

Original Research Article

Growth, Yield and Quality of Linseed under Replacement Series in Legume Intercropping System

ABSTRACT

Among the oil seeds crops grown during *rabi* season, linseed is next in importance to rapeseed and mustard in area as well as production. This crop is often grown on marginal and sub marginal land in *rainfed* conditions as pure and mixed or intercrop. It is one among minor crops which is of economic value because of its common usage in animal feed, oil extraction, etc. There are many factors responsible for lack of productivity of linseed including crop failure. There for increasing productivity and for avoiding the risk associated with complete crop failure intercropping is the way forward. Hence, a field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during two consecutive *rabi* season of the year 2019-20 and 2020-21 in Randomized Block Design (RBD), consisting of ninth different intercropping systems viz.; T₁: sole chickpea, T₂: sole linseed, T₃: sole fenugreek, T₄: (Chickpea + linseed 2:1), T₅: (Chickpea + linseed 3:1), T₆: (Chickpea + linseed 4:2), T₇: (Chickpea + fenugreek 2:1), T₈: (chickpea + fenugreek 3:1) and T₉: (chickpea + fenugreek 4:2) with four replication. The results showed that the plant height of linseed at harvest, number of branches per plant at 60 DAS and at harvest was found significantly higher under treatment T₂ (sole linseed) during the both years as well as in pooled results. furthermore treatment T₂ (sole linseed) recorded significantly higher number of capsules/plant during the year 2019-20, 2020-21 and on pooled base analysis, respectively but being comparable with treatment T₄ (chickpea + linseed 2:1) during both the years. Maximum seed yield of linseed was obtained under treatment T₂ (sole linseed) during the individual years and on pooled base analysis, respectively. Among the intercropping treatments, higher seed yield of linseed was obtained in the treatment T₄ (chickpea + linseed 2:1). While the highest straw yield and harvest index of linseed was obtained in treatment T₂ (sole linseed) during the year 2019-2020, 2020-21 and in pooled results. Treatment T₂ (sole linseed) gave the highest crude protein (%) and oil content (%) during the both years as well as pooled results.

Comment [U1]: Therefore ,

Comment [U2]: remove

Comment [U3]: F

Key Words: *Intercropping, Linseed, Chickpea Growth, Yield, Quality*

1. INTRODUCTION

In today's agriculture diversification and intensification of crop and their combination and sequence both in space and time with new adoptable and remunerative crops and their species has become absolutely necessary as the present food base has been narrowed down coupled with the effect of climate change making it prone to frequent crop failures. The high input based agriculture in the present situation is showing signs of stress, and long term cereal based or nutrients exhaustive crops are putting a question mark on long term sustainability especially. As practiced from old age, intercropping is a useful proposition for increasing the productivity and income per unit area/time in agriculture besides enhancing the water and land use efficiency.

Intercropping encompasses two or more crop species/varieties grown together in distinct row combinations simultaneously on the same piece of land with same time which ensures risks against the crop failure due to adverse weather or market fluctuations besides satisfying the dietary requirement of the explosively growing population. The most common advantage of intercropping is higher production on a given piece of land by efficient use of available growth resources using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirements based on the complementary utilization of growth resources by the component crops.

Despite possible advantages; however, intercropping has traditionally been neglected because of its complexity and management difficulties, although there is an increasing interest in intercropping **now a day**. In densely sown crop like chickpea, inter cropping through replacement series is generally practiced and is viable. Results at various locations indicated that planting geometry plays an important role in optimizing yield levels in inter cropping systems, which may vary with crop combinations, varieties and locations.

Comment [U4]: nowadays

Pulse crops play an important role in Indian agriculture as they sustain the productivity of cropping systems and constitute a major component of Indian diet. Total world acreage under pulses as recorded during the year 2022 is about 851.91 lakh ha with the production of 774.73 lakh tones and average productivity 909 kg/ha. India ranked first in the area and production in the world, followed by Pakistan, Iran and Australia. The highest productivity of 3759 kg/ha is observed in China followed by Israel, Republic of Moldova and Bosnia & Herzegovina. The average productivity of our country was 951 kg/ha yields (Anon., 2022). The unique feature of pulse crop is their deep penetrating root system, which enables them to utilize the limited available moisture more efficiently than many other crops including cereals and also contribute substantially to the loosening up of the soil (Pandit, 2013).

