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INFLUENCE OF INTERCROPS ON SEED SETTING, SEED YIELD AND ECONOMICS OF LUCERNE (*Medicago sativa* L.) UNDER ARID CONDITIONS

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Rajasthan is the largest state of India and covers nearly 342.65 lakh ha of total geographical area of the country. Rajasthan comprises 62% area of hot arid land of India which receives very little annual rainfall (220 mm). Crop production in this region is constrained by low rainfall and lack of irrigation which makes animal husbandry more important for livelihood security of the people. Animal husbandry is not only a subsidiary occupation to agriculture but it is a major economic activity, especially in the arid and semi-arid regions of the Rajasthan. The livestock population of the state as per 2012 livestock census is 577.32 lakh. Animal husbandry contributes about 10% in the GSDP of the State. This sector has a great potential for rural self-employment at lowest possible investment per unit. Therefore, livestock development is a critical pathway to rural prosperity. This region has large animal population but fodder supply for the animals is limited. Availability of adequate fodder is essential for optimum productivity of animals. Usually foliage of trees and shrubs is used as green and dry fodder for the animals. Annual crops and legumes are also used to supplement the dry fodder requirements of the animals but availability of green fodder is a constraint in providing balanced nutrition to animals. The productivity of livestock is mainly dependent on green and dry fodder. The state possesses a shortage of green fodder and compounded feed to the extent of about 27.16 percent and 35.80 percent, respectively. Current requirement of green fodder in the state is 8.10 million tons, while the availability is only 5.90 million tons. Thus the availability of green fodder is hovering around 73.0 percent in this decade. If this supply is increased, the milk production in the state will also increase and the income of the farmers will also increase. The annual dry fodder requirement of Rajasthan state is estimated around 5.0 million tonnes of which, only about 3.21 million tonnes is available which, is about 64 % of the actual requirement (ICAR-IGFRI,2021). Thus cultivation of fodder crops and fodder and feed storage systems are required to meet the fodder demand (Jha and Tiwari, 2018). Wherever irrigation facilities are available in this region, lucerne, berseem and oats, are mainly grown to supply green fodder as well as dry fodder.

Lucerne, also known as rijka or alfalfa has remarkable ability to produce high yield of rich, palatable, nutritious forage under a wide range of soil and climatic conditions (Morris *et al*., 1992, Shahida *et al*., 2018). It can survive drought condition better than several other fodder crops (Mark *et al*., 2021). Generally, seed setting and seed production of lucerne crop in arid condition where temperature is high and humidity is low is a challenge. Creation of favourable microclimate to attract more number of bees and other pollinators with enhanced activity in lucerne may result in higher seed setting. Indian mustard, fennel and dill crops attract bees and other pollinators and therefore their intercropping with lucerne might increase seed setting in lucerne. This study was conducted with the objective to find out suitable intercrop for seed setting in lucerne through improving microclimate under arid condition of Rajasthan because of seed setting and seed production of lucerne crop in arid/ dry region is challengeable for farmer due to harsh climatic condition especially in Bikaner. Bikaner comes under arid agro-climatic region and Hyper Arid Partially Irrigated Western Plain agro-climatic zone, where the mean daily maximum temperature goes up to 42°C during summer and 24°C during winters. Similarly, mean daily minimum temperature during summers come down to 27°C and to freezing point during winters.

A field experiment was conducted for three years during *rabi* 2018-19 to 2020-21 to find out the effect of intercropping of fennel, dill and Indian mustard on seed setting and seed yield of lucerne at Agricultural Research Station, SKRAU, Bikaner. The soil of the experimental field was sandy loam, slightly alkaline in reaction with pH 8.1 and electrical conductivity of 2.42 dS m^{-1} , low in organic carbon (0.13%), low in available nitrogen (90 kg ha^{-1}), medium in available P_2O_5 (22 kg ha^{-1}) and rich in available K_2O (310 kg ha^{-1}). The study comprised ten treatments viz; lucerne (sole), fennel: lucerne (1:5), fennel: lucerne (1: 10), fennel: lucerne (1:15), dill: lucerne (1:5), dill: lucerne (1: 10), dill: lucerne (1:15), Indian mustard: lucerne (1:5), Indian mustard: lucerne (1: 10) and Indian mustard: lucerne (1:15) which were replicated thrice in randomized block design. Well decomposed FYM @ 20 t ha^{-1} was applied

