timately increased the net returns (Datta *et al*. 2009; Thaneshwar *et al*., 2017).

Thus, growth, economic yield and economics of Indian mustard showed were maximum with the crop sown on 17 November and 75% RDF + 25% N through pressmud + *Azotobacter* + PSB owing to long growing period than other sowing dates and combination of pressmud compost, biofertilizers and chemical fertilizer.

REFERENCES

Bokhtiar, S.M., Roksana, S. and Moslehuddin, A.Z.M. 2015. Soil fertility and productivity of sugarcane influenced by enriched pressmud compost with chemical fertilizers. *SAARC Journal of Agriculture* **13**(2): 183–197.

Datta, J.K., Banerjee, A., Sikdar, M.S., Gupta, S. and Mondal, N.K. 2009. Impact of combined exposure of chemical, fertilizer, bio-fertilizer and compost on growth, physiology and productivity of *Brassica campestris* in old alluvial soil. *Journal of Environmental Biology* **30**(5): 797–800.

Gomez, K.A. and Gomez, A.A.. 1976. *Statistical Procedures for Agricultural Research,* edn 2, John Willey & Sons Inc, New York, the USA.

Kausale, S.P., Shinde, S.B. and Patel, C.L. 2009. Effect of integrated use of fertilizer P, pressmud and PSM on N, P, K and S content and uptake by summer groundnut under Gujarat condition. *An Asian Journal of Soil Science* **4**(1): 32–36.

Kumar, A., Singh, B., Yashaial and Yadav, J.S. 2004. Effect of sowing time and crop geometry on tetra loculor Indian mustard under southwest Haryana. *Indian Journal of Agricultural Sciences* **74**(11): 594–596.

Kumar, R. 2015. Effects of NPKS on growth yield and quality of late sown *toria* varieties (*Brassica rapa* var. *toria*) under rainfed condition of North East India. *Bangladesh Journal of Botany* **44**(4): 521–528.

Kumar, S., Meena, R.S. and Bohra, J.S. 2018. Interactive effect of sowing dates and nutrient sources on dry matter accumulation of Indian mustard (*Brassica juncea* L.). *Journal of Oilseed Brassica* **9**(1): 72–76.

Kumar, S., Meena, R.S. and Jatav, S.S. 2020. Effect of sowing dates and nutrient sources on nutrient uptake of Indian mustard (*Brassica juncea*). *Indian Journal of Agricultural Sciences* **90**(10): 1,902–1,907.

Kumar, S., Meena, R.S., Jinger, D., Jatav, H.S. and Banjara, T. 2017. Use of pressmud compost for improving crop productivity and soil health. *International Journal of Chemical Studies* **5**: 384–389.

Kumar, S., Sairam, R.K. and Prabhu, K.V. 2013. Physiological traits for high temperature stress tolerance in *Brassica juncea*. *Indian Journal of Plant Physiology* **18**(1): 89–93.

Kumari, A, Singh, R.P. and Yeshpal, 2012. Productivity, nutrient uptake and economics of mustard hybrid (*Brassica juncea*) under different planting time and row spacing. *Indian Journal of Agronomy* **57**(1): 61–67.

Meena, R.S., Lal, R. and Yadav, G.S. 2020b. Long-term impacts of top soil depth and amendments on soil physical and hydrological properties of an Alfisol in central Ohio, USA. *Geoderma* **363**: 1141164 https://doi.org/10.1016/j.geoderma.2019.114164.

Meena, D.S., Tetarwal, J.P. and Ram, B. 2013. Effect of chemical and bio-fertilizer son productivity, profitability and quality of Indian mustard (*Brassica juncea* L.) in Vertisols. *Indian Journal of Agronomy* **58**(1): 96–99.

Meena, R.S., Kumar, S., Datta, R., Lal, R., Vijayakumar, V., Britnicky, M., Sharma, M.P., Singh, G.S., Jahariya, M.K., Jangir, C.K., Pathan, S.I., Dokulilova, Pecina, V. and Marfo, T.D. 2020a. Impact of Agrochemicals on Soil Microbiota and Management: A Review. Land **9**: 34.doi:10.3390/land9020034.