In Gujarat average cultivated area of chickpea is around 45.11 thousand hectares producing 34.28 thousand tones with average productivity of 760 kg/ha. (Anon., 2022). Legumes occupy special place in intercropping due to their nitrogen fixation ability. Therefore, productivity, normally, is potentially enhanced by the inclusion of a legume in the cropping system. India is the second **the largest** (18.88 %) linseed growing country in the world after Canada and production-wise it ranks fourth (7.31 %) in the world after Canada (40.01 %), China (17.15 %), and USA (11.46 %). The area under linseed crop cannot be increased because of the inflexibility of existing cropping systems. Hence, the only way to increase the productivity of such crops is to grow them in association with other crops in such a pattern

Comment [U5]: remove

that the productivity of the base crop is least affected by the associated crop and the production per unit area is also increased.

2. MATERIALS AND METHODS

This experiment was conducted during two consecutive *rabi* season of the year 2019-20 and 2020-21 at the College of Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The soil of experimental site was loamy sand. It was low in organic carbon and available nitrogen, while medium in available phosphorus and available potassium. The soil is free from any kind of salinity and sodicity. During the field experiment, three crops were selected to know the compatibility in intercropping system. The chickpea variety Gujarat Gram (GG 5), fenugreek variety Gujarat methi 2 (GM 2) and linseed variety PKVNL 260 were selected for the experiment. The experiment was laid out in Randomized Block Design (RBD), consisting of ninth different intercropping systems *viz*; T₁: sole chickpea, T₂: sole linseed, T₃: sole fenugreek, T₄: (Chickpea + linseed 2:1), T₅: (Chickpea + linseed 3:1), T₆: (Chickpea + linseed 4:2), T₇: (Chickpea + fenugreek 2:1), T₈: (chickpea + fenugreek 3:1) and T₉: (chickpea + fenugreek 4:2) with four replication. Data on different aspects of chickpea-based intercropping with different row ratio were subjected to statistical analysis as per procedure of Randomised Block Design following the procedure prescribed by Cochran and Cox (1967).

3. RESULTS AND DISCUSSION

3.1. Growth attributes of linseed

3.1.1. Plant Height

The mean data pertaining to periodical plant height measured at 30, 60 DAS as well as at harvest as influenced by different row ratios in intercropping systems during individual years and on pooled basis are furnished in Table 1. Statistical analysis of data revealed that plant height recorded at 30 and 60 DAS failed to exert their significant variation due to different row ratio. However, sole linseed (T₂) registered numerically higher plant height of 17.71, 17.57 and 17.64 cm at 30 DAS and 60.15, 57.91 and 59.03 cm at 60 DAS during first, second year and in pooled, respectively. Significant difference was observed in plant height of linseed at harvest wherein, treatment T₂ (sole linseed) produced significantly higher plant of 68.79, 66.84 and 67.81 cm during year 2019-20, 2020-21 and on pooled basis, respectively, but it was at par with treatment T₄ (chickpea + linseed 2:1) and T₆ (chickpea + linseed 4:2) during both years as well as pooled results. The intercropping system failed to affect the plant height of linseed at 30 and 60 DAS. This might be due to the absence of competition at early stage between main crop with intercrop for resources such as space, nutrients and solar radiation; at latter stage this might be due to better competitive ability of chickpea than linseed, plant height was highest of sole planting. Similar, result was reported Malik *et al.* (2013) under pigeon pea and mungbean intercropping system.

Comment [U6]: by

3.1.2 Number of Branches/Plant

There was non-significant effect of different intercropping systems was noticed with respect to number of branches per plant at 30 DAS during 2019-20, 2020-21 as well as in pooled results. At 60 DAS,

Comment [U7]: that

sole crop of linseed (T_2) produced significantly higher numbers of branches per plant but remained on par with treatment T_4 (chickpea + linseed 2:1) during individual years and pooled results. The result pertaining to number of branches per plant recorded at harvest showed that treatment T_2 (sole linseed) recorded significantly higher number of branches per plant (12.56, 12.36 and 12.46/plant) during the year 2019-20, 2020-21 in pooled analysis, respectively but being at par with treatment T_4 (chickpea + linseed 2:1) and T_6 (chickpea + linseed 4:2) during 2019-20, 2020-21 and in pooled results only treatment T_4 (chickpea + linseed 2:1) was recorded, no significant difference with treatment T_2 . The higher number of branches per plant of linseed probably due to rapid initial growth was provided less competition with the component crop for space which helped to develop the branches. These similar results are in conformity with finding of Awasthi *et al.* (2011), Poddar *et al.* (2013) and Ramarao *et al.* (2020).