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Table 1. Effect of intercropping on branches per plant, pods per plant and seeds per pod of lucerne

Treatment	No. of branches plant^{-1}				No. of pods plant^{-1}				No. of seeds pod^{-1}			
	2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled
Lucerne (sole)	5.5	5.9	5.7	5.7	40.6	41.3	71.3	51.0	3.1	3.7	4.0	3.6
Fennel: Lucerne (1:5)	5.7	5.7	5.7	5.7	58.9	44.3	73.6	58.9	5.0	5.1	5.0	5.0
Fennel: Lucerne (1: 10)	5.8	5.6	6.0	5.8	57.4	42.7	72.1	57.4	5.1	4.2	4.9	4.7
Fennel: Lucerne at (1:15)	5.4	5.3	5.5	5.4	61.1	43.1	79.0	61.1	5.1	4.1	5.3	4.8
Dill: Lucerne (1:5)	5.0	5.4	5.3	5.2	51.1	43.6	74.3	56.3	5.0	4.3	4.9	4.8
Dill: Lucerne (1: 10)	5.2	5.7	5.7	5.5	50.3	42.1	75.7	56.1	4.9	4.1	4.7	4.6
Dill: Lucerne (1:15)	6.2	5.7	5.7	5.9	47.7	42.7	73.3	54.6	4.7	3.9	4.7	4.4
Mustard: Lucerne (1:5)	4.1	5.0	5.4	4.8	32.3	42.7	71.1	48.7	3.1	4.1	4.2	3.8
Mustard: Lucerne (1: 10)	5.3	5.3	5.3	5.3	36.6	41.9	72.5	50.3	3.3	3.8	3.9	3.7
Mustard: Lucerne (1:15)	5.6	5.6	5.4	5.5	39.6	42.0	70.6	50.7	4.1	3.8	4.1	4.0
SEm±	0.3	0.3	0.3	0.2	2.1	2.0	2.0	1.2	0.1	0.2	0.2	0.1
CD at 5%	0.9	0.8	NS	0.4	6.2	NS	5.9	3.3	0.3	0.7	0.6	0.3

prior to sowing of the crop for improvement in physical condition, aeration of soil which is required for soil microbes. The recommended doses of N: P_2O_5: K_2O fertilizers (20:32:20) were drilled at the time of sowing were using urea, single super phosphate and muriate of potash. Main crop as well as intercrops were sown in first week of November and harvested in second week on May in 21.00 m x 25.00m plot size using recommended seed rate (lucerne 24.0 kg ha^{-1}, fennel 2.0 kg ha^{-1} dill 1.0 kg ha^{-1} mustard 1.0 kg ha^{-1}) with 30 cm x 10 cm in lucerne and 60 cm x 20 row spacing in intercrops with replacing of two row of main crop. Nitrogen (16 kg ha^{-1}) through urea was top dressed after cutting of lucerne as green fodder at 60 days after sowing. Intercrops were used only for creation of favorable climatic condition for pollinators as well as lucerne crops, so only seed yield of intercrops were considered for economic evaluation. The observations on number of branches plant^{-1}and number of pods plant^{-1} were recorded on five randomly selected representative plants from each plot. Number