Mittal, R., Chakrabarti, B., Jindal, T., Tripathi, A., Mina, U., Dhupper, R., Chakraborty, D., Jatav, R.S. and Harit, R.C. 2018. Carbon footprint is an indicator of sustainability in rice–wheat cropping system: A Review. *Chemical Science Review and Letters* **7**(27): 774–784.

Rafiei, S., Delkhosh, B., Hossein, A., Rad S and Zandi, P. 2011. Effect of Sowing dates and Irrigation regimes on a Agronomic traits of Indian mustard in semi-arid area of Takestan. *Journal of American Science* **7**(10): 721–728.

Shivani and Kumar, S. 2002. Response of Indian mustard (*Brassica juncea*) to sowing date and row spacing in mid hills of Sikkim under rainfed conditions. *Indian Journal of Agronomy* **47**(3): 405–410.

Singh, A. K., Singh, A., C. Aswin and Shashidhar, K.S. 2020. Evaluation of agro-chemicals for enhancing the productivity and profitability of late-sown Indian mustard (*Brassica juncea*) under acidic soils of Manipur. *Indian Journal of Agronomy* **65** (1): 94–99.

Singh, A.K., Singh, R.R., Singh, A.K. and Singh, P.K. 2014. Influence of dates of sowing and irrigation scheduling on growth and yield of mustard (*Brassica juncea* L). *International Journal of Farm Sciences* **4**(2): 80–85.

Singh, S.M., Shukla, A., Chaudhary, S., Bhushan, C., Negi, M.S. and Mahapatra. B.S. 2018. Influence of irrigation scheduling and hydrogel application on growth and yield of Indian mustard (*Brassica juncea*). *Indian Journal of Agronomy* **63**(2): 246–249.

Patel, N., Tyagi, P.K. and Shukla, K.C. 2015. Effect of sowing dates and varieties on total dry matter and its porhoning on different plant parts and yield of Indian mustard. *Annals of Plant and Soil Research.* **17** (4) : 413–417.

Thaneshwar, Singh, V., Prakash, J., Kumar, M., Kumar, S. and Singh, R.K. 2017. Effect of Integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) in irrigated condition of upper Gangetic plain zone of India. *International Journal of Current Microbiology and Applied Sciences* **6**(1): 922–932.

Indian Journal of Agronomy **65** (4): 471–475 (December 2020)

Research Paper

Productivity and profitability of Egyptian clover (*Trifolium alexandrinum*) affected under different sowing times and dates of last cutting

SURINDER SINGH[1] AND KANWALJIT SINGH[2]

Khalsa College, Amritsar, Punjab 143 002

Receive: July 2020; Revised accepted: December 2020

ABSTRACT

A field experiment was carried out at Khalsa College, Amritsar during the winter (*rabi*) season 2016–17 and 2017–18, to study the effect of different sowing times and dates of last cutting on productivity and profitability of Egyptian clover (*Trifolium alexandrinum* L.). Forage yield was found maximum (112.9 t/ha) and minimum (75.1 t/ha) under sowing date 10th September (S_1), and 20th October (S_5), respectively, but 20th October (S_5) resulted in 33.0% more seed yield than 10th September (S_1). Under different sowing times, higher cost of cultivation (41.96 × 10^3 ₹/ha) and fodder returns (79.64 × 10^3₹/ha) were found in 10th September sowing (S_1), but it produced lower seed returns (52.01 × 10^3₹/ha). The maximum gross returns (131.65 × 10^3₹/ha) were obtained under 10th September (S_1). the highest net returns (91.12 × 10^3₹/ha) and benefit: cost ratio (3.32) were recorded under 30th September (S_3) sowing. Among 3 times of last cut, 15th April (C_3) recorded lower seed yield (0.415 t/ha) and straw yield (1.83 t/ha) but higher forage production (102.9 t/ha). Maximum cost of cultivation (40.30 × 10^3₹/ha) and fodder returns (67.67 × 10^3₹/ha) were found when the last cut was done on 15th April (C_3), which was 15.4% and 12% more than 25th March (C_1). Maximum gross returns (129.23 × 10^3₹/ha) and net returns (89.76 × 10^3₹/ha) were obtained when the last cut was done on 5th April (C_2). Benefit: cost ratio was found maximum (3.32) when the last cut was done on 25th March (C_1).