Comment [U8]: and

Comment [U9]: remove

3.2. Yield attributes and yield

3.2.1 Number of capsules per plant of linseed

Perusal of data presented in Table 2 indicated that number of capsules per plant recorded at harvest of the linseed crop showed significant variation due to intercropping systems during the years 2019-20, 2020-21 and on pooled analysis. Treatment T_2 (sole linseed) recorded significantly higher number of capsules/plant (53.21 and 50.30 /plant) during first and second year respectively and failed to prove its significant superiority over T_4 (chickpea + linseed 2:1) during first year and T_4 (chickpea + linseed 2:1) and T_6 (chickpea + linseed 4:2) during second year. In pooled result, treatment T_4 (chickpea + linseed 2:1) obtained significantly the highest number of capsules per plant of 51.75. Significantly lower number of capsules per plant (43.25, 43.20 and 43.22/plant) was registered under treatment T_5 (chickpea + linseed 3:1) during the individual year and on pooled analysis.

3.2.2 Number of seeds per capsule of linseed

Different intercropping systems did not show significant influence on number of seeds per pod during both the cropping seasons as well as in pooled analysis. However, sole linseed (T_2) recorded numerically higher number of seeds/capsule (6.69, 6.65 and 6.67/capsule) during first, second year and on pooled basis, respectively and treatment T_5 (chickpea linseed 3:1) recorded numerically least number of seeds/capsule (6.46, 6.30 and 6.38/capsule) during the year 2019-20, 2020-21 and on pooled analysis respectively.

3.2.3 Test weight of linseed

The data presented in Table 2 showed that different intercropping systems did not influenced significantly on the test weight of linseed during the year of 2019-20, 2020-21 and on pooled basis. Though the results were non-significant but numerically higher and lower value of test weight was observed under treatment T_1 and T_5 , respectively on pooled basis. Similar results were also reported by Ahlawat *et al.* (2005) and Tanwar *et al.* (2011).

Comment [U10]: influence

3.2.4 Seed yield (kg/ha)

Data on seed yield of the linseed as influenced by different intercropping systems for the years 2019-2020, 2020-2021 and in pooled basis are presented in Table 2. Significantly, the highest seed yield of linseed (1600, 1576 and 1588 kg/ha) was obtained under the treatment of T_2 (sole linseed) during the year 2019-20, 2020-21 and on pooled basis, respectively. Higher seed yield in sole linseed may be due to higher plant population in sole crop as compared to intercropping. The second-best results

were expressed by treatment T₄ however, it did not differ statistical over treatment T₆. The lowest seed yield in comparison to treatment T₂ was observed under the treatment T₅ (702, 754 and 728 kg/ha) during both the years and on pooled basis, respectively. Similar results were also founded by Meena *et al.* (2018), Gupta *et al.* (2019) and Borad (2021).

3.2.5 Straw yield (kg/ha)

The mean data on straw yield of linseed as influenced by different intercropping systems for the years 2019-20, 2020-21 and pooled analysis are presented in Table 2. It is evident from the data furnished in Table 2 that straw yield was significantly influenced due to different intercropping systems and treatment T₂ (sole linseed) registered significantly the highest straw yield of 2815, 2787 and 2801 kg/ha during the years 2019-20, 2020-21 and pooled analysis, respectively. Treatment T₅ (chickpea + linseed 3:1) recorded significantly lower straw yield of 1714, 1818 and 1766 kg/ha during the both years and in pooled analysis, respectively. The percent increase in straw yield under treatment T₄ to the extent of 17.32 and 1.91 per cent over treatment T₅ and T₆ on pooled basis respectively. The results are in conformity with those of Ahlawat *et al.* (2005), Meena *et al.* (2018) and Gupta *et al.* (2019).

