.07 and 3.79) followed by S_1T_1: 30 x 10 cm spacing + 20:100:40 NPK kg ha^{-1} (2.35 and 3.05) during *kharif* and *rabi* / *summer* season (Table 2 & 3) respectively. The highest cost benefit ratio in S1T9 and S1T1 was due to higher gross income and net income proportionately fetching higher monetary benefits than the cost of cultivation as compared to other treatment combination levels. This is in accordance with the findings of Anilkumar (2004) [2] in fenugreek, Siddaraju *et al*. (2010) [5] in cluster bean, and Sathiya Bama *et al*. (2016) [4] in alfalfa.

Table 1: Details of cost of cultivation of alfalfa (*Medicago sativa* L.) cv. RL-88 (during *Kharif* and *Rabi* season, 2015)

Sl. No	Items	Unit	Rate (Rs.)	Total (Rs.)
1	**Primary operational cost**			
	Land preparation			
	Ploughing and cultivator	2 hours tractor	450	900
	Harrowing, levelling, layout	4hr (two BP)	300	1200
	FYM	10 t	1000	10000
		5WL	200	1000
	Sowing	2BP	600	1200
		2 WL	200	400
	Basal dose fertilizer application	3 WL	200	600
2	Intercultivation	2 BP	600	1200
3	Weeding	24 WL	200	4800
4	**Input cost**			
	Seed	5 kg	700	3500
	Fertilizers (20:100:40 kg/ha)			
	Urea	43.4 kg	6.4	278
	SSP	625 kg	7.43	4643
	Mop	66.4 kg	10	6640
	Bio-fertilizer	*Rhizobium meliloti*	150/liquid broth slant	150
		Bacillus megaterium	150/liquid broth slant	150
		VAM fungi	80 per kg	80
		Frateuria aurantia	150/liquid broth slant	150
		Pseudomonas fluorescence	150/liquid broth slant	150
	Fertilizer application (Top dressing)	2WL	Rs. 200	400
5	**Allied materials cost**			
	Harvesting	18 LB	Rs.200	3600
	Gunny bags	200 nos.	2	400
	Tags	500	0.10 paisa each	50
6	Seed separation, cleaning, drying etc.	2 WL	200	400
	Cloth bag storing the seed			150
	Transportation			500
7	**Seed certification charges**			
	Registration		25	25
	Field inspection		400	400
	Sample testing cost		50	50
	Supervision and processing cost (2.5 Q)		120 per Q	300
	Courier cost		50	50
8	Seed material	1 kg	700	
9	Gross returns (GR)			
10	Net returns (NR)			
11	B:C ratio			

Note: WL: Women Labour
BP: Bullock pair

Table 2: Economics of seed production in alfalfa (*Medicago sativa* L.) cv. RL-88 (during *Kharif* season, 2015)

Treatments	COC (Rs.)	Seed yield (kg ha^{-1})	GR (Rs.)	NR (Rs.)	B:C
Spacing (S)					
S_1: 30 x 10 cm	37812	181.43	72572	34760	1.92
S_2: 40 x 20 cm	37812	65.02	26008	-11804	0.69
S_3: 50 x 20 cm	37812	70.05	28020	-9792	0.74
Nutrient levels (T)					
T_1:20:100:40 NPK kg ha^{-1} (RDF) + FYM	41661	145.43	58172	16511	1.40
T_2:10:50:20 NPK kg ha^{-1} (50% of RDF) + FYM	35881	80.7	32280	-3601	0.90
T_3:10:100:40 NPK kg ha^{-1} + *Rhizobium meliloti* + FYM	41672	96.62	38648	-3024	0.93
T_4:20:50:40 NPK kg ha^{-1} + *Bacillus megaterium* + FYM	39490	92.86	37144	-2346	0.94
T_5:20:100:20 NPK kg ha^{-1} + VAM Fungi+ FYM	38421	106.05	42420	3999	1.10
T_6:10:50:20 NPK kg ha^{-1} + *Bacillus megaterium* + VAM Fungi+ FYM	36111	84.24	33696	-2415	0.93
T_7:10:50:20 NPK kg ha^{-1} + *Frateuria aurantia* + FYM	36031	84.58	33832	-2199	0.94
T_8:10:50:20 NPK kg ha^{-1} + *Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + FYM.	36411	111.7	44680	8270	1.23
T_9:20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM	41811	180.54	72216	30405	1.73
T_{10}:*Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + FYM	30630	72.28	28912	-1718	0.94
Interactions (SXT)					
S_1T_1	41661	244.33	97732	56071	2.35
S_1T_2	35881	127.46	50984	15104	1.42