Key words: Egyptian clover, Last-cut, Productivity, Profitability, Sowing times

Livestock being, a key source of supplementary income and livelihood especially for small land holders and landless rural population, plays an important role. Adequate and continuous supply of fodder for the animal is the major problem faced by the Indian dairy farmers. Egyptian clover is always an important fodder crop of the winter season and its quality seed is in great demand in the market. Fodder of Egyptian clover contains 18–21% proteins, 1.98% calcium, 0.64% phosphorus which is the basic requirement for milch animals, having 70–75% digestibility. Egyptian clover has no anti-nutritional and toxic effects. It is mostly used as green forage, but in off season it is also used in the form of hay and pallets etc (Nigam *et al.,* 2010). Egyptian clover is cultivated on 1.9 million ha and recorded 60 to 110 tonnes green fodder productivity per hectare in India (www.indiastat.com, 2018), where dairy animals depend largely on Egyptian clover during October–November to April–May. It is a prominent leguminous fodder in irrigated areas of Punjab, Delhi, Rajasthan, Uttar Pradesh and other parts of North-western India. In Punjab, this crop is grown on 0.227 million ha, with average productivity of 95 tonnes/hectare (PAU, Ludhiana, 2018). It is very high yielding fodder crop which gave 100 to 110 tonnes per season (Thomas, 2008). Number of harvests is the major factor which influences the both fodder and seed yield of Egyptian clover (Mukharjee and Mandal, 2000). Optimum sowing time is very crucial for achieving the higher fresh fodder and seed yield. After several cuttings for fresh and hay use, only few fields are left for seed production. Since, the price of seed fluctuates during the time of sowing and harvesting, farmer pays higher price to get seed for sowing. In Punjab, more than 31% of the farmers complained about the supply of seed of poor quality and un-recommended varieties for fodder crops (Grover and Kumar, 2012). Unavailability of seeds of improved varieties of forage is the major problem in its production. Scarcity of green fodder, erratic and low seed setting discourage the farmers not to prefer for seed production. Forage scientists are giving more emphasis towards production of

[1]**Corresponding author's Email:** babbal1103@gmail.com
[1]Senior Research Fellow, School of Organic Farming, Punjab Agricultural University, Ludhiana, Punjab 143 001; [2]Associate Professor, Department of Agriculture, Khalsa College, Amritsar, Punjab 143 002

biological yield rather than seed yield. Time of last cut is a crucial factor in dual-purpose Egyptian clover. Sufficient time is required to fodder cutting for optimum vegetative growth, attainment of blooming, pollination and seed setting. Thus, proper time of the last cut to fodder and for leaving the crop for seed production may help in keeping the balance between vegetative and reproductive phases for obtaining high seed yield. Seed production of Egyptian clover is also low because of high temperature, low relative humidity prevailing during the reproduction phases and poor attention of famers to seed production (Bakheit *et al.,* 2012). Present study was conducted to investigate the productivity and profitability of Egyptian clover affected by different sowing times and date of last cut.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 2016–17 and 2017–18 at Research Farm, Khalsa College, Amritsar (31–38° N, 74-52°E, and 236 altitude mean sea-level), Punjab, on sandy loam soil. The experimental soil was basic in reaction (7.7) and medium in organic carbon (0.46), low in available nitrogen (168 kg/ha) and medium in available phosphorus (28.5 kg/ha) and potassium (330 kg/ha). The experiment was laid out in split-plot design with 15 treatments and 3 replications. Main plot treatments compared 5 time of sowings, i.e. 10th September (S_1), 20th September (S_2), 30th September (S_3), 10th October (S_4), 20th October (S_5), while sub-plots consisted of 3 different times of last cut, viz. 25th March (C_1), 5th April (C_2) and 15th April (C_3). The field was prepared by ploughing once with tractor-drawn disc harrow and 2 times with cultivator followed each time by planking. Seeds of variety 'BL 1' were sown @ 25 kg/ha by broadcasting method. Seed inoculation with Rhizobium (*Rhizobium trifolli*) @ 1.5 k/ha was done by mixing the seed with culture followed by drying in shade. Nitrogen through urea 54.3 kg/ha was applied in 2 splits, while whole of the phosphorus through single superphosphate 468.7 kg/ha was broadcast at the time of sowing.