Table 2. Effect of intercropping on seed test weight and seed yield of lucerne

Treatment	1000 seed weight (g)				Seed yield (kg ha^{-1})			
	2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled
Lucerne (sole)	2.89	2.68	4.17	3.25	42.8	49.2	95.2	62.4
Fennel: Lucerne (1:5)	3.19	3.39	4.50	3.69	60.9	66.0	83.7	70.2
Fennel: Lucerne (1: 10)	3.29	3.37	4.83	3.83	74.8	73.5	114.1	87.5
Fennel: Lucerne at (1:15)	3.33	3.37	4.93	3.88	84.7	74.2	142.9	100.6
Dill: Lucerne (1:5)	3.10	3.36	4.67	3.71	61.8	64.4	100.0	75.4
Dill: Lucerne (1: 10)	3.04	3.35	4.60	3.66	62.6	70.5	104.9	79.4
Dill: Lucerne (1:15)	3.00	3.36	4.07	3.47	60.2	69.8	86.4	72.2
Mustard: Lucerne (1:5)	2.65	2.87	3.87	3.13	20.5	42.6	68.8	44.0
Mustard: Lucerne (1: 10)	2.80	2.79	4.40	3.33	25.1	45.4	69.3	46.6
Mustard: Lucerne (1:15)	2.89	2.78	3.73	3.13	30.0	44.7	71.2	48.6
SEm±	0.08	0.05	0.20	0.07	3.3	2.8	5.9	2.5
CD at 5%	0.25	0.16	0.59	0.21	9.9	8.4	17.5	6.9

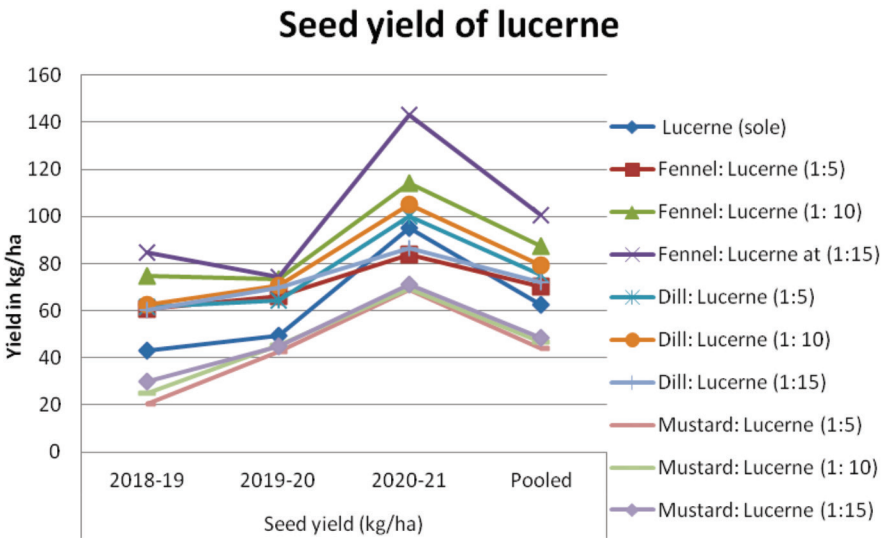

Fig. 1. Seed yield of lucerne

of seeds pod^{-1} recorded in ten randomly selected representative pods for each treatment. The seed and straw yield was recorded from net plot area of each treatment. Economics was calculated by using of crop equivalent yield on the basis of their selling price.

Branches per plant

Data in Table 1 show that intercrops influenced the plant growth with their row ratio and crop nature, if we grow lucerne crop as sole and in combination of fennel. Dill number of branches were increased in lucerne crop after one cut of lucerne as green fodder and it also helped in increment of branches due to new sprouting in plant after cutting at before flowering or initiation of flowering stage. Fennel used as intercrop with ratio 1:10 then observed 15.76 % more branches per plant in lucerne crop but, in case of mustard intercrop it was decreased up to 15.58% level as compared to sole lucerne crop.

Yield attributes

Pooled data in Table 1 indicated that significantly maximum number of pods plant^{-1} and number of seeds pod^{-1} were observed in fennel intercrop with ratio (1:15). On the basis of data, fennel crop was most suitable inter crop for better seed setting and seed yield in lucerne crop as compared to dill and mustard intercrops as well as sole lucerne. It was due to favorable microclimate and high mobility of pollinators. Meena *et al*. (2015) reported that a number of insect pollinators including honeybees were visiting fennel and many other seed spice crops in the country. A pollinator with a higher probability of leaving racemes and plants could set slightly more seed than *M. rotundata,* whereas a

Table 3. Seed yield of inter crops with lucerne crops.