3.2.6 Harvest index of linseed

Data pertaining to harvest index of linseed are displayed in Table 2 revealed that significantly the highest harvest index of linseed was noticed under treatment T₂ (36.24, 36.13 and 36.19 %) during the year 2019-20, 2020-21 and in pooled basis, respectively. While the lower harvest index was observed under treatment T₆ (chickpea + linseed 3:1) *i.e.*, 28.68, 28.66 and 26.67 % during the year 2019-20, 2020-21 and on pooled basis, respectively.

4. Quality Parameter

4.1 Crude protein content of seed (%)

The crude protein content was not influenced significantly by the intercropping treatment during both the years as well as in pooled results (Table 3). However, treatment of sole linseed (T₂) analysed more protein content (24.26, 23.95 and 24.10 %) over intercropping combinations during both the years as well as in pooled data, respectively. Numerically minimum value of crude protein content of 23.34, 22.84 and 23.09 % in linseed was observed under treatment T₅ (chickpea + linseed 3:1) during the year 2019-20, 2020-21 and pooled analysis, respectively.

4.2 Oil Content in Seed of Linseed (%)

Treatment did not induce any significant variation in oil content (%) of linseed during both the years as well as in pooled basis. Although, numerical higher value of oil content (36.37, 36.16 and 36.26 %) was recorded under treatment T₂ (sole linseed) during the year 2019-20, 2020-21 and on pooled basis, respectively. Whereas, numerically lower value of oil content (36.11, 35.92 and 36.02 %) was observed under treatment T₅ (chickpea + linseed 3:1) during the year 2019-20, 2020-21 and pooled analysis, respectively

5. CONCLUSION

Two year of field experimentation of chickpea intercropped with linseed resulted in better growth of linseed and ultimately gave the yield advantage which resulted in higher economical returns over the sole cropping of linseed or sole cropping of chickpea.

REFERENCES

1. Ahlawat IPS, Gangaiah B, Singh OM. Production potential of chickpea (*Cicer arietinum* L) based intercropping systems under irrigated conditions. *Indian Journal of Agronomy*. 2005;50(1):27-30.
2. Anonymous. Ministry of Agriculture and farmer's welfare, Govt. of India, Retrieved from <http://www.indiastat.com;2022>.
3. Awasthi UD, Tripathi AK, Dubey SD, Kumar S. Effect of row ratio and fertility levels on growth, productivity, competition and economics in chickpea + fennel intercropping system under scarce moisture condition. *Journal of Food Legumes*. 2011;24(3):211-214.
4. Borad UR. Production potential and economics of chickpea (*Cicer arietinum* L.) based intercropping system under irrigated condition. M.Sc. (Agri.) thesis submitted to the Junagadh Agricultural University, Junagadh;2021.
5. Cochran WG, Cox GM. *Experimental Designs*. Asia Publishing House. Bombay;1967.
6. Gupta KC, Kumar V, Praharaj CS, Yadav MR. Productivity and profitability of chickpea + linseed intercropping system as influenced by spatial arrangement of crops in semi-arid eastern plain zone of Rajasthan. *Journal of crop and weed*. 2019;15(2):110-114.
7. Malik JK, Singh R, Singh, Thenua O, Kumar A. Response of pigeonpea + mungbean intercropping system to phosphorus and biofertilizers. *Legume Research*. 2013;36(4):323-330.
8. Meena D, Bhushan C, Shukla A, Singh, VK, Pareek N. Effect of planting patterns and fertility levels in chickpea and linseed intercropping in Tarai Region of Uttarakhand, India. *International Journal of Current Microbiology and Applied Sciences*. 2018;7(8):1957-1961.
9. Pandit AK. Agronomic evaluation of linseed (*Linum usitatissimum* L.) in chickpea + linseed (4:2) intercropping system. M.Sc. (Agril.) thesis submitted to Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh;2013.
10. Poddar R, Kumar S, Pannu RK, Dhaka AK. Evolution of chickpea (*Cicer arietinum* L.)-spices based intercropping systems on yield and economics. *Annals of Biology*. 2013;29(3):327-330.
11. Ramarao, Chandranath HT, Babalad HB, Hegde Y. Growth, yield and oil quality of mustard in chickpea (*Cicer arietinum* L.) and mustard (*Brassica juncea* L.) intercropping system under different row ratio in northern transition zone of Karnataka. *Indian Journal of Agricultural Research*. 2020;54(3):322-328.
12. Tanwar SPS, Rokadia P, Singh AK. Effect of row ratio and fertility levels on chickpea (*Cicer arietinum*) and linseed (*Linum usitatissimum*) intercropping system. *Indian Journal of Agronomy*. 2011;56(3):217-222.