All cultural practices were followed as per package of the Punjab Agricultural University, Ludhiana. The first cutting of fodder was done 55 days after sowing and thereafter at 30 days interval. The total number of fodder cuttings depended on the sowing time and last cutting time and sale in the market. The cost of cultivation was worked out using the prices of different agronomic practices and the inputs used in a particular treatment by following variable cost components. The gross returns were calculated by multiplying yield in each cutting with prevailing market prices. The net return over variable cost was calculated as the difference between the gross return and variable cost. Harvest index was calculated dividing economic yield by the total biological (grain + straw) yield and benefit cost ratio was calculated by dividing gross return with total cost of cultivation. Data for 2 seasons were pooled for final statistical analysis.

After each cutting of crop, green fodder was sold in the market on prevailing rates which were fluctuated throughout the season. The sale price (/tonne) of green fodder

Ist week of November–last week of November, Ist week of December–last week of December, Ist week of January–last week of January and February- April was 900, 750, 600 and 500 respectively. The sale price of seed was ₹1,40,000/tonne.

At each cutting of fodder, random samples were taken by quadrate and weighed immediately for fresh weight using standard procedure (Rana *et al*., 2014). After the time of last cut, crop was left for the seed production and the crop was harvested manually with sickle at maturity and left it for sun drying. After that, crop was threshed and the yield estimated on per hectare by following standard procedure.

RESULTS AND DISCUSSION

Yield attributes and yield

The maximum fresh forage yield was recorded in treatment S_1, being 48.2% higher than S_5 (Table 1), which might be owing to more numbers of cuts. Availability of more number of cuts might be owing to longer growing period in treatment S_1 (205 days) than S_2 (195 days), S_3 (185 days), S_4 (175 days) and S_5 (165 days) (data not given). Similar results were also reported by Sardana and Narwal (2000). Among 3 time of last cut, treatment C_3 showed significantly higher green fodder yield. More number of total cuts in C_3 and C_2 might be the reason for the higher yield than C_1 (Table 1). Sardana and Narwal (2000) also reported similar findings. Maximum seed yield was recorded with late sowing S_5 and minimum seed yield was observed in S_1. Mohamed *et al.* (2017) also found that late sowing resulted in higher seed yield than early sowing. Maximum seed yield might be owing to the cumulative effect of physiologically younger plants and optimum exposure of growing period with favourable climatic conditions reported by Sardana and Narwal (2000).

Among different time of last cut, C_1 recorded with the maximum seed yield, which might be owing to fewer fodder cuttings which resulted in better production and translocation of photosynthates from source to sink. Maximum plant growth along with highest seed yield and quality owing to fewer fodder cuttings was in conformity with Srivastava (2016). Yadav *et al.* (2015) studied improvement in seed yield through cutting management by taking different dates of last cut and found that the last week of February to first week of March was more suitable period for the last cut to result in higher seed yield. Maximum straw yield was recorded with 20th October (S_5) sowing date, which might be due to delayed sowing. The results corroborate the findings of Sardana and Narwal (2000). Cutting treatments showed non-significant difference in straw yield. Harvest index in all the treatments were found non-significant.