S_1T_3	41672	182.08	72832	31160	1.75
S_1T_4	39490	168.83	67532	28043	1.71
S_1T_5	38421	163.24	65296	26875	1.70
S_1T_6	36111	149.54	59816	23706	1.66
S_1T_7	36031	147.23	58892	22862	1.63
S_1T_8	36411	200.59	80236	43826	2.20
S_1T_9	41811	320.57	128228	86417	3.07
S_1T_{10}	30630	110.47	44188	13558	1.44
S_2T_1	41661	112.33	44932	3271	1.08
S_2T_2	35881	57.15	22860	-13021	0.64
S_2T_3	41672	48.22	19288	-22384	0.46
S_2T_4	39490	51.23	20492	-18998	0.52
S_2T_5	38421	75.9	30360	-8061	0.79
S_2T_6	36111	49.46	19784	-16327	0.55
S_2T_7	36031	42.2	16880	-19151	0.47
S_2T_8	36411	60.91	24364	-12047	0.67
S_2T_9	41811	111.31	44524	2713	1.06
S_2T_{10}	30630	41.48	16592	-14038	0.54
S_3T_1	41661	79.62	31848	-9813	0.76
S_3T_2	35881	57.49	22996	-12885	0.64
S_3T_3	41672	59.56	23824	-17848	0.57
S_3T_4	39490	58.53	23412	-16078	0.59
S_3T_5	38421	79.01	31604	-6817	0.82
S_3T_6	36111	53.72	21488	-14623	0.60
S_3T_7	36031	64.31	25724	-10307	0.71
S_3T_8	36411	73.61	29444	-6967	0.81
S_3T_9	41811	109.74	43896	2085	1.05
S_3T_{10}	30630	64.89	25956	-4674	0.85

Table 3: Economics of seed production in alfalfa (*Medicago sativa* L.) cv. RL-88 (during *Rabi* season, 2015)

Treatments	**COC (Rs.)**	**Seed yield (kg ha^{-1})**	**GR (Rs.)**	**NR (Rs.)**	**B:C**
Spacing (S)					
S_1: 30 x 10 cm	37812	245.12	98048	60236	2.59
S_2: 40 x 20 cm	37812	112.19	44876	7064	1.19
S_3: 50 x 20 cm	37812	93.2	37280	-532	0.99
Nutrient levels (T)					
T_1:20:100:40 NPK kg ha^{-1} (RDF) + FYM	41661	199.16	79664	38003	1.91
T_2: 10:50:20 NPK kg ha^{-1} (50% of RDF) + FYM	35881	109.99	43996	8116	1.23
T_3:10:100:40 NPK kg ha^{-1} + *Rhizobium meliloti* + FYM	41672	147.06	58824	17152	1.41
T_4:20:50:40 NPK kg ha^{-1} + *Bacillus megaterium* + FYM	39490	146.51	58604	19115	1.48
T_5:20:100:20 NPK kg ha^{-1} + VAM Fungi+ FYM	38421	172.15	68860	30439	1.79
T_6:10:50:20 NPK kg ha^{-1} + *Bacillus megaterium* + VAM Fungi+ FYM	36111	114.08	45632	9522	1.26
T_7:10:50:20 NPK kg ha^{-1} + *Frateuria aurantia* + FYM	36031	116.44	46576	10546	1.29
T_8:10:50:20 NPK kg ha^{-1} + *Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + FYM.	36411	144.01	57604	21194	1.58
T_9:20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM	41811	256.15	102460	60649	2.45
T_{10}:*Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + FYM	30630	96.17	38468	7838	1.26
Interactions (SXT)					
S_1T_1	41661	316.83	126732	85071	3.04
S_1T_2	35881	181.66	72664	36784	2.03
S_1T_3	41672	252.05	100820	59148	2.42
S_1T_4	39490	250.59	100236	60747	2.54
S_1T_5	38421	269.89	107956	69535	2.81
S_1T_6	36111	202.34	80936	44826	2.24
S_1T_7	36031	200.14	80056	44026	2.22
S_1T_8	36411	230.07	92028	55618	2.53
S_1T_9	41811	396.38	158552	116741	3.79
S_1T_{10}	30630	151.23	60492	29862	1.97
S_2T_1	41661	156.94	62776	21115	1.51
S_2T_2	35881	76.73	30692	-5189	0.86
S_2T_3	41672	101.71	40684	-988	0.98
S_2T_4	39490	102.9	41160	1671	1.04
S_2T_5	38421	134.6	53840	15419	1.40
S_2T_6	36111	76.07	30428	-5683	0.84
S_2T_7	36031	79.83	31932	-4099	0.89
S_2T_8	36411	109.92	43968	7558	1.21
S_2T_9	41811	213.19	85276	43465	2.04