Comment [U11]: italicize

Comment [U12]: Italicize all journal names.

13. Yadav AK. Performance of chickpea (*Cicer arietinum* L.) based intercropping system. M.Sc. (Agri.) thesis submitted to Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur;2005.

UNDER PEER REVIEW

CV %	9.76	9.24	9.51	9.76	7.45	8.75	6.32	7.01	6.66	10.68	10.27	10.47	8.32	8.29	8.30	9.71	8.51	9.15
------	------	------	------	------	------	------	------	------	------	-------	-------	-------	------	------	------	------	------	------

Table 1: Plant height and number of branches per plant of linseed

UNDER PEER REVIEW

CV %	7.21	6.25	6.76	7.06	8.99	8.06	9.87	7.14	8.63	9.12	6.54	7.92	9.13	7.16	8.19	4.00	2.51	3.33
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

UNDER PEER REVIEW

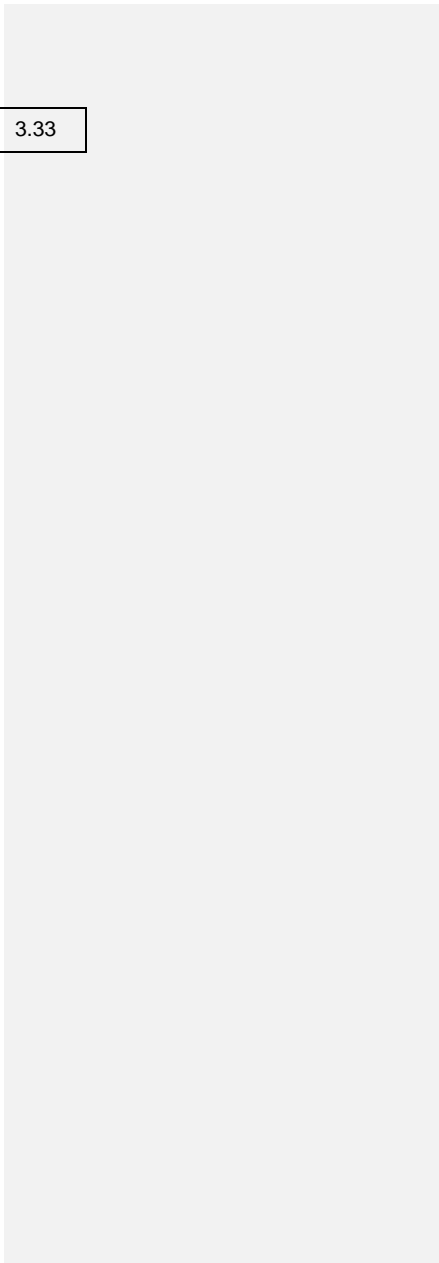


Table 3: Quality parameters of linseed

Treatments	Crude protein (%)			Oil content in seed (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Intercropping system						
T ₂ : Sole linseed	24.26	23.95	24.10	36.37	36.16	36.26
T ₄ : Chickpea + linseed 2:1	23.51	23.46	23.48	36.17	36.02	36.09
T ₅ : Chickpea + linseed 3:1	23.34	22.84	23.09	36.11	35.92	36.02
T ₆ : Chickpea + linseed 4:2	23.50	23.04	23.28	36.15	35.97	36.06
SEm±	1.73	1.46	1.08	1.36	1.56	0.96
CD (P=0.05)	0.73	0.95	0.55	NS	NS	NS
Y effect	NS	NS	NS	--	--	NS
CV %	--	--	NS	7.49	8.67	8.10