Economics

Higher cost of cultivation (Table 2) was recorded in S_1 treatment due to higher number of cuttings (6 cuttings after that crop left for seed production) which was only 4 with late-sown crop. Cost of cultivation was higher in treatment C_3 due to longer duration of the crop and more number of cuttings which resulted in higher fodder yield and fodder returns. Lower cost of cultivation in C_1 treatment was due to lesser fodder cuttings. Treatment S_1 gave higher fodder returns but lower seed production and seed returns. Gross returns from early sowing (S_1) were higher than the other treatments. On the other hand, earliest time of last cut C_1 produced lower returns from fodder (60.39× 10^3₹/ha), but higher returns from seed. This might be due to less number of fodder cuttings in C_1, which offered optimum time for seed setting and development. The highest gross returns were observed in C_2 treatment owing to higher fodder return in C_2 than C_1 treatment and higher seed return in C_2 than C_3 treatment and this led to overall highest gross returns in C_2 treatment. Maximum net returns and benefit: cost ratio (3.32) were found in S_3 treatment owing to cumulative effect of lower cost of cultivation than S_1 and S_2 treatment and higher fodder returns than S_4 and S_5 treatment. Among 3 times of last cut, C_2 treatment gave highest net returns, whereas highest benefit : cost ratio was recorded in C_1 which might be due to lowest cost of cultivation.

Operation-wise cost distribution

Different sowing dates and time of last cut affected production cost and resource usage in Egyptian clover (Table 3). More number of cuttings consumed more labour and it was 21.1–31.6% of total cost of cultivation. Single cutting of Egyptian clover on 1 ha consumed 7 man-days which increased with the increase in the number of cuts by early

Table 1. Effect of different sowing and last cutting dates on seed yield attributes of Egyptian clover

Treatment	Green fodder yield (t/ha)	Seed yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Time of sowing				
10th September S_1	112.9	0.372	1.68	18.2
20th September S_2	101.9	0.412	1.78	19.1
30th September S_3	97.8	0.448	1.90	19.4
10th October S_4	86.0	0.469	1.97	19.6
20th October S_5	75.1	0.495	2.01	19.9
CD(p=0.05)	11.0	0.035	0.16	NS
SEm±	5.18	.016	.075	.712
Time of last cut				
25th March C_1	87.6	0.457	1.92	19.5
5th April C_2	94.7	0.436	1.87	19.1
15th April C_3	102.9	0.415	1.83	18.7
SEm±	2.61	0.009	0.064	0.361
CD (P=0.05)	5.27	0.019	NS	NS

Table 2. Effect of different sowing and last cutting dates on economics of Egyptian clover

Treatment Time of sowing	Cost of cultivation (× 10^3₹/ha)	Seed return (× 10^3₹/ha)	Fodder return (× 10^3₹/ha)	Gross return (× 10^3₹/ha)	Net return (× 10^3₹/ha)	Benefit: cost ratio
10th September S_1	41.96	52.01	79.64	131.65	89.69	3.13
20th September S_2	40.58	58.94	72.45	131.39	90.80	3.23
30th September S_3	39.19	63.98	66.33	130.31	91.12	3.32
10th October S_4	37.80	66.92	57.13	124.05	86.24	3.28
20th October S_5	36.47	69.30	49.43	118.73	82.26	3.25
Time of last cut						
25th March C_1	37.84	65.24	60.39	125.63	87.79	3.32
5th April C_2	39.47	62.30	66.93	129.23	89.76	3.27
15th April C_3	40.30	59.36	67.67	127.03	86.73	3.15

Table 3. Operation-wise cost distribution on per hectare basis

Operations	Man-day	Cost (× 10^3₹/ha)	Total cost (× 10^3₹/ha)	Percentage
Land preparation				
Tractor hours			2.75	7.6
Sowing	2	0.27	0.54	1.5
Seed cost	25	0.20	5.00	13.9
Manure and fertilizers	23 kg (urea)	0.67	2.28	6.3
	468.7 kg (SSP)	2.11		
	Rhizobium (1.5 kg)	0.10		
Total labour cost	2	0.27	0.540	1.5
Irrigation cost				
Total labour cost	9	0.27	2.43	6.77
Green fodder cuttings				
Total labour cost	7	0.27	1.89*each cutting 7.56–11.34₹	21.1–31.6
Transportation cost	1 single cut	1	2.000*each cutting 8.00–12.00₹	22.3–33.5
Weeding				
Total labour cost	4	0.270	1.08	3
Roughing				
Total labour cost	2	0.270	0.54	1.5
Harvesting				
Total labour cost	7	0.270	1.89	5.27
Threshing				
Total labour cost	10	0.270	2.70	7.53

SSP, Single superphosphate

sowing and leaving the crop late for the last cut. Early sowing and delay in the last cut resulted in more fodder yield which increased the transportation cost by 22.3–33.5%.