S_2T_{10}	30630	70.04	28016	-2614	0.91
S_3T_1	41661	123.72	49488	7827	1.19
S_3T_2	35881	71.56	28624	-7257	0.80
S_3T_3	41672	87.4	34960	-6712	0.84
S_3T_4	39490	86.05	34420	-5070	0.87
S_3T_5	38421	111.96	44784	6363	1.17
S_3T_6	36111	63.82	25528	-10583	0.71
S_3T_7	36031	69.33	27732	-8299	0.77
S_3T_8	36411	92.04	36816	406	1.01
S_3T_9	41811	158.88	63552	21741	1.52
S_3T_{10}	30630	67.25	26900	-3730	0.88

Table 4: Details of cost of cultivation in different treatments (Rs. ha^{-1})

Sl. No.	Items	Unit	Rate (Rs.)	Total (Rs.)	S_1	S_2	S_3	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
1	**Land preparation**																
	a. Cultivator	2hr	750/hr	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
	b. Harrowing	2hr	750/hr	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
2	FYM	10 t	1000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
		5WL	200	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
4	Sowing	2BP	600	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
		2 WL	200	400	400	400	400	400	400	400	400	400	400	400	400	400	400
	Seed	5 kg	700	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
5	**Fertilizers**																
	Urea	43.4 kg	6.40	278	180.7	180.7	180.7	278	139	139	278	278	139	139	139	278	0
	SSP	625 kg	7.43	4643	3018	3018	3018	4643	2322	4643	2322	4643	2322	2322	2322	4643	0
	Mop	66.4 kg	10.00	6640	4316	4316	4316	6640	3320	6640	6640	3320	3320	3320	3320	6640	0
	Biofertilizers				197	197	197	0	0	150	150	80	230	150	530	150	530
6	Fertilizer application	4WL	200	800	800	800	800	800	800	800	800	800	800	800	800	800	800
7	Intercultivation	2 BP	600	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
8	Weeding	25WL	200	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
9	Harvesting	20WL	200	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
10	Total cost of cultivation				37812	37812	37812	41661	35881	41672	39489	38421	361100	36030	36410	41811	30630

S_1: 30 x 30 cm
S_2: 40 x 20 cm
S_3: 50 x 20 cm

Treatment details

T_1: 20:100:40 NPK kg ha^{-1} (RDF) + FYM	T_6: 10:50:20 NPK kg ha^{-1} + *Bacillus megaterium* + VAM Fungi+ FYM
T_2: 10:50:20 NPK kg ha^{-1} (50% of RDF) + FYM	T_7: 10:50:20 NPK kg ha^{-1} + *Frateuria aurantia* + FYM
T_3: 10:100:40 NPK kg ha^{-1} + *Rhizobium meliloti* + FYM	T_8: 10:50:20 NPK kg ha^{-1} + *Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + FYM.
T_4: 20:50:40 NPK kg ha^{-1} + *Bacillus megaterium* + FYM	T_9: 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM
T_5: 20:100:20 NPK kg ha^{-1} + VAM Fungi+ FYM	T_{10}: *Rhizobium meliloti* + *Bacillus megaterium* + VAM Fungi + *Frateuria aurantia* + FYM

Conclusion

The practical utility of this experiment to the farmers is that use of closer spacing in combination with fertilizer application + bio-inoculants treatments (30 x 10 cm, 20:100:40 NPK kg ha^{-1} + *Pseudomonas fluorescens* + FYM) helps in getting better economic return in alfalfa seed production.

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