Treatments	Fennel (qha^{-1})				Dill (qha^{-1})				Mustard (qha^{-1})			
	2018-19	2019-20	2020-21	Mean	2018-19	2019-20	2020-21	Mean	2018-19	2019-20	2020-21	Mean
Lucerne (sole)												
Fennel: Lucerne (1:5)	405.0	665.1	473.3	514.5								
Fennel: Lucerne (1: 10)	275.2	467.1	308.6	350.3								
Fennel: Lucerne at (1:15)	184.8	364.8	251.7	267.1								
Dill: Lucerne (1:5)					874.2	901.4	778.5	851.4				
Dill: Lucerne (1: 10)					725.5	734.9	537.8	666.1				
Dill: Lucerne (1:15)					493.2	499.9	305.6	432.9				
Mustard: Lucerne (1:5)									893.5	983.2	787.8	888.2
Mustard: Lucerne (1: 10)									785.2	797.3	654.6	745.7
Mustard: Lucerne (1:15)									413.7	503.9	339.4	419.0

Table 4. Effect of intercropping on economics of lucerne

Treatments	Net returns (Rs. ha^{-1})				B:C			
	2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled
Lucerne (sole)	43175	46720	52315	47404	1.95	2.03	2.17	2.05
Fennel: Lucerne (1:5)	146527	127649	59505	111227	4.52	3.93	2.39	3.61
Fennel: Lucerne (1: 10)	121895	106972	59742	96203	3.84	3.43	2.38	3.22
Fennel: Lucerne at (1:15)	103786	93000	63656	86814	3.35	3.07	2.44	2.95
Dill: Lucerne (1:5)	133635	139188	48597	107140	4.07	4.21	2.14	3.47
Dill: Lucerne (1: 10)	120539	125465	50398	98801	3.71	3.84	2.16	3.24
Dill: Lucerne (1:15)	92799	97823	48572	79731	3.05	3.18	2.10	2.78
Mustard: Lucerne (1:5)	86611	101378	58995	82328	2.99	3.33	2.38	2.90
Mustard: Lucerne (1: 10)	87519	95170	59097	80595	2.97	3.15	2.36	2.83
Mustard: Lucerne (1:15)	58685	71759	63606	64683	2.31	2.59	2.43	2.44
SEm±	4534	6166	2115	2647	0.10	0.14	0.05	0.06
CD at 5%	13470	18320	6284	7504	0.31	0.41	0.14	0.17

Sale price of seeds (Rs. 150.00 per kg lucerne, Rs. 100.0 per kg fennel, Rs. 75.00 per kg dill and Rs. 65.00 per kg mustard)

pollinator with a lower probability of leaving racemes and plants would be more affected by flower standing crop than is *M. rotundata.* The distribution of flowers visited per raceme by bees in alfalfa can be predicted by super imposing the movement probability on the distribution of open flowers per raceme (Strickler and Vinson, 2000).

Test weight and Seed yield

Data presented in Table 2 revealed that lucerne sown with fennel and dill intercrops was significantly affected by these crops and it was observed that test weight increased with intercropping system and increased up to 24% ultimately seed yield of lucerne was increased up to 61.16 % over sole lucerne cultivation. The maximum test weight 3.88 and seed yield (100.60 kg ha^{-1}) were recorded in fennel intercropping with lucerne in the ratio of 1:15. Seed yield of lucerne is also presented graphically (Fig.1). It was due to attraction of insects, which are responsible for pollination in most of the crops. Higher seed setting and obtaining higher seed yield of onion, pollinator attractant crop fennel and/or coriander can be planted in a sequence of two rows for every alternate 10 rows of onion including border (Uddin *et al.*, 2015). Fennel was shown to be highly adapted to a promiscuous pollination regime. It has many features which make it attractive to a wide variety of insect pollinators (Reynolds, 1995).

Economics

Economics of the crops was calculated on the basis of crop equivalent yield of intercrops and green fodder yield of lucerne crops (Table. 3). The data on lucerne equivalent grain yield (kg ha^{-1}) was influenced by intercropping. The significantly highest lucerne equivalent yield was found in intercrops of 1:5 (fennel: lucerne) due to high production of fennel crop as compared to other crops combination (Table.4).The highest pooled net returns (Rs. 111227 ha^{1}) and B: C (3.61) were recorded in intercrop of fennel with lucerne in the 1:5 ratios. The main objective the work was to produce good seed yield of lucerne through creating a micro climate of promoting the pollinators in lucerne crop for good seed setting.

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