Higher number of cuts increased the cost of cultivation through transportation cost which was 2.0 × 10^3₹/ha per cut and total cost was 8.0–12.0 × 10^3₹/ha. The expenditure incurred on seed purchase was 5,000/ha. The average total expenditure on the manure and fertilizers was was 6.3% of the total cost of cultivation and the average expenditure incurred on field preparation was 7.6% of the total expenditure. Total man-days consumed by threshing and harvesting were 7 and 10, respectively, being 1.89 × 10^3₹/ha on threshing and 2.70 × 10^3₹/ha on harvesting the crop for seed production. Minimum expenditure consumed by roughing was 1.5% of the total expenditure.

The present study clearly indicated that the maximum green fodder yield and seed yield were recorded in early sowing (10th September) and late sowing (20th October) crop (variety 'BL 1'), respectively. To harness the maximum benefits of dual-purpose crop, it is inferred that 30th September (S_3) was the optimum time of sowing which gave maximum net returns and benefit: cost ratio. On the other hand, 25th March (C_1) was optimum time of the last cut in Egyptian clover.

REFERENCES

Bakheit, B.R., Ali, M.A. and Helmy, A.A. 2012. The influence of temperature, genotype and genotype × temperature interaction on seed yield of berseem clover (*Trifolium alexandrium* L.). *Asian Journal of Plant Sciences* **4**: 63–71.

Grover, D.K. and Kumar, S. 2012. Economics of production, processing and marketing of fodder crops in India (consolidated report). Punjab Agricultural University, Ludhiana.

Mohamed, A., Asmaa, A., Bakheit, B.R., Teama, E.A. and Fathy, F.M. 2017. Effect of planting date, variety and their interaction on seed yield and its components of Egyptian clover (*Trifolium alexandrinum* L.). *Assiut Journal of Agriculture Sciences* **48**(2): 1–11.

Mukharjee, A.K. and Mandal, S.R. 2000. Effect of dates of sowing, cutting management and levels of P application on seed yield of shaftal and berseem. *Environment and Economics* **18**(2): 506–508.

Nigam, P.N., Srivastava, R.I. and Verma, N.C. 2010. Effect of different cutting and growth retardant (cycocel) on higher forage yield and seed yield in berseem (*Trifolium alexandrinum* L.). *International Journal of Plant Sciences* **5**(2): 660–663.

PAU, 2018. *Package of Practices for rabi crops*. Punjab Agricultural University, Ludhiana, pp. 91.

Rana, K.S., Choudhary, A.K., Sepet, S., Bana, R.S. and Dass, A. 2014. *Methodological and Analytical Agronomy*. Post-graduate School, Indian Agricultural Research Institute, New Delhi, India, pp. 276.

Sardana, V. and Narwal, S.S. 2000. Influence of time of sowing and last cut for fodder on the fodder and seed yields of Egyptian clover. *Indian Journal of Agricultural Sciences* **134**: 285–291.

Srivastava, S. 2016. Maximization of seed yield and quality seed production in berseem (*Trifolium alexandrinum*). M.Sc. Thesis, Caudhary Charan Singh Haryana Agricultural University, Hisar, Haryana.

Thomas, C.G. 2008. Egyptian clover crop. (In) Forage Crop Production in Tropics, pp. 195–198., Kalyani Publication, Ludhiana.

www.inidastat.com. 2018. Area and production of berseem in India.

Yadav, P.S., Vijay, D. and Malaviya, D.R. 2015. Effect of cutting management on seed yield and quality attributes in tertapolid berseem. *Range Management and Agroforestry* **36**(1): 47–51.

Indian Journal of Agronomy **65** (4) : 476–478 (December 2020)

Research Paper

Evaluation of clusterbean (*Cyamopsis tetragonoloba*) intercrop in agri-silviculture system in south-western Punjab

SUKHDEEP KAUR BRAR[1] AND AVTAR SINGH[2]

Regional Research Station, Punjab Agricultural University, Bathinda, Punjab 151 001

Received: February 2020; Revised accepted: December 2020

ABSTRACT

An experiment was conducted during the rainy season of 2016 and 2017 at Bathinda, Punjab, to check the intercropping feasibility of guar or clusterbean (*Cyamposis tetragonoloba* (L.) Taub] under an agri-silvicultural model comprising 2 year-old plantation of eucalyptus (*Eucalyptus tereticornis* Sm.), poplar (*Populus deltoids* Bartr. Ex Marsh.) and Malabar neem or dek (*Melia dubia Cav.; syn. M. composita* Willd.) at the spacing of 7 m × 3 m. Clusterbean was also sown as sole crop in open space as the control. During the first year of study, plant growth attributes of clusterbean like plant height and days taken to 50% flowering were non-significant. Although the trend was similar in 2nd year, treatment combination under tree canopies took more days (1–2 days) to attain 50% flowering and maturity. There was increase (7–10%) in tree height (1.27, 0.65 and 1.24 m), girth (1.70, 1.20 and 1.45 mm) and canopy cover (0.29, 0.47 and 0.36 m) in all the 3 tree species of eucalyptus, dek and poplar, respectively, which prolonged the days to attain flowering and maturity of the crop grown under the plantation crop. Number of branches (3.33 and 3.20) were more in sole crop in comparison to treatment combination during both the years. Number of pods and number of seeds/pod were at par in 1st year, while differences were significant in the next year. Seed yield (1.06 and 1.05 t/ha) was significantly higher in sole system during both the years, but the differences were more wider in later year. Thus, sole crop gave highest seed yield but agri-silvicultural model with legumes as intercrop will provide opportunities to diversify as well as increase overall land productivity than individual systems.

Key words: Cluster bean, Dek, Eucalyptus, Inter crop, Poplar, Seed yield

In the era of global warming and pressure of ever growing population, agri-silviculture is the need of the hour. Intercropping is a common practice, not only in India but worldwide, because it minimizes the risk of crop failure due to adverse effects of pests, improves the use of limited resources, reduces soil erosion, increases yield stability and is cost effective (Chandra *et al*, 2009). Growing non-leguminous crops with legumes provides climbing support to the later, reduces disease attack, facilitates weed management and reduces the harmful impacts of continuous and intensive cereal cultivation on soil fertility (Nadir *et al*., 2018). Intercropping a legume with a non-legume would be more valuable because of the advantage to the non-legumes from nitrogen fixed by the legume (Rathore, 2016). Furthermore, companion cropping leads to greater yield stability over different seasons, better use of land resources, possibility of better control of weeds, pests and diseases. The yield of intercrops was recorded higher in sole crop than intercropping situation but the biomass production is adequately compensated due to the overall productivity (tree+ crop) which is generally greater than sole agricultural system (Newaj *et al.,* 2003). It will help increase the total production and production per unit area in the farm. Diversification and sustainability in production are the two main goals. It is necessary to simulate viable, acceptable, diversified and sustainable cropping systems, which ensure enhanced crop production by maximizing utilization efficiency of resources available. Moreover, the ever-increasing demand for wood products could be minimized by growing timber trees in agriculture landscape. To address these problems, various fast-growing and industrially important tree species like poplar, eucalyptus, melia, and *shisham* are grown in these regions. In the light of these facts, the present study was undertaken with the objectives to evaluate the feasibility of clusterban or guar intercropping as a means of sustainable intensification of agro-forestry systems

[1]**Corresponding author's Email:** brarsehaj@gmail.com
[1]Agronomist, PAU, RRS, Bathinda. (Punjab)
[2]Principal Scientist (Forestry)

MATERIALS AND METHODS

The experiment with agri-silvicultural model, comprising the tree species of forest red gum tree, poplar and Malabar neem or dek intercropped with leguminous clusterbean in the rainy (*kharif*) season was tested to evaluate the agronomic feasibility of clusterbean in tree species as a means of intensification with an objective to compare the productivity of intercropping with the sole cropping of *guar* in open as the control. The present study was carried out at PAU, Regional Research Station; farm Chak Ruldu Singh Wala, district Bathinda during 2017 and 2018. Experimental site was located at 30° N and 74 78' E at an elevation of 202m above means sea-level. Being located in south-western region of the state and far away from the Shivalik ranges in the north of the state, it is nearest to the Thar Desert of Rajasthan climatically, it has a very hot summer with scorching heat. Dust storms are a regular feature in the summer season when the mercury sometime touches 50°C in the peak summer. The monsoon is scanty and meager. The average annual rainfall was 410 mm. The soil was sandy loam with medium N, P and K (275.2, 16.8 and 221.4 kg/ha). Tree species of eucalyptus was 'C 413', Dek ('Local') and poplar (L 48/89). All the 3 tree species spaced at 7 m × 3 m were two year old when cluster bean was taken as an intercrop during first year. The clusterbean was sown as intercrop between the tree species in ramdomized complete block design with 3 replicas, and then same experiment was carried out next year. The plantation of sole crop of clusterbean as a control was also done for comparison. The sowing of crop was done using 20 kg/ha seed in rows, 45 cm apart, in the first fortnight of July and the crop was raised as per recommended the package of practices. The crop was harvested manually with sickle and threshing was also done manually. Observations on plant growth and yield-attributing characters were recorded to assess the performance of model as compared to sole system. Analysis of variance was performed by using CPCS-1 software as a statistical tool on all the parameters. The difference between means of various treatments was compared with Fishers' least significant difference test at 5 % probability level.

RESULTS AND DISCUSSION

Growth characters

Tree species: During the first year, tree height was recorded as 12.83, 6.85 and 12.20 m in eucalyptus, dek and poplar, respectively (Table 1). During the second year, about 7–10 % increase was observed in all 3 tree species. The maximum tree height was attained by the eucalyptus. Being perennial in nature, diameter/plant (girth) steadily increased with age of the trees. Tree spread in north-south and east-west direction increased in all the 3 species with advancement in age. The maximum tree spread was recorded in dek might be due to spreading nature of the dek than eucalyptus and poplar. Chavan and Dhillon (2019) reported increased diameter at breast height in poplar in north-western India. Similarly, Kaur *et al.* (2017) also found the increased girth at breast height and crown spread in tree species of poplar, eucalyptus and toon with advancement of age from 1 to 6 years.

Clusterbean: There was no significant difference among the growth characters like plant height, number of days taken to 50% flowering during the first year except days taken to maturity (Table 2). However, a significant reduction was observed in plant height during the second year in all intercropping combinations as compared to sole crop.

Table 1. Effect of agri-silvicultural system on growth parameters of tree species

Treatment	Height (m)		Diameter (mm)		Canopy spread (m)	
	2018	2019	2018	2019	2018	2019
Eucalyptus	12.83	14.10	116.50	118.20	2.75	3.04
Dek	6.85	7.50	122.80	124.00	4.43	4.90
poplar	12.20	13.49	143.75	145.20	3.50	3.86

Table 2. Effect of agri-silvicultural system on growth parameters of clusterbean

Treatment	Plant height (cm)		Days to 50 % flowering		Days to maturity	
	2018	2019	2018	2019	2018	2019
Eucalyptus–clusterbean	103.7	103.0	39.0	39.7	98.8	99.2
Dek–clusterbean	101.6	101.0	40.0	40.6	100.0	100.7
Poplar–clusterbean	101.5	101.1	39.6	40.0	99.7	100.4
Sole crop (clusterbean)	104.8	105.0	38.3	38.7	95.7	95.8
SEm±	1.3	1.3	0.2	0.3	0.6	0.6
CD (P=0.05)	NS	1.5	NS	NS	2.4	2.4